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*"To the solid ground*
*Of nature trusts the Mind that builds for aye"* —WORDSWORTH

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# CONSERVATION OF WORLD RESOURCES

THE Materials Policy Commission, established by President Truman on January 22, 1951, to make a long-range study of the materials problem of the United States, having regard to the needs and resources of friendly nations, was also charged with assisting the formulation of materials policy. The Commission was assisted by a comprehensive staff, as well as by a panel of the National Research Council and by numerous industrial firms, universities and other bodies. The work of the Commission has now been made available in a comprehensive report* running to five volumes, of which the first, entitled "Foundations for Growth and Security", embodies the bulk of the findings and recommendations, constituting a summary and broad analysis of the whole problem. With the fourth volume, "The Promise of Technology", it is the part of the report of most interest to the scientific worker, though the technologist will also be concerned with the second and third volumes, dealing with the outlook for key commodities and energy sources, respectively. The fifth volume presents a few of the basic studies prepared to assist the Commission.

The report of this Commission, known from its chairman, Mr. W. S. Paley, as the Paley Commission, was sent to Congress on July 1, 1951, and the National Security Resources Board was asked by President Truman to study the Commission's seventy-eight specific recommendations. A special body was set up by that Board to submit suggestions for implementing those recommendations as well as to assist in continuing the review of materials and energy policies and programmes. Originally the proposals of the National Security Resources Board were to be forthcoming within sixty days; but this task proved too great for the original time limit Nevertheless, the report of the Materials Policy Commission seems likely to result in definite action by the United States Government.

One of the most interesting features of the report is, however, the way it endorses an opinion expressed earlier in the year in "Facts and Figures for the Chemical Process Industries" by E. W. Pehrson, of the United States Bureau of Mines, that, from a mineral point of view, the United States are a 'have-not' nation in several indispensable minerals, and that for some of these the United States cannot hope to improve their position significantly through increased domestic output. Pehrson, in this article, listed thirty-eight important natural raw materials, and showed that in only nine of these are the United States self-sufficient, and for twelve they produce only ten per cent or less of their needs. The Paley Commission, in the first volume of its report, lists the production and reserves of twenty-two key materials in the free world, on all of which the United States are already substantially reliant or likely to become more reliant. Furthermore, with but 6·3 per cent of the world's population, the United States use 45 per cent of the world's minerals and are responsible for 50 per cent of the world's industrial output.

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* Resources for Freedom. (A Report to the President by the President's Materials Policy Commission.) Vol. 1: Foundations for Growth and Security. Pp. viii+184. 1.25 dollars. Vol 4: The Promise of Technology. Pp x+228. 1.75 dollars. (Washington, D.C.: Government Printing Office, 1952.)

During the first fifty years of this century, the population of the United States has doubled, while the national output increased five times. While the consumption of agricultural products of all kinds, including food, increased two and a quarter times, the consumption of minerals, including fuels, increased sixfold. By 1950, in comparison with 1900, the output of coal had increased two and a half times, of copper three times, of iron ore three and a half times, of zinc four times, of natural gas twenty-sixfold, and of crude oil thirtyfold. This trend is expected to continue. It is estimated that by 1975 the demand for minerals as a whole will be twice as heavy as in 1950, though it is difficult to forecast the increased demand for any particular material.

To readers of the report outside the United States the most interesting feature, however, in its analysis of the materials situation is not the realization by the United States of the worsening relationship between their requirements and their means of satisfying them, but rather the outlook revealed by the Commission. There is official recognition that supplies are not inexhaustible, that even the United States must learn to be less wasteful of their natural resources of minerals, great as they are, and must accept the necessity of re-using the products of those resources many times over, and improve their techniques for the discovery and development of mineral resources. The Paley Commission points out that by making fuller use of known resources either by the avoidance of wastes, the exploitation of materials of lower grade or quality, or the utilization of waste products, the supplies of domestic materials can be expanded. This is largely a matter of expanding technology, though new physical knowledge may also be required.

Both factors contribute to the improvement which could result by shifting from the use of scarce to more abundant materials, or the more economical use of materials which comes when they are used under conditions having closer regard alike to their intrinsic properties and to the purpose to be served. Whatever advantage can be drawn from the synthesis of new materials to relieve existing shortages, the recovery of valuable materials from waste products or scrap, the prevention of corrosion and the reduction of losses in storage or transport depend on technological skill and scientific knowledge. Furthermore, they may also determine the capacity of the United States for dealing with what the Commission describes as the real threat in their materials problem.

This threat does not relate to absolute shortages but is due to the insidiously rising real costs—the hours of human work and amounts of capital required to bring a pound of industrial material or a unit of energy into useful form. During most of the twentieth century these real costs of materials have been declining, and this decline has assisted in raising standards of living in the United States. The Paley Commission believes that this trend has now been retarded, sometimes stopped and even reversed.

The central challenge of the materials problem in the United States is accordingly to meet expanding demands with expanding supplies, while averting a rise in real costs per unit. This question of costs is manifestly likely to be more difficult to overcome than in the past. Only in chemicals have real costs apparently declined faster in the past decade than in the previous four; and whereas wholesale prices of commodities in general advanced about 105 per cent between 1940 and 1950, that of zinc rose 119 per cent, petroleum 149 per cent, farm products 152 per cent, lead 157 per cent and lumber 218 per cent. Other materials, including aluminium, iron ore, nickel, sulphur and copper, rose less than the general average. But the rate of technological progress, which could help to counteract this situation, depends largely on the supply of scientifically trained personnel and the expansion of the fundamental scientific knowledge upon which technology is based; here the Paley Commission states that available evidence shows that the prospective flow of scientific men and engineers from the universities is alarmingly below apparent needs.

The Commission accepts the view that the United States have been less assiduous in increasing the store of fundamental knowledge than in applying such knowledge in industry, and that fundamental research in the United States should be more in balance with the expenditure of effort on applied research and development. It does not believe, however, that the United States Government has a philosophy of research commensurate with its present responsibilities for the allocation of financial support. At no point in the government organization can a comprehensive picture be obtained of the pattern of technological activity financed by the Government or an appraisal of that pattern.

In general terms, the Commission formulates six main tasks for technology: the fostering of new techniques for discovery; the utilization of new materials; the broader application of the principle of re-cycling; the handling of low concentrations of useful materials; the development and more economic use of renewable resources, such as solar energy; and the use of more-abundant materials to lessen or eliminate the use of a scarce material. These are dealt with in a subsequent chapter in the first volume, but detailed discussion is reserved for the fourth volume, in which specific problems are indicated. Here we can only consider the Commission's further judgment of the United States resources of trained man-power and their direction, which are examined in the chapter on "Government and Materials Research".

The United States are estimated to have roughly 625,000 scientific workers and engineers, of whom some 76,000 scientists and 59,000 engineers are engaged in research—nearly 60 per cent in industrial laboratories, about 20 per cent in government laboratories and 20 per cent in educational institutions, scientific foundations, and the like. As already indicated, the Commission concurs in the view that there is likely to be an acute shortage of technical man-power in the immediate future, and it recommends that both industry and the government should give the maximum support to programmes for advanced training consistent with the number of young scientific workers willing and able to continue their work. It also recommends that the appropriation of the National Science Foundation should be increased to the limit of 15 million dollars which Congress inserted into its basic Act, and that Congress should re-examine the bases upon which it set this limit so low.

The most pressing need, however, is for better co-ordination. The Commission believes that establishment of an active co-ordinating body is essential for shaping and executing a comprehensive, effective national policy of materials research. Such an organization would estimate and appraise the impact of technology and other forces upon supply. It would, for example, revise continually estimates of reserves in the light of new discoveries and the development of new uses and methods; estimate annually requirements of supplies at least ten years into the future on the basis of scientific and technological developments, as well as data on domestic production and consumption, and imports and exports; report potential shortages of important materials far enough in advance to permit corrective action; and maintain an up-to-date list of the materials research and development projects that should be undertaken. For such projects that cannot normally be assumed by industry, it would consult with the appropriate advisory bodies and, if necessary, bring the problem before the President or Congress. Such an organization would necessarily occupy a high place in the structure of the Federal Government and maintain close relations with the National Science Foundation and many other government agencies as well as with industry. The Commission recommends that the National Security Resources Board should be directed to provide such a co-ordinating service.

Whatever action may be taken on the Paley Commission's report in the United States cannot affect its value as a record of a reasonable appraisal of the situation over the next twenty-five years. Moreover, although in the lineage of Vannevar Bush's "Science, the Endless Frontier" and the Steelman report on "Science and Public Policy", it does more than record the view that the United States should be increasingly concerned with the conservation of resources: it asserts that the problem is one for the free world as a whole, and in which international co-operation is indispensable. The major premise of the report is, in fact, that the overall objective of a national materials policy for the United States should be to ensure an adequate and dependable flow of materials at the lowest cost consistent with national security and with the welfare of friendly nations. The Commission recommends that increasing emphasis be given under the United States programmes of technical assistance to under-developed areas for geological survey, preliminary exploration, and advice on mining technology. Support for these programmes should be increased to as much as four million dollars a year; but the extension of technical assistance in these fields should be accompanied by assurances to the United States that the recipient country will promote conditions favourable to developing such resources as may be discovered.

This objective inquiry has thus summoned the United States to conserve natural resources and co-ordinate them along with those of the other free nations to the ends of common growth, common safety and common welfare, almost simultaneously with Prof. A. V. Hill's reference to this question of world resources and world population in his presidential address to the British Association. Prof. Hill emphasized the challenge of the present situation to the responsible use of knowledge and the combined resources of science, humanity and statesmanship. The Paley Commission affirms its belief in the principle of growth and in private enterprise as the most effective means of performing industrial tasks in the United States; but it believes also that the destinies of the United States are inextricably bound up with those of the free world. There is much technical detail of wide interest to be found in these reports, but there is nothing more encouraging or more widely welcome than the evidence they contain of this spirit of co-operation and of readiness to approach the common problem of raising the standards of living of the free world as a whole, responsibly and imaginatively, with all the resources which science and technology can put at the disposal of statesmanship.

## THE SOLAR SYSTEM

### The Origin of the Earth

By Prof. W. M. Smart. Pp. viii+239+8 plates. (Cambridge: At the University Press, 1951.) 12*s*. 6*d*. net.

PROF. W. M. SMART has written this book for the general educated reader, who, in the first part, will find an admirably descriptive account of the solar system, which is complete in itself. The material is presented so as to lead up to the conclusion that the uniformities of orbital and rotational motions in the solar system are so pronounced as to make it very probable that the whole system must have come into being as the result of a single cosmical process. There are exceptions to these uniformities, the most striking being the existence of retrograde satellites. But there is a rational explanation; it is significant that the retrograde satellites are mainly to be found at the outermost fringes of the planetary systems concerned. To quote Prof. Smart: "There is perhaps a little justification for the suggestion that the satellites not conforming to the majority rule may have been originally minor planets which, through the interplay of planetary and other attractions, have been captured by the parent planets".

Having decided that the solar system originated as the result of a single cosmical process, the next question is: When did this happen? The second part of the book is devoted to the answer to this question, and an obvious starting-point is the age of the earth. Prof. Smart recalls the nineteenth-century controversy between Kelvin and the geologists, and he then gives an excellent résumé of the main facts of radioactive and nuclear phenomena, leading up to a clear account of the radioactive method of determining the age of the earth's crust, which is tied down to something between two and four thousand million years. He then passes on to an account of the astronomical evidence which leads to estimates of the ages of the moon, sun and universe. The evidence from these phenomena of the expansion of the universe is outlined, leading to the conclusion that "we are left with a time scale of a few thousand million years within which the universe has reached its present development from an initial state of high concentration. The evidence from the lengthening of the day as a consequence of tidal friction leads to the conclusion that about 4,000 million years ago the moon's centre was but 8,000 miles from the earth's centre, and that then the period of orbital revolution of the moon was equal to the rotational period of the earth, both being about 4 hours". The further suggestion seems to be unavoidable that the moon had then just been formed from the earth, from which it follows that the age of the moon is about 4,000 million years at most.

As regards the age of the sun, Prof. Smart indicates how current ideas of the source of stellar energy lead to the conclusion that the sun's age "must then be much less than 8,000 million years". I feel that in this part of his book Prof. Smart may have produced an impression in the general reader's mind which is rather too dogmatic. He gives an admirable account of the known thermo-nuclear reactions which may have been effective in the life-history of the sun. But I think he could have made it clearer that our knowledge of these processes is probably incomplete and that other nuclear processes, of which at present we are ignorant, may have been effective. Until the method of synthesis of the more complex nuclei is understood, it is probably imprudent to be dogmatic. But having said this much, I hasten to add that the general reader will find a fascinating and well-written account of those thermo-nuclear reactions which have been studied and are now well understood.

There remains the question of the exact mechanism of the cosmical process whereby the solar system was formed. The answer really is that we do not know, and in the third part of the book all that Prof. Smart can do is to give an account of the various theories that have been advanced. He records the conclusion that "the scientific search for an answer to our final question has thus failed, up to date, to reach a solution agreeable to astronomers other than those perhaps who individually are concerned with the formation of a particular theory". A very sound and salutary conclusion !

The high standard of presentation is only what one expects from the Cambridge University Press. The book is excellently illustrated.

W. M. H. GREAVES

# PREHISTORY OF UGANDA

**The Pleistocene Geology and Prehistory of Uganda**
Part 2: Prehistory. By Dr. C. van Riet Lowe. (Geological Survey of Uganda, Memoir No. 6.) Pp. x+113+54 plates. (Entebbe: Geological Survey of Uganda, 1952.)

PROF. C. VAN RIET LOWE, of the University of the Witwatersrand, Johannesburg, has won a great reputation among archæologists for the work he has accomplished on the prehistory of South Africa. What then could be more fortunate than the collaboration of a man who knows as much as he does of the prehistory of the subcontinent with a colleague like Mr. E. J. Wayland, the director of the Geological Survey of Uganda—a man whose knowledge of his subject is unrivalled and who shares Prof. Lowe's love for prehistory ! Part 1 of Memoir No. 6 of the Geological Survey of Uganda has yet to appear, and in it Mr. Wayland will deal with the Pleistocene geology of the Uganda area ; it is to be hoped that he will not delay too long in publishing the fruits of his researches. Meanwhile, and happily, Part 2 ("Prehistory") of the Memoir has appeared, the result of some months of field- and museum-work in Uganda carried out in 1939 by Prof. Lowe, who worked at Mr. Wayland's sites with him and collaborated very closely. The work is exactly what one could have hoped for—a straightforward and lucid account of the Stone Age cultures of Uganda based on the geological and archæological investigations of Mr. Wayland.

It is perhaps to be regretted that the author was unable, as he states, to examine an earlier work on the area—Mr. T. P. O'Brien's "The Prehistory of the Uganda Protectorate"—while he was working in the country. One questions whether a most understandable desire to avoid entering the lists of East African prehistoric controversialists really does excuse the ignoring of this book ; for though O'Brien was not a geologist, he did have geological advice, including much kind help from Mr. Wayland, and had some experience in typology—and he did produce an impressive volume. It was always clear that his presentation of the story was open to criticism ; in this case, for example, it would seem that Prof. Lowe does not agree with all his conclusions, such as the dating of the Kafuan culture ; but it would have been a great help to prehistorians who have not worked in Uganda to have had the criticisms of the work of Prof. Lowe's predecessor from the pen of one who does know the country.

The memoir opens with a historical review—necessarily mainly an account of Wayland's connexion with Uganda. While not going into details, the geological setting is here given and, a little later, there is a diagrammatic section of the Kagera river valley near Nsongezi showing terraces and the 'M', 'N' and 'O' horizons. There are chapters on the various cultures, starting with the Kafuan and reviewing the African Chellean, the African Acheulean, the Sangoan, and the Upper and Epi-palæolithic cultures and concluding with the Neolithic. In dealing with the Magosian culture, in the publication of which I was proud to be associated with Mr. Wayland in 1932, Prof. Lowe regrets that as all the material was sent to Cambridge he can only summarize the descriptions given in the paper referred to. There are thus no illustrations of the Magosian industry in this book—a notable lack in such a definitive work on the prehistory of the country. Yet reproduction of the original drawings or a choice re-drawing of the specimens could easily have been arranged. A brief but excellent summary and conclusions, with a useful table of climatic and geological correlations and, later, a bibliography, complete the text of 113 pages. Commenting on the surprising absence of any expression of the 'Capsio-Aurignacian complex' in Uganda, the author suggests that this may have been due to the lack of any fine-grained material such as flint, obsidian or indurated shale suitable for the manufacture of blade-and-burin industries. I have always felt that early man was very much at the mercy of physical Nature and feel sure that, as prehistorians discussing distribution maps, we often pay too little attention to this kind of circumstance. Lastly come fifty-four full quarto pages of illustrations of stone industries. These are well-chosen and very well drawn, many of them from the gifted pen of Mrs. Leakey—and it is no easy matter to interpret specimens of fairly crude industries when they are made from coarse-grained materials lacking the clearly defined flake intersections of flint and similar materials.

Altogether Prof. van Riet Lowe is to be heartily congratulated on having accomplished so much in his visits to Uganda (none of them very long), on having written a clear and much-needed account of the industries of the country founded on sound geological premises, and on having made available for study in the illustrations a large number of stone implements of various ages and cultures. M. C. BURKITT

# 'MAXWELL'S SPOT' IN COLOUR VISION

New Means of Studying Color Blindness and Normal Foveal Color Vision

With some Results and their Genetical Implications. By G. L. Walls and R. W. Mathews. (University of California Publications in Psychology, Vol. 7, No. 1.) Pp. iv+172. (Berkeley and Los Angeles: University of California Press; London: Cambridge University Press, 1952.) 2.50 dollars.

THE storms that periodically affect the world of colour show few signs of abating, and a fresh disturbance from the west, indeed from as far west as California, is heralded by this monograph. Dr. G. L. Walls is already well known as the author of "The Vertebrate Eye and its Adaptive Radiation", but the present work is in no sense a staid text-book. On the contrary, it is a trenchant criticism of many orthodox views and many orthodox workers, and perhaps we should be grateful that at least two British men of science in this field, Dr. W. S. Stiles and Dr. F. H. G. Pitt, emerge relatively unscathed.

For once, however, it is not the three-component theory of colour vision that is under attack. At the outset, the authors make it clear that they are staunch supporters of this theory, and, while their main theme concerns defective colour vision, it is their views on the yellow macular pigment that will probably create the greatest interest. A yellow pigment is believed by many authorities on vision to occupy the central macular area of the retina, and variations in its density are commonly regarded as a major cause of individual differences of colour perception and colour matching. The present authors do not actually deny the existence of the pigment, but they do deny that it plays the important part that is frequently attributed to it.

A subjective demonstration of the macula is obtained when a uniform area of light such as the sky is viewed through a filter which transmits mainly at the far red and far violet ends of the spectrum. A diffusely defined reddish area is seen projected against the sky, and, as the gaze is directed from one part of the sky to another, so the spot follows the direction of view. It quickly disappears owing to local adaptation of the retina, but is restored to view if the filter is momentarily removed and then replaced. Sometimes the spot can be seen, without the aid of a filter, projected on a material dyed with a dichroic dye, although such dyes are normally avoided both because of their apparent spottiness and their marked change of colour with quality of the lighting.

James Clerk Maxwell studied this spot in some detail, and it is often referred to as 'Maxwell's spot'. An obvious and commonly held explanation was absorption of the blue radiation by the yellow macular pigment, and it is this explanation that Walls and Mathews flatly reject. They have been to considerable trouble to discover a filter which shows the effect as clearly as possible, and, with the aid of an experimental Wratten filter, detailed structure within the spot can be observed. The structure varies considerably from observer to observer and even between the right and left eyes of a given observer, but most often a central red spot subtending about $\frac{1}{4}$° is seen, and then an annular clearing of the same colour as the background, surrounded by a further red zone the diameter of which is some 3–4°. Occasionally, a tiny pip of the colour of the background is located at the centre of the central spot, an effect I can see in my left eye using Walls's filter, but not in the right.

Walls and Mathews point out with some logic that a yellow pigment impregnated in the retinal tissue could scarcely account for the structure of Maxwell's spot, since the retina is thinnest in the central $\frac{1}{4}$° of the fovea in just the area where the blue absorption should be greatest. They therefore attribute the phenomenon to variations in distribution of the retinal colour receptors, and they point in particular to the recent experiments in foveal tritanopia (which they call tetartanopia) as evidence that the blue receptors are missing in the foveal centre.

A number of other arguments are assembled to demolish the macular hypothesis, including the discovery that one group of colour-defectives, the deuteranopes, are unable to see the Maxwell spot. The latter half of the monograph is, in fact, mainly devoted to a description of the spots seen by colour-defectives and to a discussion of the observation as a colour vision test.

There is much here that deserves detailed study, and the analysis is undoubtedly made more difficult by the fact that in some respects both a yellow pigment and absence of blue receptors could produce rather similar effects. It does no harm for orthodoxy to be subject to the fierce criticism that we have here, but not all the arguments are equally valid. Many people would probably give greater weight to the histological arguments if reference had been made to Polyak's work. Then the authors criticize the use of data derived by calculation from the C.I.E. colorimetric system in place of direct experimental observations, yet their own neutral-point determinations were calculated on the C.I.E. chromaticity chart.

Perhaps the main misinterpretation, however, is in attributing colour-matching differences to differences in receptor distribution. Two different physical stimuli that have the same colour would remain a match however much the proportions of red to green to blue receptors were changed in the area of the retina viewing the two lights. The appearance of the lights would change, but they would still match. On the other hand, if the spectral sensitivities of the receptors were altered, or if a colour filter were introduced in the two beams, the match would break down.

Actually, colour matches differ from one observer to another very much as if a yellow filter of differing density had been introduced, hence the argument for the yellow macular pigment.

Yet difficulties do remain, and we can still be grateful to the authors of this monograph for their ruthless exposure of some of the fallacies of the pigmentary theory of Maxwell's spot without necessarily accepting all their arguments and conclusions.

W. D. WRIGHT

# TEXT-BOOK OF PLANT PHYSIOLOGY

## Principles of Plant Physiology

By James Bonner and Arthur W. Galston. (A Series of Biology Texts.) Pp. x+499. (San Francisco: W. H. Freeman and Co.; London: Bailey Bros. and Swinfen, Ltd., 1952.) 5.50 dollars; 47*s*.

DESPITE (or perhaps because of) the rapid progress during the past twenty years in the elucidation of plant physiology, text-books in this field of natural knowledge have remained notoriously few and far between. The appearance of a new one is thus an event of unusual interest.

This new volume, originating chiefly from the California Institute of Technology, is distinguished especially by the excellence of its treatment of the more biochemical aspects of the activities of the plant, and there are admirable chapters on photosynthesis, carbohydrate metabolism, respiration, nitrogen metabolism and enzyme action. The capacity and enthusiasm of the authors are, however, by no means exhausted by their labours on nutrition and metabolism, as is shown when they proceed, in the last third of the book, to give a stimulating and authoritative treatment of growth and development, in which the plant hormones, tissue culture and photoperiodism receive especial attention.

In general the information provided is thoroughly up to date, and, though references are not cited in the text, a short list of sources is appended to each chapter. The book as a whole is written at a level approximating to that of a general degree course in botany, but in biochemical and some other aspects the standard of treatment is nearer to that of a special course. Omissions that may be noted include a failure to attempt an adequate explanation of root pressure, or to mention frequently observed phenomena such as guttation, nastic movements, haptotropism or nutation. Minor objection could be taken to a preliminary statement on p. 11, which might be interpreted to mean that the oxygen of photosynthesis originates from carbon dioxide—the correct position on this is of course clearly indicated later in the chapter—and also to a slight uncertainty in the text as to whether or not the authors intend photosynthesis to be reckoned as a part of the metabolism of the plant.

In contrast with most other text-books on plant physiology, this one is copiously illustrated by means of drawings, diagrams, cartoons and graphs, to a total of 218. Many of these are excellent and some decidedly novel, such as that in which the familiar Askenasy apparatus is depicted as seen obliquely from above. But a few of the illustrations fall below the high standard set by the text. Fig. 11–9, purporting to illustrate the legume root nodule, is decidedly crude. The diagrams referring to plasmolysis fail to accord with the text in that they show no overall shrinkage in the size of the cell. The seedlings portrayed in Fig. 14–4 and stated to be "beans" seem more likely to be those of a cucurbit.

These minor criticisms do not detract significantly from the assessment of this new work as a notable achievement. It is written in a lucid and interesting style, and is printed in a large, easily read type. A first reading has yielded only a single misprint. In so far as the rather high price permits of it, this text-book should be in the hands of all students reading for a general or special degree in botany.

G. BOND

# PLANT RESPIRATION

## Respiration in Plants

By Prof. Walter Stiles and Prof. William Leach. (Methuen's Monographs on Biological Subjects.) Pp. vii+172. (London: Methuen and Co., Ltd.; New York: John Wiley and Sons, Inc., 1952.) 10*s*. 6*d*. net.

THIS little book was first published in 1932 and no monograph of plant respiration has appeared during the succeeding twenty years. It has therefore carried a heavier burden than perhaps even its authors anticipated, and, meanwhile, much has happened to the subject it describes. The foundations of the study of plant respiration were firmly laid about the start of the century, so it would be too much to say that the progress of the past twenty years has been revolutionary; but it has advanced to new levels and depends on different tools.

In preparing the third edition it has not been found necessary to alter the plan of the book, or to rewrite the first three of its four chapters, though a number of important additions have been introduced. The pages of text have been increased from 108 to 142, and 21 of the new pages are in the last chapter, which has been extensively rewritten. This is a fair reflexion of the present emphasis on the study of intermediate stages and chemical mechanisms.

The description of so complex a branch of metabolism within such narrow limits necessarily assumes a great deal of background knowledge on the part of the reader—perhaps about the amount commonly assumed in advanced lectures. It also necessitates the making of statements—such as that the end-products of aerobic respiration are the same as those of hexose combustion—without much evidence or discussion. It is presumably for the same reasons that one might be led to suppose that virtually the whole energy turnover of anaerobic respiration may be usefully transferred. To keep such difficulties within bounds, the authors have limited their choice of topics, and have in general succeeded in giving good grounds for the opinions they have adopted. While it would be difficult always to agree with them, it is good to note the caution with which they approach controversial matters. It is refreshing to find in so brief an account more than one idea of the fate of pyruvic acid and a reluctance merely to assume the identity of anaerobic respiration and alcoholic fermentation.

The changes noted in this new edition are all for the good; and, even when setting the first edition within the framework of its time, the new edition seems a better book and likely to be even more useful to students than its predecessor.

W. O. JAMES

# 'KRILIUM' AND SYNTHETIC SOIL CONDITIONERS

By Prof. J. H. QUASTEL, F.R.S.

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THE announcement of a synthetic soil conditioner, for the improvement of soil structure on a wide scale, was first made at a meeting of the American Association for the Advancement of Science held in Philadelphia on December 29, 1951, where a symposium on the improvement of soil structure by the application of organic matter took place. The papers read at this symposium have been published[1], and I have given a summary of them[2]. The present article is intended to give some account of the development and properties of soil conditioners.

## Soil Organic Matter and Soil Structure

The organic matter of soil plays an essential part in securing in soil the structure that is required for high fertility. The maintenance of the supply of organic matter to arable soils is, indeed, a matter of the greatest economic importance, for productive capacity is largely dependent upon it. It is a well-known fact that an arable soil regularly supplied with farmyard manure has an improved and more stable structure than the same soil that has not received organic additives. A more friable crumb structure resistant to disintegration by water is produced.

The organic matter of soil is primarily derived from the decomposition products of plants and from the products of autolysis of the immense numbers of micro-organisms which develop at the expense of substances of plant origin. A dynamic equilibrium exists in the soil between the numbers of bacteria, protozoa, yeasts and fungi, etc., that inhabit the soil and the organic matter being continually supplied by the decaying animal and vegetable tissues. Soil, therefore, normally contains a wide range of substances commonly classed as metabolites of animal and plant tissues. The speeds of change of these substances may be very great, the rates depending on the temperature, hydrogen ion concentration, aeration, availability of water and mineral content of the soil. A number of substances, derived from animal, plant or microbiological life, are, however, relatively resistant to breakdown, and these substances make up for the most part what is commonly known as organic matter. Such substances have the physical and chemical properties which together help to determine the structure and to influence the fertility of a soil.

Among the most characteristic of the products making up the soil organic matter is the black colloidal material having high hydrophilic power known as humus. This is a complex mixture of substances which was once thought to be formed solely from the cellulose in soil but which is, in fact, a natural system varying in composition and consisting largely of various derivatives of lignins, proteins and celluloses. This organic matter greatly influences the structure of a soil, and therefore the air–water relationships upon which the fertility of a soil depends.

The structure of a soil refers to the grouping or clustering of soil particles into aggregates or crumbs that at once influence water-movement, aeration and heat transfer. The granules that make up a soil of good structure may have a tremendous internal surface like that of a highly porous sponge, and it is in this large surface area that many of the biochemical and chemical changes take place that so markedly affect fertility. It is here where develop micro-organisms which convert organic nitrogenous compounds into the nitrate required by the plant roots, where metallic ions required by the plant are held by the soil in a base-exchangeable, or dissociable, form, where oxygen is dissolved and carbon dioxide is generated influencing local acidity and the metabolism of the plant root.

Aggregating substances are found uniformly distributed in soil crumbs. These consist[3] of organic compounds resulting from the decomposition of fresh organic matter and of a group of substances, including oxides of iron and aluminium, fats, waxes and resins, which are less efficient than the former as soil aggregators. It is well known that bacterial slimes and fungal mycelia play an important part in soil aggregation and the resistance of soils to erosion.

It is now known that among humus constituents are the polyuronides, substances related to the sugars and existing in a polymerized form. Forsyth[4] has, for example, isolated from soil a polysaccharide fraction containing uronic acid units. These are widely distributed in plants, composts and soils. The quantity of polyuronide present in soil varies with the type of soil[5], and there is evidence that the more fertile the soil the greater is the quantity of polyuronide present. Polyuronides include such well-known substances as pectic acid, alginic acid and a variety of bacterial polysaccharides. They compose the plant gums that are found in soils containing decaying vegetable matter. Bacterial polysaccharides such as the levans and dextrans also have marked aggregating effects on soils[6,7].

## Alginic Acid and Soil Structure

The large effect of a polyuronic acid, such as alginic acid, in increasing the water-holding power and crumb-stability of a soil was first shown by Quastel and Webley in 1947[8] in work carried out during 1941–45 in the Agricultural Research Council Unit of Soil Metabolism at the Rothamsted Experimental Station, Harpenden. These investigators used a manometric method of assessing the availability of oxygen to living cells, such as those provided by micro-organisms and plant roots, present in soils. The technique made it possible to investigate rapidly the immediate effects of the addition of various forms of organic matter on water-holding power and crumb-stability of soil. It was speedily found that the incorporation into soils of a variety of substances may greatly increase the amount of water that can be added to a soil before the availability of oxygen, defined as the aeration factor, falls. Sodium alginate, in particular, greatly increases both the water-holding power of a soil and its crumb-stability. Results

Table 1. AERATION FACTORS OF SOILS CONTAINING ALGINATE AND OTHER SOIL CONDITIONERS (Quastel and Webley, ref. 8)

| | Percentage water content per dry weight of soil | | | |
|---|---|---|---|---|
| | 25 | 37·5 | 50 | 62·5 |
| | Aeration factor values* | | | |
| Standard soil alone (a heavy clay) | 82·7 | 48·6 | 29·4 | 14·9 |
| + 0·1% sodium alginate | 88·4 | 76·4 | 42·7 | 17·2 |
| + 1·0% sodium alginate | 97·4 | 96·3 | 67·9 | 39·0 |
| Garden soil | 101·0 | 83·2 | 72·0 | 21·7 |
| + 1·0% sodium alginate | 108·4 | 112·0 | 123·4 | 96·0 |
| Standard soil alone | 86·4 | 55·1 | 27·0 | 16·0 |
| + 1% cellulose acetate | 97·1 | 89·2 | 58·6 | 31·7 |
| + 1% methyl cellulose | 91·7 | 88·8 | 53·7 | 21·5 |
| + 1% carboxymethylcellulose | 100·4 | 94·3 | 52·6 | 25·6 |
| + 2% farmyard manure (dried and ground) | 86·2 | 69·6 | 32·5 | 12·6 |
| + 2% horse dung | 104·0 | 107·5 | 83·7 | 76·1 |
| + 2% ground peat | 88·2 | 68·1 | 36·5 | 18·5 |
| + 2% extract of peat | 100·5 | 94·8 | 56·9 | 24·5 |
| + 2% extract of garden soil | 109·4 | 123·5 | 86·8 | 35·3 |

* Optimal aeration is given by aeration factor = 100

showing the effect of adding alginate to a standard soil depleted of organic matter are given in Table 1. It is seen that the addition of 1 per cent sodium alginate increases the aeration factor of a poor soil to that found for a fertile garden soil. The effect of the alginate rapidly increases to a maximum with increase of concentration. Even a garden soil, with a fairly high content of organic matter, showing good aeration at a high water-content, is affected by addition of alginate so as to improve the hydrophilic properties of the soil (Table 1).

## Soil Conditioners

Not only is a polyuronide effective in improving soil structure; cellulose esters such as cellulose acetate, methyl cellulose and carboxymethylcellulose will also improve the air–water relationships in soil (Table 1).

These are substances which may be termed soil conditioners. They improve the structure of a soil by increasing the water-holding power and the soil crumb-stability. This improvement of structure enables more oxygen to become available to the cells, micro-organisms or plant roots, present in soil, at the water contents that the cells need for their metabolism. The increased stability of the soil crumbs diminishes soil disintegration by weathering, etc., and hence diminishes soil erosion. Soil conditioners are not plant nutrients. They yield nothing of service to the plant itself. But, by altering the soil structure, they make more oxygen and water available to the plant roots.

The addition of farmyard manures greatly improves the air–water relationships and crumb-stability of soil, and so does the addition of sewage sludges, composts and refuses generally in proportion to the amount of organic matter present. Extracts of soils and peats may be also very effective (see Table 1) in accordance with their content of organic matter.

These observations make it clear that the commonly occurring forms of organic matter in soils and manures greatly improve the hydrophilic properties and crumb-stability of soils. Yet the practical importance of such substances is greatly dependent on the rate at which they decompose in soil and lose their improving properties. That the addition of alginate to a soil will improve the yield of a crop, grown under glass, was shown by Quastel and Webley[8] and confirmed by Owen[10] and by Hedrick and Mowry[11] (see Table 4); but it soon became certain that the fact that the polyuronide breaks down fairly rapidly in soil militates against its use on a wide scale as a soil conditioner. Again, relatively large quantities are required for the improvement of soil structure (perhaps 5–10 tons per acre) and they may cause harmful effects due to the liberation of cations which have to be added to the polyuronic acid to preserve neutrality.

It was my objective to find a substance, or substances, which would have the improving effects of alginate on soil structure but which would be relatively stable in soil. For use on a large scale, as a substitute for the organic matter of manures and composts, such substances would have to be, weight for weight, more effective than alginate, and without harmful effects on micro-organisms, plants or animals. The advantages of these substances for the improvement of fertility in soils relatively poor in, or depleted of, organic matter would be enormous.

Thanks to the recent discoveries of the scientific staff of the Monsanto Chemical Company, with whose investigations in the field of soil conditioners I have been associated, such substances are now available.

## Synthetic Soil Conditioners

Hedrick and Mowry, of the scientific staff of the Monsanto Chemical Co., using initially the manometric technique adopted by Quastel and Webley, and later a modification of the wet-sieving technique of Yoder[12], began the screening of a large number of substances, most of which were synthesized in the Monsanto laboratories, to see if any had improving effects on soil structure. They soon found that only certain water-soluble polymeric electrolytes of high molecular weight were effective at the extremely low concentrations required by practical considerations. One of the most active substances was made by the hydrolysis of polyacrylonitrile to what is predominantly a sodium salt of a polyacid. Other substances that showed excellent effects were also polymers of nearly related structure. These substances had very great improving effects on soil aeration and soil aggregation[11]. A few typical results are shown in Table 2.

Table 2. AERATION FACTORS OF SOILS TREATED WITH POLYELECTROLYTES (Hedrick and Mowry, ref. 11)

| Chemical added to standard soil (sandy loam) | Concentration (percentage) | Aeration factors | | | |
|---|---|---|---|---|---|
| | | 25% water | 37·5% water | 50% water | 62·5% water |
| Standard soil alone | — | 83 | 55 | small | small |
| Sodium alginate | 1·0 | 108 | 106 | 73 | 20 |
| Sodium alginate | 0·1 | 118 | 85 | 28 | small |
| Pectin | 1·0 | 86 | 77 | small | small |
| Lignin | 1·0 | 90 | 67 | small | small |
| *CRD*-186 | 1·0 | 130 | 99 | 63 | 30 |
| *CRD*-186 | 0·1 | 128 | 92 | 66 | 40 |
| *CRD*-189 | 0·1 | 113 | 99 | 72 | 35 |

The two materials on which most work was carried out were *CRD*-189, the sodium salt of a hydrolysed polyacrylonitrile, and *CRD*-186, another carboxylated polymer used as a partial calcium salt. Both these polymers are polyanions, that is, they contain recurring carboxyl groups along the carbon chain.

These polymers have a very great effect upon crumb (or aggregate)-stability and upon soil aeration. A comparison of the effects of preparations of

Table 3. PARTICLES < 0·25 mm. AGGREGATED INTO WATER-STABLE AGGREGATES > 0·25 mm. BY TREATMENT WITH *CRD*-186

(Hedrick and Mowry, ref. 11)

| Soil | Percentage aggregation | | |
|---|---|---|---|
| | Untreated | 0·02% *CRD*-186 | 0·1% *CRD*-186 |
| Paulding clay | 26 | 29 | 63 |
| Sacramento clay | 8 | 25 | 47 |
| Miami silt loam | 7 | 48 | 96 |
| Cherokee silt loam | 7 | 34 | 94 |
| Pond loam | 1 | 38 | 87 |
| Renville loam | 5 | 13 | 57 |
| Barboursville sandy loam | 11 | 78 | 86 |

*CRD*-186 and *CRD*-189 with those of several other substances on the aeration values of a sandy loam is shown in Table 2. *CRD*-186 and *CRD*-189 gave better aeration values at levels of 0·1 per cent in soil than any of the other materials at 1 per cent. This effect of *CRD*-186 occurs with a large variety of soils. The aggregate stability, as measured by wet-sieving technique, was greatly increased by application of the polymers to the soil, the quantity of large crumbs being increased with a higher rate of application of the polymers. Results of laboratory applications of *CRD*-186 to a number of structurally deficient soils are shown in Table 3. Very pronounced improvement in the workability of all soils treated with *CRD*-186 and *CRD*-189 took place. They became crumbly and friable at high water contents.

Although the primary effect of the polyelectrolyte is on aggregate stability, the percolation-rate through a treated soil may show a hundred-fold increase over an untreated soil. The moisture equivalent of a soil is also improved, and evidence from experiments on the wilting of plants has indicated that all the increase in water held by the soil is available for plant growth. Treatment of soil with the polyelectrolyte results in a reduction of the rate of surface evaporation.

Crumbs of soil treated with *CRD*-186 have remained stable under constant perfusion with water and air for 32 months at 76° F., indicating negligible biological breakdown of the soil conditioner in this period. The untreated crumbs broke down in a few minutes under the same conditions.

An important question concerning the action of the synthetic soil conditioners was whether they affect adversely plant and animal life in the soil. The Warburg evaluation technique indicated that the polymers are not toxic to yeast or bacteria in the soil; moreover, the processes of nitrification are not disturbed. Spectroscopic analyses of kidney beans, wheat and radish plants grown in treated and control soils have indicated that nutrients and trace elements are not rendered unavailable in any way. Nor are the polymers toxic to earthworms, which have appeared in greater numbers in the more friable and well-aerated soil. Rats and chicks have been fed with relatively large doses of *CRD*-186 and *CRD*-189 with no apparent ill effect.

Table 4. EFFECT OF *CRD*-189 AND ORGANIC FERTILIZERS ON GROWTH OF RADISHES IN MIAMI SILT LOAM (Hedrick and Mowry, ref. 11)

| Treatment | Dosage (per cent) | Average radish weight factor |
|---|---|---|
| None | — | 1·0 |
| *CRD*-189 | 0·05 | 1·7 |
| *CRD*-189 + artificial fertilizer* | 0·05 | 3·4 |
| Sodium alginate | 1·0 | 0·04 |
| Sodium alginate + artificial fertilizer* | 1·0 | 2·6 |
| Commercial compost | 1·0 | 1·1 |
| Activated sewage sludge | 1·0 | 0·6 |
| Rotted cow manure | 1·0 | 2·3 |
| Peat | 1·0 | 1·1 |

* Artificial fertilizer is 0·1 per cent N.P.K. (6-10-4)

The effects of application of *CRD*-189 and of other substances to a silt loam on the growth of radishes are shown in the results of Hedrick and Mowry, given in Table 4. It will be noted that alginate in the presence of added artificial fertilizers gives excellent growth, though alone it induces little or no growth owing to its mobilization of available nitrogen due to its breakdown in the soil. The synthetic polymer shows no such inhibitive effect.

## Crop Yields

According to Allison[13] the application of *CRD*-186 and *CRD*-189 at rates of 0·025 per cent and 0·1 per cent to several saline and alkali soils from the western United States produce high water-stable aggregations, with considerable increases in permeability of soils. Crop yields were favourably affected. Sweet corn was grown on treated and untreated soils; whereas the untreated soils gave poor stands of corn owing to heavy crust formation, full stands were obtained on the treated soils. The quality of corn was excellent and yields were good despite the prevailing high temperatures during the experiments.

Further experiments indicated that administration of *CRD*-186 facilitated removal of salt and exchangeable sodium after irrigation of the soils, a property of importance in soil reclamation.

Martin, Taylor, Engibous and Burnett[14] found also that application of the conditioners to various soils greatly improved water-stable aggregation and such related properties as porosity and permeability. Crop yields, particularly those of corn, oats and carrots, were considerably increased. Some of their results with sweet corn and beet are shown in Table 5.

Table 5. EFFECT OF *CRD*-186 ON AGGREGATION AND SWEET CORN AND BEET YIELDS ON PAULDING CLAY

(Martin, Taylor, Engibous and Burnett, ref. 14)

| Treatment | Aggregation (particles >0·25 mm.) (%) | Sweet corn | | Red beets | |
|---|---|---|---|---|---|
| | | height (in.) | increase over untreated (%) | weight per 30-ft. row (lb.) | increase over untreated (%) |
| Untreated | 45 | 12·1 | — | 6·7 | — |
| 0·05% *CRD*-186 | 85 | 21·3 | 76 | 7·7 | 15 |
| 0·15% *CRD*-186 | 94 | 24·4 | 102 | 8·7 | 30 |

## Control of Soil Erosion

Equal in importance to the experiments showing the effects of soil conditioners on the improvement of crop yields on various soils are those demonstrating the remarkable effects of conditioners in the control of soil erosion. Work by Weeks and Colter[15] has shown that surface soil can be satisfactorily stabilized to the erosive action of rainfall by treating the surface with the soil conditioner. The permeable film produced by the conditioners not only stabilizes the soil, but also prevents run-off. The effect was much the same as that due to the application of a high rate of straw mulch. Addition of half to one pound of conditioner to 100 sq. ft. provided satisfactory protection to the soil. One set of results on the effects of artificial rainfall on experimental plots showed that erosion equal to a loss of 50 tons of soil per acre was reduced to a loss of 3 tons per acre by application of the soil conditioner.

## 'Krilium'

'Krilium' is the trade mark adopted by the Monsanto Chemical Company for substances such as *CRD*-186 and *CRD*-189 sold as soil conditioners. The advent of these conditioners heralds a new phase in agricultural science, of equal importance perhaps with that brought about by the first application of the artificial fertilizers. The possibilities of improvement of fertility in the semi-arid wastes of many parts of the world, which have suffered through neglect of proper cultivation or lack of application of organic matter, are very obvious. But apart from the important economic consequences of the administration to suitable soils of the synthetic soil conditioners, it is clear that these substances afford most valuable material for further studies of the relationship between organic matter and soil fertility.

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# SCIENTIFIC CENTENARIES IN 1953

By JOAN M. EYLES

WHILE science, in the modern sense, is often taken to date from about 1600, a year marked, for example, by the publication of Gilbert's "De Magnete", its roots are to be found far back in earlier ages. No one would deny the right of the Greeks to have some mention in a history of science, and few would omit the name of Plato, who is said to have died in 347 B.C., 2,300 years ago. Many biologists, and geologists, too, have heard of Anaximander, who died two hundred years before Plato, in 547 B.C. To include, in this annual review, the names of men who flourished before the Christian era certainly requires a rather optimistic reliance on the accuracy of historical chronology. Our justification must be that, if absolute accuracy be demanded, it might become necessary to omit the names not only of such men, but also of natural philosophers who lived many centuries later. With this apology, we return to Anaximander (c. 611–547 B.C.), a citizen of Miletus, and pupil and friend of Thales, who was not only interested in astronomy and geography, but also believed that the first animals were generated from moisture, being thus the first teacher of the doctrine of abiogenesis. He also taught that the ancestors of men were of aquatic origin.

Plato (428–347 B.C.) must be regarded with mixed feelings. His attitude towards physical science, which he thought should be discussed as idealized by the mind rather than as presented by the senses, was called by Sir James Jeans a major disaster for physics. Others admire him for the immense stimulus he gave to the development of mathematics. He insisted on the value of mathematics in the development of logical thought, and over the entrance of his Academy was inscribed, "Let no one enter who is unacquainted with geometry". Although his interest in astronomy redeemed it from the reproach of atheism and thus made it respectable, his opinion that the perfection of the universe required planetary motion to be circular dominated astronomical thought for centuries, until the time of Kepler.

Passing over the Dark Ages, now being illuminated by the questing beams of historians, we come to the thirteenth century A.D., when the founding of a school of science in Oxford can be attributed to Robert Grosseteste, who was born at Stradbroke, Suffolk, about 1173, and died in 1253. Grosseteste studied at Oxford, and later lectured there, ultimately becoming chancellor of the University. About 1224 he was appointed rector of the school established by the Franciscans. Here one of his pupils was Roger Bacon, who said of his master, "One man alone, our Lord Robert, knew the sciences", and it was probably due to the early influence of Grosseteste that Bacon plunged so deeply into scientific studies. Grosseteste himself was one of the earliest of the experimental scientists, and was particularly interested in optics, which he considered to be the basic science. His writings include a discussion of vision, a treatise on the rainbow, and another on comets. He was made Bishop of Lincoln in 1235, an appointment which he held until his death on October 9, 1253.

Coming to more modern times, three men who died in 1553 must be mentioned here. They are Reinhold, the mathematician and astronomer, Fracastoro, the physician, and Servetus, who earned a niche in medical history for his remarks on the minor or pulmonary circulation. Erasmus Reinhold (1511–53) became professor of mathematics at Wittenberg, a university founded in 1502 and closely linked with Luther and the early days of the Reformation. Reinhold, a friend and colleague of Rheticus, who was the first disciple and staunch supporter of Copernicus, applied himself to recalculating to a greater degree of accuracy the tables given by Copernicus in his "De Revolutionibus", and these were published in 1551 as the "Prutenicae Tabulae" (so called in honour of Albert, Duke of Prussia, Reinhold's patron). These tables were well received at their first appearance, and were only supplanted by the "Tabulae Rudolphinae" of Kepler, published in 1627. Reinhold died on February 19, 1553, at Saalfeld, his birthplace, where he had fled in a vain attempt to escape the plague. A text-book on surveying, including mine surveying, which he had written, was published posthumously at Saalfeld in 1574. This was in use as a standard work in Germany for very many years (see *Nature*, 67, 42; 1902).

Girolamo Fracastoro (1483–1553) was a Veronese physician who studied at Padua for some years. The fact that Copernicus was a fellow student adds interest to his astronomical work, "Homocentrica". This is an elaborate and somewhat obscure attempt to offer a new planetary system. In it he made the important observation that comets' tails are always turned away from the sun. When, in 1517, certain excavations revealed fossil shells, Fracastoro's comment that they must be remains of once living creatures earned him a place in the history of geology. His fame, however, rests on two medical books. In one, a poem, "Syphilis sive Morbus Gallicus", he described the disease which came to be known by the title of the poem; and, in his later and more important work, "De Contagione", he classified for the first time modes of infection and gave detailed descriptions of a number of fevers, including typhus.

A younger contemporary of Fracastoro was the unfortunate Spaniard, Miguel Servet y Reves (1509–53), better known as Michael Servetus, who was burnt to death at the stake, at Geneva, by Calvinists for the heretical opinions expressed in his "Christianismi Restitutio", a copy of which was tied to his waist. It was in this book that Servetus described the passage of the blood through the lungs. His account could have attracted little attention at the time, for, of the edition of about a thousand copies, half were burnt with an effigy of Servetus by the Catholic Inquisitor at Vienne on June 17, 1553, and the other half, which had been sent to Frankfurt, were destroyed at the request of Calvin some months after Servetus's death on October 27. It was well over a century before anyone directed attention to his contribution to physiology.

Two naturalists born in 1553 were Thomas Moufet and Prospero Alpino. Moufet (1553–1604), the son of a Scottish haberdasher, was born in London and educated at Cambridge. He studied medicine and later became a fashionable physician. He is remembered for the "Theatrum Insectorum", the first British work devoted to insects, which, however, did not appear until thirty years after his death. It was based on the work of Thomas Penny; but the manuscript, which survives in the British Museum, has many excellent drawings by Moufet. Alpino, another physician, born at Marostica in the Republic of Venice on November 23, 1553, studied at Padua and took his doctor's degree there in 1578. He spent three years in Egypt, and afterwards published several works on the natural history of that country, the best known being his "De Plantis Aegypti Liber" (1592). He enriched the botanical garden at Padua with Egyptian plants.

No outstanding scientist seems to have died in 1653, but two men born in that year have some claim to fame. J. Conrad Peyer, a Swiss zoologist, has his name commemorated in Peyer's patches, the intestinal glands which he figured in 1677, though he was not the first to describe them. He was also the author of a monograph on the compound stomach of ruminants. Peyer died at Basle in 1712.

To have been deaf and dumb until the age of seven, and even after that age always to lack a normal voice and ear, would seem handicap enough in life without inviting further embarrassment by taking up the study of the physics of sound. Yet that was the choice of Joseph Sauveur, born at La Fleche on March 24, 1653. He was a student of the popular Rohault, and was elected to the Royal Academy of Sciences, Paris, in 1696. Although he has been described as the founder of acoustics, it has recently been shown (Lloyd, Ll. S., *Notes and Records Roy. Soc.*, 3, 149; 1941) that much of his work on harmonics had been anticipated by contributors to the *Philosophical Transactions*. He died in 1716.

Before noting bicentenaries, one cannot pass without remark the fact that in 1703, two hundred and fifty years ago, occurred the death of the famous Robert Hooke and the almost equally celebrated mathematician John Wallis.

The year 1753 is an epic one in the annals of natural history in Britain, for it was in the course of that year that Parliament passed "An Act for the Purchase of the Museum or Collection of Sir Hans Sloane and of the Harleian Collection of Manuscripts, and for providing one General Repository for the better reception and more convenient use of the said Collections", that is, virtually, for the foundation of the British Museum. Sloane had died on January 11, 1753, in his ninety-second year, and it was his wish that his enormous collections, which included 40,000 books, as well as manuscripts, coins, and botanical, zoological and mineralogical specimens from all over the world, should pass to the nation. He therefore instructed his trustees to offer them to the King or to Parliament for the sum of £20,000, which he believed to be less than a quarter of their true worth. If the offer was refused then other countries were to be approached, and he named the Royal Academies of Sciences at St. Petersburg, Paris, Berlin and Madrid, in that order. George II showed little interest in the offer when approached by Sloane's trustees, remarking, with good reason, that there was not £20,000 in the Treasury. Parliament, however, urged on by Speaker Onslow, passed the Act referred to above. To raise the necessary sum it was agreed to hold a national lottery, which was intended to produce £100,000. Although the lottery was successful in the latter aim, the traffic in tickets by the jobbers and gamblers who handled the business became a public scandal.

Sloane, the son of a Scot, was born in Ulster in 1660. As a student of botany and medicine in London he became friendly with John Ray and Robert Boyle. He continued his studies in France, and returned to London in 1684 with many rare plants and seeds. In 1687 he went as physician with the Duke of Albemarle to the West Indies. Here, during a stay of some fifteen months, he made an extensive collection of plants, animals and minerals. His collections grew steadily as the years passed, and he purchased or acquired by bequest those of other collectors. Sloane was elected a Fellow of the Royal Society in 1685, and became secretary in 1693. In many ways he did good work for the Society, and in 1727 he succeeded Sir Isaac Newton as president, only resigning fourteen years later, when he felt his advancing years no longer permitted him to discharge his duties satisfactorily He then retired to his country house in Chelsea, where his museum and belongings were removed, and where he died. His statue by Rysbrack still stands in the Chelsea Physic Garden, and the monument over his grave in Chelsea churchyard has been more fortunate than the church in escaping war damage.

Three days after Sloane, on January 14, 1753, another famous Fellow of the Royal Society died. This was Bishop Berkeley (1685–1753), the philosopher, who, like Sloane, was born in Ireland. Berkeley's philosophical works are well known, as well as his controversy with the mathematicians over the method of fluxions. A different aspect of his character is revealed by his cherished scheme to found a college in the Bermudas, where the English youth of the Plantations could study side by side with "the young American savages". Berkeley was actually successful in persuading Parliament to vote him £20,000 to promote his proposals; but, although he immediately crossed the Atlantic with his wife, and then spent three years in Rhode Island awaiting funds, he eventually despaired of receiving the money and returned to England in 1731. He died quite suddenly a few months after settling in Oxford, and was buried there in Christ Church.

Three other scientists who died in 1753 call for brief mention. Nicholas Fatio de Duillier (1664–1753) was a Swiss mathematician who spent much of his life in England, and was elected a Fellow of the Royal Society in 1688. He was prominent in the Newton–Leibniz controversy, being the first to accuse Leibniz of plagiarism. He demonstrated to the Royal Society the use of jewelled bearings for watches, and also wrote on navigation. Becoming involved with a group of religious fanatics, in 1707 he appeared in the pillory at Charing Cross for publishing prophecies likely "to terrify the Queen's people". After some years abroad he retired to Worcestershire, where he died on April 24 in his ninetieth year.

Georg Wilhelm Richmann, one of science's martyrs, was born at Pernau in 1711, and became professor of experimental philosophy at St. Petersburg in 1745. He deduced a formula for calculating the temperature of mixtures, which was used by Wilcke in his experiments on the melting of snow. Richmann met his end in an unusual way. An enthusiastic student of electric phenomena, he was killed in the summer of 1753 during a thunderstorm by a flash of lightning which passed through his body from a lightning collector with which he was experimenting. The strange manner of his death was made known in two communications to the *Philosophical Transactions*.

Thomas Melvill (1726–53), a Scot, was only twenty-six when in 1752 he communicated a paper to the Edinburgh Philosophical Society in which he described the examination through a prism of flames into which different salts had been introduced. These experiments establish him as one of the pioneers of spectrum analysis. He died in December of the following year at Geneva.

The stars of 1753 seem to have shone favourably for the birth of inventors, for six men born in that year whom we notice all had a strong bent towards practical science. The best known of them is Sir Benjamin Thompson, Count Rumford, who led a varied and colourful life. Born in Massachusetts on March 26, 1753, he arrived in England in 1776, his Royalist sympathies having made it advisable for him to leave America. In the War of Independence he served as an officer in the British Army, but at the end of the war, in 1783, he returned to England again. Soon afterwards he set out to visit Europe. In 1784 he entered the service of the Elector of Bavaria, and, becoming his principal adviser, he carried out many social reforms. It was during this period that he made in Munich his famous experiments on heat. He had been knighted by George III in 1784, and seven years later was created a Count of the Holy Roman Empire, when he chose to commemorate in his title the Massachusetts township (now Concord) with which he had close associations. Returning to London in 1798, he applied himself enthusiastically to drawing up proposals for founding a public institution "for diffusing the knowledge and facilitating the general introduction of useful mechanical inventions and improvements". These proposals led to the founding of the Royal Institution in 1799. In his house in Brompton Row (a little east of Brompton Oratory, in what is now Brompton Road) he installed the many improvements in heating to which he had devoted so much of his time. The house was freely exhibited to visitors from all classes of society, and for several years attracted curious sightseers. Its furniture included beds disguised by day as elegant sofas, built-in cupboards, and hinged panels which could be raised to form writing-tables near the fire or window. Rumford spent his last years in France, where he died at Auteuil at the age of sixty-one.

Another somewhat unusual character born in 1753 was Charles, third Earl Stanhope. Elected a Fellow of the Royal Society at the age of nineteen, he devoted much of his income to experiments in natural philosophy. He made two calculating machines, now in the Science Museum at South Kensington, and constructed the first iron printing press. The latter, together with his invention of stereotyping by a plaster process, he presented to the Clarendon Press in 1805, and they were in use for some years. Stanhope died in 1816. A man in a very different walk of life to the noble earl was Samuel Crompton (1753–1827), inventor of the spinning mule which did so much to raise the status of the cotton industry. Other contemporaries were Edward Troughton (1753–1835), the renowned maker of astronomical instruments, who received the Copley Medal of the Royal Society in 1809, and William Nicholson (1753–1815), who with Sir Anthony Carlisle was the first to construct a voltaic pile in Britain, and with it observed the electrolytic decomposition of water. He was also the founder and editor of *Nicholson's Journal*, one of the first of the independent scientific journals in Britain. We must also mention F. K. Achard (1753–1821), the German chemist who discovered a commercial method of extracting sugar from the sugar-beet, so laying the foundation of an industry which rapidly became of considerable economic importance.

In 1853, geological science suffered two losses in the deaths of C. L. von Buch (born 1774) and H. E. Strickland (born 1811). Von Buch had been a pupil of Werner at Freiberg and an intimate friend of Humboldt. He made many valuable contributions to geology, in particular a description of the Canary Islands, which he visited in 1815. He also made important observations on the change of sea-level along the Swedish coast, compiled the first geological map of Germany, and made notable contributions to palæontology. Von Buch reached the ripe age of seventy-nine; but Strickland was only forty-two when he was killed by a train while making geological observations in a railway cutting near Retford. He was the author of a number of geological and ornithological papers, and in 1850 was appointed deputy reader in geology at Oxford, during the illness of Buckland. Strickland was one of the founders of the Ray Society, and edited for the Society the "Bibliographia Zoologiæ et Geologiæ" based on the manuscripts of Agassiz, though on account of his untimely death the fourth volume was completed by his father-in-law, Sir William Jardine. Strickland was also joint author of a classic memoir on the dodo.

French scientists lost several of their number during 1853, the best known being Dominique François Jean Arago, physicist and astronomer, born near Perpignan in 1786. At the age of eighteen he became secretary to the Observatory in Paris, and two years later accompanied Jean Baptiste Biot to Spain in order to assist him in completing the meridional measurements begun by Delambre. After Biot had returned to Paris, Arago became involved in the most fantastic adventures, which included imprisonment in a fortress, escape in a fishing boat, and capture by a Spanish corsair. Eventually he arrived back in Paris, still in possession of the records of his survey, which he had preserved through all his vicissitudes. Soon after his return he was elected to the Academy of Sciences at the remarkably early age of twenty-three, and about the same time Napoleon appointed him as one of the astronomers of the Royal Observatory. Arago carried out notable researches on the polarization of light. He also discovered the "magnetism of rotation", which was not interpreted until Faraday discovered electro-magnetic induction. Arago received the Copley Medal of the Royal Society in 1825 and died on October 2, 1853. His compatriot, Auguste Laurent (1808–53), a brilliant young chemist who died a few months before, on April 15, had led a very different life from that of the accomplished and successful Arago. Always struggling against poverty, and apparently ostracized by his French colleagues, some of his experimental work was carried out in a damp cellar while he worked as assayer to the Mint. He is credited with a number of discoveries in the field of organic chemistry. He died of consumption, and his famous "Méthode de Chimie" was published posthumously. Another organic chemist, Leopold Gmelin (1788–1853), perhaps the best known of a distinguished German scientific family, died two days before the unfortunate Laurent. He was professor at Heidelberg, and the author of the great "Handbuch der Chemie", translated into English (1848–72) for the Cavendish Society by Henry Watts.

Other deaths in the same year were those of C. J. Doppler (born 1803), the Austrian physicist who discovered the principle named after him, K. J. B. Karsten (born 1782), the German mineralogist, and M. J. B. Orfila (born 1787), the celebrated toxicologist. In America the deaths were reported of Sears Cook Walker (born 1805), astronomer, and William Beaumont (born 1785), physiologist. The latter, an American surgeon, for many years made observations on the stomach of a French-Canadian trapper who had suffered a severe gunshot wound. The persistent opening in the wall of his stomach permitted Beaumont to make experiments which threw considerable light on the nature and flow of the gastric juice.

A number of particularly distinguished men were born in 1853, including four who received Nobel Prizes. Wilhelm Ostwald, born at Riga on September 2, held a professorship of chemistry at the Baltic Polytechnical School of Riga during 1883–87, and then became professor of physical chemistry at Leipzig. When he retired in 1905, at his own request, in order to devote himself to research, he was nominated by the Emperor of Germany as the first exchange professor with the United States. In 1909 he received the Nobel Prize for chemistry. His contributions to physical chemistry were numerous, and too well known to need detailing here; but it is worth recalling that in the industrial field he developed the process for producing nitric acid by the catalytic oxidation of ammonia, which became the main source of Germany's supply of nitric acid during the First World War. Ostwald died on April 4, 1932.

A contemporary of Ostwald's, who worked with him for a time at Leipzig, was Ernst Beckmann (1853–1923), who became director of the laboratory for applied chemistry there in 1897, a position he held until 1912. The Beckmann thermometer and Beckmann freezing-point apparatus for the determination of molecular weights are well known.

An outstanding figure of the period under review was the Dutch physicist, Hendrik Antoon Lorentz, born at Arnheim on July 18, 1853. At the age of twenty-five he was appointed professor of theoretical physics at Leyden, and occupied the chair there with great distinction for forty-five years. The Lorentz transformation, made known in 1903, became the basis of the theory of special relativity. With Zeeman, he was awarded the Nobel Prize for physics in 1902. He was a Foreign Member of the Royal Society, and received the Rumford Medal in 1908 and the Copley Medal in 1918. He died at Haarlem on February 4, 1928.

Another eminent Dutchman, only a few months younger than Lorentz, was the genial Heike Kamerlingh Onnes (1853–1926). Born at Groningen, he passed several years at Heidelberg under Bunsen and Kirchhoff. Appointed professor of experimental physics in Leyden in 1882, he founded the famous Cryogenic Laboratory, where he achieved his great triumph, the liquefaction of helium, in 1908. Like Lorentz, he was awarded a Nobel Prize for physics (1913), and was a Foreign Member of the Royal Society. A fellow student of Onnes at Heidelberg in 1872 was W. F. Hillebrand (1853–1925), the American geochemist, who after joining the U.S. Geological Survey in 1880 became specially distinguished for his analyses of rocks and minerals. He made many analyses of the mineral uraninite between 1882 and 1892, and was puzzled by the presence in it of an inert gas, afterwards identified by Ramsay in 1895 as helium. Later, his highly skilled analyses of radioactive minerals were used in determinations of the age of the earth by Holmes and others.

A distinguished Italian mathematician, M. M. G. Ricci (1853–1925), who developed the tensor calculus, also comes into this period.

In the biological sciences two men must be mentioned. Albrecht Kossel (1853–1927), trained as a physiologist, devoted his researches to chemical subjects and became one of the leaders in the then new science of biochemistry. He was professor of physiology at Heidelberg during 1901–23, and did notable work as director of the Institute for Protein Investigation. He was awarded the Nobel Prize for Medicine in 1910, and died at Heidelberg on July 6, 1927.

No admirer of the work of Pasteur will have forgotten his devoted young assistant Emile Roux (1853–1933), who was so closely connected with the renowned researches on anthrax and rabies. With Alexandre Yersin he discovered the diphtheria toxin, an achievement leading to the discovery of the antitoxin by Emil von Behring in 1890. In 1904, Roux succeeded Duclaux as director of the Institut Pasteur in Paris. He died just before his eightieth birthday, on November 3, 1933, and received a national funeral. Roux had been elected a Foreign Member of the Royal Society in 1913, and received the Copley Medal in 1917.

In conclusion, it seems worth reminding readers that at the anniversary meeting of the Royal Society in November 1853, the president, the Earl of Rosse, informed the Society of a memorial made to the Government bearing some two hundred signatures, including those of many Fellows of the Society, requesting a building for the housing of scientific societies in the metropolis. As a result of this petition, Burlington House was eventually made available to the Royal and other societies, after a site at South Kensington had been refused by men of science on account of its inconvenience.

# GEO-MORPHOLOGY OF $F_2$-REGION IONOSPHERIC STORMS*

By DR. D. F. MARTYN, F.R.S.
Radio Research Board, Australia

DURING the International Polar Year of 1932–33, Appleton and Ingram[1] established a correlation between magnetic storms and temporary reductions of $F_2$-region electron densities at high latitudes. At moderately high latitudes, too (Slough, England), they found that $F_2$-region perturbations were associated with magnetic storms; but here the perturbation was sometimes an increase followed by a decrease of $F_2$-maximum electron density. At equatorial latitudes Berkner and Seaton[2] showed that the normal tendency was for $F_2$-electron densities to increase during magnetic disturbance.

On the basis of these facts, Appleton and Piggott[3] have proposed a system of classification of ionospheric storms which bears a superficial resemblance to that adopted by Birkeland for magnetic storms (for example, 'negative polar storm', 'positive equatorial storm'). On this method of classification certain anomalies appear; for example[3], "Washington (lat. 38·5° N.; long. 77° W.) mostly behaves like an auroral-zone type of station, whereas Burghead (lat. 58° N.; long. 3° W.) and Leningrad (lat. 60° N.; long. 30° E.) are predominantly non-auroral type medium-latitude stations, although all three lie on the same magnetic latitude".

This tentative classification of Appleton and Piggott's is based on the study of noon values of $F_2$-electron densities. Martyn[4] has already pointed out that there is a pronounced diurnal (local time) variation in $F_2$-region parameters during magnetic disturbance. This is found to be big enough to produce inconsistencies if Appleton and Piggott's mode of classification be followed. For example, if midnight instead of noon values be taken, auroral observatories show an increase of $F_2$-electron densities.

A satisfactory method of classification of ionospheric storms almost necessarily presupposes the existence of a plausible theory of their occurrence. Until 1950 it was generally supposed that such storms were due to local impact of particles from the sun, which in high latitudes heated the ionosphere, so reducing electron densities, and in low latitudes contributed to the ionization in some unexplained way. In that year Martyn[5] put forward the hypothesis that disturbances of the $F_2$-region associated with magnetic activity were due in all cases (save possibly 'great' magnetic storms) not to direct particle bombardment, but to the effect of an electrostatic field which spreads over the earth from the intense current systems set up in the auroral zones during all magnetic storms. This field, if it has the magnitude and phase necessary to produce the solar diurnal ($S_D$) current system in the ionosphere, will, it is found, produce the observed perturbations of the $F_2$-region by causing electron (and ion) drifts in accordance with concepts previously advanced[6] to explain tidal phenomena in the ionosphere.

Using this theory as a preliminary hypothesis, an extensive study has been made, during the past three years, of the geo-morphology of $F_2$-ionospheric perturbations associated with magnetic storminess. On this basis it was logical to examine both $S_D$ ($f^0F_2$ and $h'F_2$) and $D_{st}$ ($f^0F_2$ and $h'F_2$) using the methods and terminology developed by Chapman for the corresponding magnetic variations; namely, in the case of the ionospheric $D_{st}$ (disturbance, storm-time), to measure time from the beginning of the sudden or gradual commencement of the corresponding magnetic storm.

Using this procedure the following conclusions have been reached: All major perturbations of the $F_2$-region, save those associated with the relatively small travelling disturbances[7] of unknown origin, are associated with magnetic storms. There is no evidence that such storms travel from the polar zones, with travel-times of the order of hours or days, as has been suggested from time to time. The ionospheric storm at all latitudes begins, either simultaneously with, or in a time less than one hour after, the commencement of the corresponding world-wide magnetic storm. The effect of a magnetic storm on the $F_2$-region depends markedly on the season. In summer, the general tendency of a storm is to lower electron densities, and to raise the heights at which

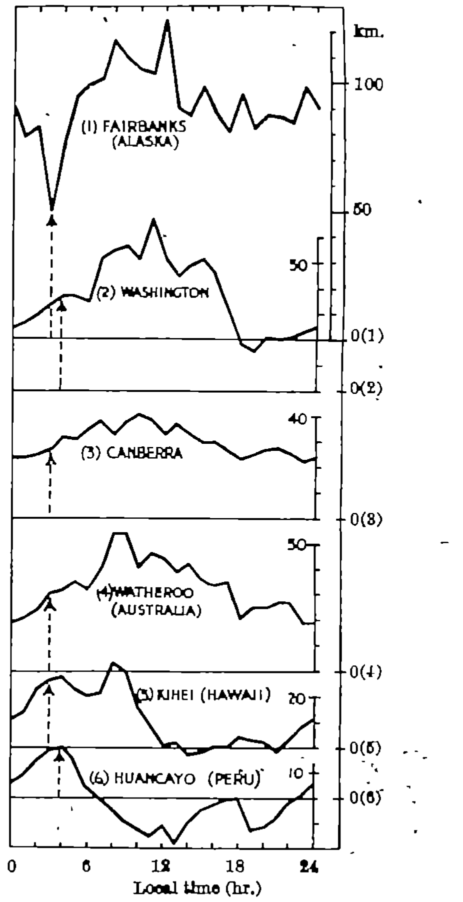

Fig. 1. $S_D(h'F_2)$ average diurnal variation of $h'F_2$ (minimum equivalent height of $F_2$-region) for five International magnetically disturbed days each month minus same variation for five International quiet days each month, for:

(1) Fairbanks, magnetic latitude ($\Phi$) = 64·7° N., April 1944–Dec. 1948.
(2) Washington ($\Phi$ = 50·3° N.), Jan. 1941–June 1948.
(3) Canberra ($\Phi$ = 44·0° S.), March 1937–June 1948.
(4) Watheroo ($\Phi$ = 41·7° S.), Jan. 1944–Dec. 1948.
(5) Kihei ($\Phi$ = 20·9° N.), March 1946–Dec. 1948.
(6) Huancayo ($\Phi$ = 0·6° S.), Jan. 1942–Oct. 1948.

The scale unit is 10 km. in each case.

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* Substance of papers presented at the recent meetings of the International Scientific Radio Union and of the Mixed Commission on the Ionosphere, at Sydney and Canberra, Australia.

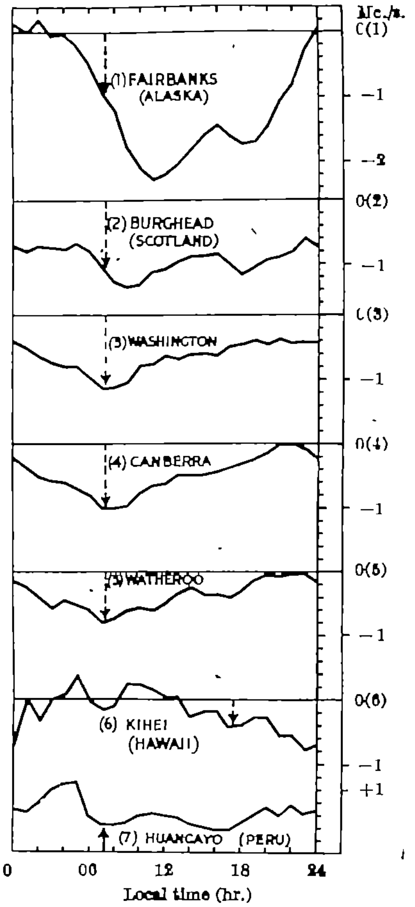

Fig. 2. $S_D(f^{\circ}F_2)$ average diurnal variation of $f^{\circ}F_2$ (critical penetration frequency of $F_2$-region) derived as for $h'F_2$ in Fig. 1 for

(1) Fairbanks (see Fig. 1).
(2) Burghead (Φ = 60·7° N.), Jan. 1943–Dec. 1946.
(3) Washington (see Fig. 1).
(4) Canberra (see Fig. 1).
(5) Watheroo (see Fig. 1).
(6) Kihei (see Fig. 1).
(7) Huancayo (see Fig. 1).

The scale unit is 0·2 megacycle per second in each case.

the maximum densities occur. In winter the densities are reduced in the morning hours, and raised in the afternoon hours.

There is a general tendency for electron densities to be lowered on the average at high latitudes and raised at low latitudes. However, as mentioned above, this statement has to be taken in conjunction with the local time at which such densities are studied. For example, at local midnight, electron densities are above average at high latitudes and below the average in tropical latitudes not too near the magnetic equator (for example, Hawaii, Fig. 2).

The $S_D$ (local time) variation is large and predominantly diurnal (Figs. 1 and 2). Densities are lowest in the mornings and highest in the evenings. The phase of the diurnal variation advances by about four hours as one passes from auroral to equatorial latitudes. At Fairbanks (Alaska) minimum densities (and greatest heights) occur at 11 hr. local time; in equatorial zones at about 07 hr.

There is no evidence that any magnetic storm affects the northern and southern hemispheres differently, when due allowance is made for the seasonal effect described above. The initial effect of any magnetic storm on the $F_2$-region depends markedly on the local time of commencement. If the storm commences at a time when the local $S_D(f^{\circ}F_2)$ curve is at its highest point (say 22 hr. at temperate latitudes), the initial disturbance is a decrease of $f^{\circ}F_2$ (that is, the variation initially follows the $S_D(f^{\circ}F_2)$ curve). If, on the other hand, the storm commences at, say, 10 hr., the initial effect is an increase in $f^{\circ}F_2$. It is suggested that the anomalous result found by Appleton and Piggott[3] for Washington is due to the inclusion of a preponderance of storms commencing in the (local) evening hours in their data. When allowance is made for this bias, Washington is found to have the appropriate characteristics of a temperate-latitude station. This effect is shown for Watheroo in Fig. 3, which exhibits the departure of $f^{\circ}F_2$ from normal during the first three days of magnetic storms which commenced between (*A*) 08 and 11 hr. local time, and (*B*) 20 and 23 hr. local time. (In group *A* are included 17 storms, in *B* 11 storms.) It will be seen that on Appleton and Piggott's classification Watheroo would be classified as a temperate-latitude station on the basis of group *A* storms, and as an auroral station on the basis of group *B* storms.

It appears that $F_2$-region ionospheric storms, like magnetic storms, have a unitary character, and may be regarded as manifestations of a single world-wide phenomenon. The local effects produced by this single phenomenon, which it is suggested is the electrostatic field of the $S_D$ current system, depend markedly on local time and season.

The theoretical (Chapman) diurnal, seasonal and latitude characteristics of the $F_2$-region are normally perturbed by solar tidal electric fields, along lines previously reported[4]. It appears that the phase of the additional electric field present during magnetic storms is such as to increase these perturbations at high latitudes, and to reduce them at low latitudes. This is specially obvious at Huancayo, where the normal daily departures of the $F_2$-region from 'Chapman' behaviour are large, leading to noon

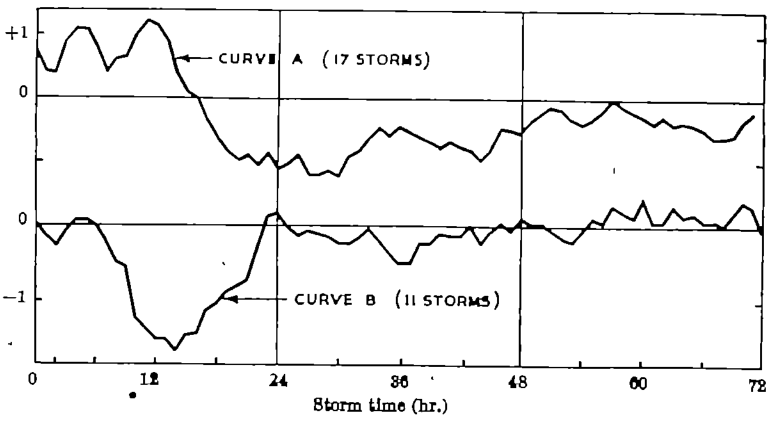

Fig. 3. $D_{st}(f^{\circ}F_2)$ at Watheroo. Hourly values of $f^{\circ}F_2$ for first three days of magnetic storms minus corresponding hourly values for magnetically quiet days, for (*A*) storms commencing between 08 and 11 hr. local time and (*B*) storms commencing between 20 and 23 hr. local time

minima of ionization density, and abnormally rapid pre-dawn reduction of these densities. During magnetic storms these anomalies are removed, and the diurnal variation of $F_2$-region electron densities in the vicinity of the magnetic equator approximates more closely to that anticipated for a simple 'Chapman' region.

This work is published by permission of the Radio Research Board of the Commonwealth Scientific and Industrial Research Organization. I am indebted greatly to Miss B. Hardwick, who has supervised the reduction into appropriate form of ionospheric data from co-operating observatories.

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# OBITUARIES

## Mr. H. C. Sampson, C.I.E.

HUGH SAMPSON, whose death at the age of seventy-four occurred on November 29, was an authority on tropical agriculture. His knowledge was gleaned during service in many countries. Born in Simla and educated at Bedford School and the University of Edinburgh, he joined the Transvaal Department of Agriculture in 1903; but after a couple of years he accepted the post of agricultural expert to the Madras Court of Wards. The great renaissance of Indian agriculture was just beginning, and Sampson was one of the first officers to join the newly constituted Indian Agricultural Service. For the next fifteen years he worked in Madras, first as deputy director, with headquarters at Tinevelly, and later as director. His work during this period led to marked improvement in the agricultural methods of the Madras Presidency. He was the first to admit the difficulties that held back progress. Among these were the limitations caused by debt and the system of tenure, and he always, therefore, advocated a cautious approach and preached the necessity for the thorough investigation of natural methods before attempting to discard or alter them. In spite of these hindrances, he was able to effect improvements in the seed supply and modifications in the types of agricultural implements. A notable example was the introduction of a long-stapled American Upland cotton which he introduced from Cambodia after a visit he had made to Indo-China.

In 1923 Sampson resigned from the Indian Agricultural Service and went to Nyasaland as cotton specialist under the Empire Cotton Growing Corporation. He worked there for three years and was successful in laying the foundations of the excellent experimental work that has been carried out in this Protectorate, and in sorting out the mixed cottons that were then grown, initiating modern plant-breeding methods and a proper seed supply.

In 1927 he joined the staff of the Royal Botanic Gardens, Kew, as economic botanist, a post that had been newly created with the connivance of the Empire Marketing Board. He retired from Kew in 1938, but during his term of office he visited the Caribbean Colonies and wrote reports on them for the Empire Marketing Board. He was instrumental in organizing the dispatch of planting material of several new economic crops to various Colonies where prospects seemed suitable. Perhaps the most notable of these was the introduction of tung oil into Nyasaland and Swaziland. His 'magnum opus' was the publication of a *Kew Bulletin* entitled "The Cultivated Crop Plants of the British Empire and the Anglo-Egyptian Sudan", a work that entailed an immense amount of labour and which remains a standard work of reference.

Sampson had a likeable character. His quiet voice, whimsical manner and kindliness endeared him to all his associates. He had the satisfaction in retirement of knowing that the work he had done during those early days in India has had a lasting effect, and one imagines that his memory is still green and respected in the Madras Presidency. G. EVANS

## Dr. J. Henderson Smith

JOHN HENDERSON SMITH, who died on November 28, graduated from Baliol College, Oxford, in 1898, proceeded to Edinburgh, where he took his medical degree in 1903, and then returned to Oxford as Philip Walker Student in pathology. Later, he was appointed bacteriologist to the Lister Institute. Here he did some promising work on immunology; in one of his early investigations, published in 1907, he demonstrated that the concentration of anti-toxin in the blood at any time depends on the route of introduction. Later, in conjunction with Brooks, he studied the influence of the dose of antigen on the output of the antibody and on its time of appearance; the results were published in 1912. All this work was characterized by cleanness and accuracy of experimental technique, and by careful and critical examination of the results; he seemed to have the prospect of a very promising career in his subject.

Then, unfortunately, he was struck down with tuberculosis, and although he made gallant attempts to continue his work he had to give it up; in 1916 he left the Institute.

Henderson Smith refused, however, to abandon scientific work. Fortunately the Rothamsted Experimental Station was beginning to expand and had brought plant diseases within its ambit. Its policy was to bring in young people each well trained in some pure science which he or she could apply to the problems of the Station; in connexion with the new developments, it was desired to find someone well grounded in human or animal pathology who could introduce new ideas and methods into the study of plant pathology. Henderson Smith was attracted to the work; by 1919 he had recovered sufficiently to join the staff, and the healthy surroundings and the devoted care and attention of his wife enabled him to stay out his full term of service with no further serious trouble. He retired on reaching the age limit in 1940.

Henderson Smith's first investigations at Rothamsted were on the growth-rate of fungal hyphæ, but he soon turned to more fundamental studies of the killing of fungus spores by phenol; these proved to be a valuable contribution to the general theory of disinfection. Plant virus diseases were then coming into prominence and he turned over to them: his work soon attracted attention, and following a request from the Imperial Mycological Conference of 1929 that virus diseases should be more fully studied, the Empire Marketing Board provided funds for a research team under his leadership. The work included the nature of the cell inclusions—the so-called X-bodies,—the concomitant bacteria in virus diseases, and the size of the viruses.

When W. B. Brierley left Rothamsted in 1932 to occupy the chair of agricultural botany in the University of Reading, Henderson Smith was appointed to succeed him as head of the Department of Mycology; it continued to expand and to attract able young people, becoming one of the most vigorous at Rothamsted. He served as president of the Association of Applied Biologists, and was also president of the Virus Section of the 1939 International Congress of Microbiology.

'H. S.', as he was always affectionately called, enjoyed much quiet esteem among his colleagues. Under his wife's watchful care he had to be cautious in all matters pertaining to health, but this did not restrict his interests. Like his wife, he was well read; in addition, he was a recognized authority on book plates, of which he was a discriminating collector, and an ardent and competent player of golf and of bridge. He never sought popularity, but his courage and his persistent determination to go on with his work in spite of threatened ill-health won him much respect from those who knew him well.

E. John Russell

## Dr. Franz K. Nagelschmidt

Franz Nagelschmidt, a pioneer of physical medicine, died on October 4 in Manchester. He was born in Berlin on January 29, 1875. He studied medicine, but soon became also interested in physics, for he thought that the many advances in modern experimental physics taking place at the end of the past century could be utilized for medical purposes. He went first to Copenhagen to work with Finsen, the founder of light therapy. He then returned to Berlin and established a light treatment institute at the Charité, where he installed the first X-ray unit for therapeutic purposes in 1903. In 1904, he founded a light treatment institute in Breslau, where he applied radium rays for the first time for treatment. In 1906, he settled in Berlin and founded the Finsen Clinic, of which he was in charge until 1933. Here he developed diathermy—the name was coined by him, and generally adopted, for the creation of heat inside the tissue by external application of electric currents, his best-known discovery. He also designed and introduced an ultra-violet lamp without water cooling. This lamp, the prototype of modern ultra-violet lamps, carried his name for several years. In 1911, he designed an apparatus to produce 'electro-rhythmic current' for electrical vibration treatment. In 1912, he invented the neon lamp, originally for medical purposes.

In 1933, Dr. Nagelschmidt left Germany for Great Britain, where he was immediately made an honorary consultant of physiotherapy at the Jewish hospital in London. In 1934, he had been awarded the "Golden Key" of the American Congress of Physical Therapy for "outstanding service to the science of physical medicine". In 1936, he qualified in Edinburgh as a medical practitioner and settled in Manchester as honorary consultant in physiotherapy at the Jewish hospital. He also founded a private therapeutic institute where he practised physiotherapy and carried out research until about three hours before his death.

Nagelschmidt was a man of many talents and many interests, in art as well as in science. In spite of all his achievements, he was a very modest man. This modesty made him call all the therapeutic establishments installed by him after his teacher Finsen, and this may explain why the scientific world knows the name of Finsen, who first conceived light therapy, much better than the name of Nagelschmidt, who developed it and who added all the other forms of physiotherapy to it. It may also account for the fact that few honours were bestowed on this great man.

W. Roman

We regret to announce the following deaths:

Mr. E. G. Dymond, reader in natural philosophy in the University of Edinburgh, on October 26, aged fifty-two.

Prof. M. G. Evans, F.R.S., professor of physical chemistry in the University of Manchester, on December 25, aged forty-eight.

Prof. A. H. Jameson, emeritus professor of civil engineering in the University of London (King's College), on December 23, aged seventy-eight.

Prof. E. Allison Peers, Gilmour professor of Spanish in the University of Liverpool, and author, under the pseudonym "Bruce Truscot", of books on the functions of universities in present-day Britain, on December 21.

# NEWS and VIEWS

## A Further Cœlacanthid Fish

On December 22, 1938, a fish of Crossopterygian type was taken by trawl-net, at a depth of about 40 fathoms some miles west of East London. The animal was unquestionably alive when caught. It was 1,500 mm. in total length and weighed 127 lb. The colour was a bright metallic blue which faded to brown with preservation. Miss Courtenay-Latimer, curator of the East London Museum, took charge of the catch, and eventually Prof. J. L. B. Smith, now research professor of ichthyology in Rhodes University, Grahamstown, was able to examine it (*Nature*, 143, 455; 1939). Prof. Smith immediately named it *Latimeria chalumnae* gen. et sp. nov., as a tribute to Miss Latimer. This discovery naturally aroused great interest, although, in spite of Miss Latimer's care, much disintegration of parts had occurred. Until then, only fossil records of cœlacanthid fishes, believed to have been extinct for about fifty million years, had been available. Further details of this fish were published in *Nature* (143, 748; 1939) by Prof. Smith.

Now comes a report of a further catch. This second fish was reported as having been caught on December 20 off the island of Anjouan in the Comoro group, two hundred miles west of Madagascar. It was reported to be about 5 ft. long and to weigh about 100 lb. On December 29, the fish was received by Prof. Smith, who had flown to the island to retrieve it and to take it to Rhodes University for further study. Preliminary reports suggest that Prof. Smith is very satisfied with the state of preservation of the fish, and he has named it *Malania anjouanae*, as a tribute to Dr. Malan, the Prime Minister, who had placed an aeroplane at Prof. Smith's disposal. It is of interest to note that the fish was caught in 20 m. of water by an Arab, using a line, and that the islanders claim that two or three such fish are caught each year in the same region and sold in the local market. Further details will be awaited with considerable interest.

## University of Leeds

AT a meeting of the Court of the University of Leeds on December 17, the vice-chancellor, Dr. C. R. Morris, commenting on the difference of opinion as to whether national service should be done before or after embarking on university work, said that while war service in general encourages the development of the intellectual life, there is evidence that national service in peace-time is inimical to it and ability and personality are not developed in the same way. As regards research in universities, he said that, while there may be some research which it would be wrong for universities to undertake, the great increase in the extent of university research in recent years is an advance in the right direction. The national interest requires full use of the highly trained and expert man-power to be found in university departments, and this would require the provision of more money for the maintenance of departments. It has been, he said, a cardinal point of policy with the University of Leeds also to maintain a strong and numerous teaching staff in relation to students, and experience is showing without doubt that this policy is right. Dr. Morris referred to disappointments in progress with halls of residence: more progress has been made with accommodation for women than for men during the past two or three years. The construction of the new refectory and staff house is well advanced and work on the Rayon Building for the Department of Textile Industries is expected to begin in March or April.

## *British Chemical Abstracts*

A QUESTION was asked by Sir W. Wavell Wakefield in the House of Commons on December 16, inquiring whether the Government intends to give any effective support to prevent the termination of the arrangements for the publication of *British Chemical Abstracts*. In reply, Mr. A. E. H. Molson said that the Lord President of the Council was informed of the difficulties that had arisen in regard to the publication of *British Chemical Abstracts*, and that when the question was referred to his predecessor the latter had asked for the advice of the Royal Society. Certain recommendations have recently been received from the Royal Society, designed to ensure the continued publication of these abstracts. These recommendations are at present being examined as a matter of urgency, in consultation with the chemical industry.

## Studies on Primates

THE two recent parts of Vol. 122 of the *Proceedings of the Zoological Society* (Part 1, May; Part 2, August, 1952) contain, *inter alia*, interesting and valuable contributions to our knowledge of the Primates, living and fossil. The former part has a paper by W. C. Osman Hill, Annie Porter and Margaret D. Southwick on the natural history and parasites of the tarsier, *Tarsier carbonarius*, based on studies of two females and one male which were kept alive in the Society's gardens for 692, 957 and 1,043 days, respectively. During these times careful daily records were kept of their behaviour, including the sexual cycle and their reactions to various situations and conditions. The paper also includes an account of their ailments and treatments and a detailed study of their endoparasites. W. C. Osman Hill also describes fully the external features and visceral anatomy of the rare and almost unstudied African olive colobus monkey, *Procolobus verus*. The identity and relationships of a number of the members of the Colobidae are not satisfactorily established, and this study, with its comparative treatment, is a step towards that end. During 1949–51 the British–Kenya Miocene Expedition collected a considerable amount of fossil hominoid material, which is reported upon by Prof. W. E. Le Gros Clark in Part 2. He has been able to add important details concerning five species belonging to the genera *Proconsul* and *Limnopithecus*. The same part also contains an extensive monograph by Dr. A. J. Haddow on the African red-tailed monkey, *Cercopithecus ascanius schmidti*. This is a most meticulous account of the identification, synonymy, biology, ecology and distribution of this species based on the examination of 143 specimens and on countless observations in field and laboratory. It is a more complete study of any African monkey than has been published heretofore, and clears up some of the confusion that exists in this important group of animals.

## Fakes and Forgeries in Museum Objects

IN a paper on "Fakes and Forgeries in Museums" (*Museums Journal*; September 1952), Dr. H. J. Plenderleith, of the Research Laboratory of the British Museum, gives some interesting examples of how the scientific worker can help scholarship in the detection of deception. The methods used are naturally those mainly associated with non-destructive testing. Among many interesting tests, he relates the study of a Greek bronze which could not be sectioned. A coin of known date and composition from Delhi was used as control; it showed certain surface features of decay. When sectioned, however, it revealed a crystalline structure with evidence of inter-crystalline oxidation and even a copper-rich area arising from the secondary reduction of cuprite. Micro-cracks were revealed in the brittle interior and an internal granulated condition at the deepest points of attack. The same tests applied under the base of the Greek bronze yielded results which indicated its genuineness. Such micro conditions would be impossible to fake. The patina of the bronze was, however, olive green in colour, easily detached and showed no foundation of cuprite. These suspicious observations were confirmed by X-ray diffraction. It was therefore clear that, although the bronze was genuine, the patina had been faked.

## Newton's "Principia"

IN the March issue of *Scripta Mathematica*, a quarterly journal devoted to the philosophy, history and expository treatment of mathematics (Yeshiva University, 20th and Northampton Streets, Easton, Pa.), an article is published under the title "A Survey of the Number of Copies of Newton's Principia in the United States, Canada, and Mexico". The survey was inspired by the late Dr. David Eugene Smith and has been carried out by Frederick E. Brasch, a consultant in bibliography, of Stanford University, California. The article directs attention to the Western trend of scientific progress and to the distribution of books—a symbol of this progress. The author rightly maintains that Newton's "Principia" is one of the great books which have laid the foundation of modern mathematics and astronomy and have influenced many aspects of the physical sciences as well as various phases of philosophy and religion. A brief outline of Newton's life is followed by a more detailed study of the "Principia" and its publication, with special reference to the third edition. An interesting section is devoted to the annotated and corrected editions of the "Principia" and includes an account of the so-called folio size copies of the third edition. In the statistical survey with which the article concludes, some seventy-two copies of the "Principia" and their locations are mentioned with appropriate references and comments. The whole forms an interesting and instructive piece of research both from the bibliographical and cultural points of view.

## Plant Growth Regulators

The rapid expansion of our knowledge of the natural plant growth substances and the almost unprecedented success of the practical application of closely related synthetic chemical homologues in agriculture and horticulture have brought with them the usual terminology difficulties, which have unfortunately been aggravated by careless and ambiguous usage, particularly by workers in applied fields of research. Plant physiologists in general have been conscious of the need for a review of this terminology and for authoritative definitions based on modern knowledge and ideas on action and function in the plant. This need has perhaps been felt most strongly in the United States, where an American Society of Plant Physiologists study committee, composed of four leading workers in this field of research (H. B. Tukey, F. W. Went, R. M. Muir and J. van Overbeek), has, for the past two years, been drawing up a new classification to embrace all 'chemical regulators' in plants. They have rightly appreciated that the system should be of world-wide application and have invited comment on their draft scheme from plant physiologists in Great Britain. It is hoped that their final recommendations will be universally acceptable. Their task is no light one since, for example, there are some who might even oppose the use of the term 'regulator' for the many compounds that merely act as cell poisons albeit below the lethal threshold. However, when finally framed and accepted, it should be rigidly applied by all. We must remember, however, that no matter how well it may suit our present needs it cannot be more than an interim classification, and will need further revision as we increase and deepen our knowledge of the exact function and mode of action of these compounds in cell and tissue.

## Water Problems in Dutch Agriculture

A lecture entitled "Lack of Water in a Land of Water", delivered in the international language under the auspices of the British Esperantist Scientific Association, was given by Dr. G. F. Makkink, of the Central Institute for Agricultural Research, Wageningen, on October 21 at University College, London. Dr. Makkink dealt with the problems facing agriculture in the Netherlands as a result of low rainfall combined with the excessive porosity of the soil and also as a result of the ingress of salt water. This latter factor occurs not only by seepage through the dykes but also at the sea-locks and (in dry seasons) by penetration of salt water up the estuaries. He stated, for example, that the sea-locks at Amsterdam admit daily 21 × $10^5$ kgm. of salt into the Zuider Zee, and that during a dry season 24 × $10^7$ kgm. of salt may enter the estuaries daily and not return; during 1949 salt water penetrated 45 km. up the Waal River and threatened the economy of important areas. Dr. Makkink concluded by outlining the ambitious programme of works which is being undertaken not only to reclaim the land out to the arc of the Frisian Islands but also partially to divert the Rhine waters into the Zuider Zee and thus form a huge reservoir of fresh water for agriculture and for use in the battle against the intrusions of sea water.

## National Central Library, London: Report for 1951–52

The thirty-sixth annual report of the executive committee of the National Central Library, London, covers the year ended February 29, 1952 (pp. 22; published by the Library), and records an increase of the Treasury grant-in-aid from £25,000 to £27,250 for 1951–52; of this, £1,000 was to compensate for the discontinuance of the Carnegie United Kingdom Trust's contribution. Contributions from libraries of all types, adult class organizations and individuals increased by 40 per cent to £5,210. The Carnegie United Kingdom Trust has agreed to the merging in the Library's general account of the separate fund for the Union Catalogue of Periodicals in University Libraries. Total issues of books from or through the Library increased from 94,220 during 1950–51 to 98,308; for the Scottish Central Library the corresponding figures are 12,616 and 15,708, and for the Irish Central Library for Students, 11,959 and 12,089. Total applications increased by 9·3 per cent, and 69·37 per cent were dealt with successfully, compared with 65·3 per cent during 1950–51. Issues to university libraries increased by 26·09 per cent, and those to outlier libraries, libraries of government departments, industrial and research organizations, and educational and cultural bodies also increased. University libraries lent 38,962 volumes under the national system. Loans made to foreign libraries remained at a high level (1,589 books to thirty-seven countries); but books borrowed from foreign libraries increased from 584 to 885 books from eighteen countries. The report refers to the need for extra funds for union cataloguing and the development of the outlier library system, as well as to progress in the union cataloguing of Russian books and periodicals available in Britain, and to the increased activities of the British National Book Centre in re-allocating 'unwanted' books and periodicals between British libraries and between libraries in Britain and those abroad. The reconstructed building of the National Central Library was opened by the Earl of Elgin in June 1952.

## Physics of Particle-Size Analysis: Conference in Nottingham

The Institute of Physics is arranging a conference on "The Physics of Particle-Size Analysis", to be held in the University of Nottingham during April 6–9, 1954. It is anticipated that the various sessions will cover not only such fundamental physical processes as the fluid dynamics and the optics of particles and systems of particles, but also accounts of other phenomena encountered in particle-size analysis such as the aggregation and dispersion of particles in a fluid. Arrangements will be made also for a discussion on automatic methods of counting and sizing, to which great attention is being given at the present time. Although the conference will be primarily concerned with the physical principles of particle-size analysis, the development of new instruments and their use will receive attention, particular interest being attached to the systematic comparison of different methods of particle-size analysis. Papers describing original work are invited for reading and discussion at the conference, and synopses of such contributions should be sent before February 3 to the honorary secretary of the conference, Mr. R. L. Brown, at the Institute of Physics, 47 Belgrave Square, London, S.W.1.

### Static Electrification: Conference in London

THE Institute of Physics has arranged a conference on static electrification, which will be held at Bedford College, London, during March 25–27. Prof. F. A. Vick, of the University College of North Staffordshire, Stoke-on-Trent, will give the opening lecture, and the other sessions will each take the form of an introductory survey, followed by specialized papers and discussion. The introductory surveys will be given by Dr. P. S. Henry (general principles of the generation and dissipation of static electricity), Mr. E. S. Shire (electrostatic machines) and Mr. H. W. Swann (harmful static electrification). The more specialized papers will be available as pre-prints to those attending the conference, and the proceedings of the conference will later be published by the Institute. Further information can be obtained from the conference secretary, Mr. N. Clarke, at the Institute of Physics, 47 Belgrave Square, London, S.W.1.

### University of London

THE title of reader in the University of London has been conferred on the following: Dr. N. A. Barnicot, in physical anthropology, in respect of the post held by him at University College; and Dr. J. M. Coulson, in chemical engineering, in respect of the post held by him at the Imperial College of Science and Technology. The degree of D.Sc. has been conferred on Mr. Harold Barnes.

### Announcements

M. JULES BAILLAUD, honorary director of the Pic du Midi Observatory and honorary astronomer of the Paris Observatory, has been elected a member of the Astronomy Section of the Paris Academy of Sciences in succession to the late B. Lyot.

ON the occasion of his retirement from the post of research professor in agriculture in the University of Sydney, Prof. W. L. Waterhouse has been elected an honorary life member of the Royal Agricultural Society of New South Wales, in recognition of his outstanding investigations on cereals.

DR. F. A. FOX, formerly deputy director of the British Welding Research Association, has been appointed superintending scientist in charge of the Chemical and Physical Research Laboratories, Australian Government Department of Supply, Maribyrong, Melbourne.

THE following have been appointed to senior lectureships in the University of Sheffield: Dr. J. S. D. Bacon (biochemistry) and D. R. Wood (pharmacology).

MR. P. ARTHUR WELLS, deputy secretary of the Royal Sanitary Institute, has been appointed secretary of the Institute in succession to Dr. J. W. Dudley Robinson, who has recently retired (see *Nature*, October 25, 1952, p. 693). Mr. Wells also becomes secretary of the Royal Sanitary Institute and Sanitary Inspectors Examination Joint Board and secretary of the National Nursery Examination Board. Previously he has been director of education to the International Wool Secretariat and general secretary of the Society of Dyers and Colourists.

THE Scottish Branch of the Science Masters' Association will hold its annual meeting at the Heriot-Watt College, Edinburgh, during April 7–10, with the principal of the College, Dr. H. B. Nisbet, as president. Other speakers will include Prof. G. F. Marrian, Dr. Neil Campbell, Dr. D. B. McIntyre, R. M. Sillitto, N. G. Matthews, G. Barclay and W. W. Fulton. Visits will be arranged to various places of scientific interest in the neighbourhood, and there will be exhibitions by members of the Association, publishers and manufacturers of scientific apparatus. Further details can be obtained from the organizing secretary, J. Turpie, Trinity Academy, Edinburgh 6.

A JOINT meeting of the Hospital Physicists' Association and the Industrial Radiology Group of the Institute of Physics is to be held at the Royal Institution, Albemarle Street, London, S.W.1, on January 16, at 7 p.m., and January 17, at 9.30 a.m., to discuss "Radiation Protection". Particulars can be obtained from the joint honorary secretary of the Industrial Radiology Group of the Institute of Physics, B. R. Byrne, Railway Executive, Research Department, Ashford Works, Kent.

THE Aslib Aeronautical Group of technical librarians and information officers serving the aircraft industry will hold its second annual conference at the College of Aeronautics, Cranfield, during March 27–30. Technicians and librarians from Europe, America and the British Commonwealth will be contributing papers, and all who are interested in promoting the efficient exchange of aeronautical information are welcome to attend. Further information can be obtained from the secretary of the Group, Mr. C. W. Cleverdon, College of Aeronautics, Cranfield, Bletchley, Bucks.

A DAVID ANDERSON-BERRY Silver-Gilt Medal and a sum of £100 is being offered by the Royal Society of Edinburgh to the person who, in the opinion of the Council, has recently produced the best work, published or unpublished, on the therapeutical effect of X-rays on human diseases. Applications, which should be accompanied by relevant papers on the work, must be sent to the General Secretary, Royal Society of Edinburgh, 22 George Street, Edinburgh 2, before March 31.

THE Medical Research Council is offering a number of fellowships in clinical research, tenable in the United Kingdom during the academic year 1953–54, which are open to suitably qualified medical graduates who desire to prepare themselves for a career in clinical research. The fellowships will be awarded for one year in the first instance, renewable annually up to a maximum of three years, and will carry a stipend of £850 a year, with annual increments of £75. Applications must be sponsored in each case by the head of the appropriate department in the candidate's university or medical school. Application forms can be obtained from the Secretary, Medical Research Council, 38 Old Queen Street, London, S.W.1, to whom they must be returned not later than March 1.

# TEACHING OF ACOUSTICS

A DISCUSSION on the teaching of acoustics, under the joint auspices of the Acoustics Group of the Physical Society and the Education Group of the Institute of Physics, was held at the offices of the Institute in London on November 19, 1952, Mr. W. West, chairman of the former Group, presiding.

Dr. R. W. B. Stephens, in introducing the subject, said that acoustics has for long been somewhat neglected in schools and universities of Great Britain. This state of affairs is unfortunate; for the study of vibrations is fundamental to the whole of physics, and acoustics is probably the best vehicle for illustrating wave motion, as it provides a means of actually observing the nature of the motion as distinct from inferring it—for example, as in the case of light. In schools, a reason for the somewhat scanty attention to the subject most probably arises from the very crowded syllabus and from the fact that, viewed from the aspect of passing the General Certificate Examination (ordinary level), it has a limited value. It has been the practice for some time for only one or two questions to be set, and these in general have been modifications on a very restricted theme, which must have brought about a tendency to limit the teaching of the subject to the consideration of the few types of questions which are likely to occur. It is evident, thought Dr. Stephens, that examiners cannot escape criticism, for in the wording of questions more attention might be directed to the physics of a problem rather than making it a problem in algebra and a substitution in a formula.

In college and university there is the tendency to restrict the teaching of acoustics and regard it perhaps somewhat as an applied subject which by modern standards puts it on a lower academic plane, compared with theoretical nuclear physics. In point of fact, however, modern acoustical theory uses all the tools of mathematical physics. The treatment of acoustics as a Cinderella subject is somewhat unfortunate, as apart from academic considerations (and these are widespread, for basic acoustic theory and techniques permeate into the fields of aeronautics, applied mechanics, light electrical engineering, rheology, etc.) there is also the impact of the subject on modern everyday life which is made increasingly evident—to mention a few examples—by the problems arising from noise and vibration in aircraft, flats, factories, etc.; design of concert halls; development of electronic musical instruments, etc.

Dr. Stephens then gave the results of a questionnaire on this subject circulated to universities by the Acoustics Group. It appears that most universities think that a course is desirable, and most do give their students a specialized course of ten to fifteen lectures. There are seven postgraduate courses in all, and a number have facilities for research.

Mr. E. Nightingale, as a schoolmaster of long experience, admitted that in schools the subject does not receive anything like the attention it deserves. This is due partly to the greatly expanding physics syllabus, and partly to the fact that many teachers are afraid of the subject unless they are musically minded. Also, one must face the fact that, in the early stages, the subject does not lend itself to practical work mainly owing to the necessity for quiet in many of the experiments. This leads to the complete exclusion of the subject at this stage and to an inadequate and sketchy treatment in the sixth form. In the old days, when 'heat, light and sound' was an examination subject for the School Certificate, acoustics received far more adequate treatment than at present.

The teaching of acoustics, continued Mr. Nightingale, can be begun informally quite early by means of a useful talk on the meaning of frequency, overtone and harmonic, illustrated by simple experiments on the piano and the violin or 'cello. There is also great scope for a series of formal lessons illustrated by simple experiments of the 'sealing wax and string' type. These can give a far better training in basic physics than any number of spectacular experiments using boxed-up apparatus of the push-button type. The mathematical theory of wave motion must be left largely to the sixth form, when the necessary mathematical equipment should be available. But the fundamental ideas of frequency, period, wavelength, the equation $V = n\lambda$, the simple treatment of resonance and beats, the dependence of quality on overtones, can all be taught in the pre-Certificate course.

Mr. Nightingale then illustrated some simple experiments within the capabilities of a secondary school and showed—on a tape record—what could be done on a piano.

Dr. E. G. Richardson pointed out that acoustics is now firmly established as a subject for special study and research in four British universities, mainly with the aid of the University Grants Committee and of certain government institutions, which are anxious to have available personnel trained in the subject. Though this is good so far as it goes, the facilities in acoustics compare unfavourably with some other countries. In both the United States and Germany there are university departments or whole institutes devoted to this subject. (In the United States a number are called applied physics, but they are really acoustics plus electronics or radio waves, and the same combinations are found in Germany.) In some other European countries there are acoustics departments attached usually to technological universities, but in other countries acoustical work is done in government institutes with but a slender attachment or none to a university faculty.

Four types of students in universities require instruction in sound. Physicists certainly do, but more restricted courses are also given to architects, electrical engineers and musicians. Until he gets into the special honours school, the physics student gets little sound, but in fifteen lectures enough can be done to prepare the student for a post in industry or to start postgraduate research. There is no doubt, said Dr. Richardson, that nowadays a student could scarcely undertake experimental research in sound without a good working knowledge of electronics. In the days of Rayleigh and Lamb, hydrodynamics was the handmaid of acoustics. The pendulum has swung too far in the direction of making acoustics a branch of radio communication, which Dr. Richardson thinks is undesirable except for electrical engineers.

In the general discussion that followed, Mr. W. A. Mercer gave details of courses he is giving to honours physicists in the University of Southampton; he divides the subject into classical and modern acoustics, devoting more time to the latter. Drs. H.

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Lowry and W. H. George spoke of the difficulties of teaching sound to music students, and the latter spoke also of the new M.Sc. course in the University of London, while Mr. S. R. Humby amplified previous speakers' comments on the teaching of wave motion to sixth-form schoolboys. At the conclusion of the discussion, experiments suitable for demonstrations were inspected.

# PHYSIOLOGY OF THE HOST–PARASITE RELATIONSHIP IN FUNGI AND BACTERIA

THE annual plant-pathological meeting of the British Mycological Society, which was held on October 17 in the Physics Lecture Theatre of Birkbeck College, London, took the form of a symposium on the physiological relationship of host plant and parasite. Nine papers were read dealing with various aspects of this wide problem.

Prof. W. Brown (Imperial College of Science and Technology, London), who introduced the discussion, dealt primarily with the type of facultative parasite which is relatively non-specialized and which characteristically brings about a distinct rotting and killing of the host tissue. This is probably the simplest of all types and the one most open to investigation, as the effects arising are localized to the neighbourhood of the parasite and can, to a large extent, be reproduced *in vitro*. It is logical, therefore, to begin by attempting to elucidate the mechanism of the more generalized parasites and to proceed from there to the more specialized types, as illustrated by the obligate but also by many facultative parasites.

Events which take place before the parasite has penetrated the outer wall of the host and the act of penetration itself are of considerable interest and practical importance, and the physiology of these stages could be further clarified. It is, however, when entry has taken place that the most interesting relationships develop. The tissue-destroying agents are metabolites excreted by the parasites, and, though it is not safe to ignore any of these, chief attention has been paid to pectolytic enzymes and organic acids. With some fungi, such as *Botrytis cinerea*, pectin-dissolving enzymes appear to be the sole agents. The study of this parasite and of others which act similarly, for example, *Pythium* spp., *Bacterium aroideae*, has thus become largely enzymological, with special reference to the conditions which govern enzyme secretion, and to the detailed differences in behaviour (such as selective action on various cell walls and constituents of cell walls, relation to *p*H and to various retarding and inhibiting agents, etc.) which are shown by the pectolytic enzyme systems of various parasites and saprophytes.

The part played by contact stimulation (thigmotropism) in the physiology of obligate parasites was discussed by Dr. S. Dickinson (Cambridge). It has been shown that the latter (rusts, powdery and downy mildews) respond to a contact stimulus by division of their nuclei, such stimulation being given on contact with stomatal guard cells, cuticle of epidermis, mesophyll wall and perhaps even outer layer of the protoplast. Thigmotropism is therefore a primary factor in obligate parasitism, a view which accords with recent American work in this field. It is suggested that this particular response to contact stimulation is the chief distinguishing characteristic between obligate and facultative parasites, and that in other ways, for example nutrition, they do not materially differ.

Dr. S. E. Jacobs and Mr. A. H. Dadd (Imperial College of Science and Technology, London), dealing with the leafy-gall organism (*Corynebacterium fascians*) and its behaviour on a wide range of host plants, showed that diffusible antibiotic substances are present in seeds of some of these host species. An inverse relation was discovered between percentage of seedling infection and the degree of inhibition of the bacterium brought about by exudates from seed. The inhibitory substance, when present, could be removed by soaking the seeds, but this treatment did not lead to increased infection; it had the reverse effect, possibly because of simultaneous removal of diffusible nutrients. Extracts of crushed seeds, especially after being allowed to undergo a certain amount of bacterial decomposition, stimulated growth of the parasite and increased the pathogenicity of all pathogenic strains, but failed to stimulate non-pathogenic strains to attack the host. These effects were likewise obtained by use of various chemical substances.

Mr. J. E. Crosse (East Malling Research Station) outlined the annual cycle of the bacterial canker disease of cherry caused by *Pseudomonas mors-prunorum*, an over-wintering canker phase on the bark alternating with an over-summering leaf-spot phase. Infections of the bark take place in the autumn and mainly through the scar-wounds which arise at leaf-fall. Experiments with concentrated inocula gave a much higher percentage infection of a resistant as compared with a susceptible variety than was normally encountered in the field. This disparity was traced to the fact that in the autumn the parasite was more abundant on the leaves of the susceptible than of the resistant variety. As the infective bacteria are washed down by rain, the concentration of inoculum in the infection drops is likely to be higher in the susceptible variety.

A series of inoculation experiments, carried out with a range of concentrations of inoculum and at four dates during the leaf-fall period, showed clearly that the concentration of inoculum necessary to give 50 per cent infection was higher with the resistant variety. Resistance to canker under field conditions was thus a compound of two factors, a lower prevalence of the parasite on the leaf surface and a higher threshold concentration of inoculum required for infection. As a result, the conditions necessary for successful invasion were less often realized at ports of entry on the resistant variety. Infectivity of leaf scars had also been shown to vary with the date at which inoculum was applied; but the precise relationship had not yet been worked out.

Dr. P. S. Nutman (Rothamsted Experimental Station) discussed the interaction between leguminous plants, in particular clover, and strains of the nodule-forming organism. 'Effective' or symbiotic strains produced a limited number of nodules which were large and which fixed nitrogen; 'ineffective' or parasitic strains gave nodules in abundance, but these remained small because of early degeneration of their growing-points and they did not fix nitrogen. Incompatibility between the clover plant and a bacterial strain which was normally effective was also shown in certain nutritive states of the former, and the same appearances resulted as with an atory. He took samples under water in the infralittoral and littoral zones during high water, by diving, "using nothing but glasses, flippers and a belt with pieces of lead fixed to it". Eight weeds were chosen, and one sample of *Gelidium corneum* yielded the astonishing number of 2,818 animals per gram of dry weed, including 600 Nematodes and 1,864 specimens of *Lasæa rubra*. Observations under water, using a modified frogman apparatus, were also made by Mr. R. Bainbridge, who describes the swimming habits of *Calanus* and *Sagitta*.

The necessity to control the bacterial contamination of mould-free phytoplankton cultures led Mr. C. P. Spencer to experiment with the antibiotics penicillin and streptomycin, the former being the more effective in keeping the culture pure. Miss B. Ross studied the changes in chemical composition at various ages of *Himanthalia elongata*, and found that any estimate of the chemical composition at different seasons should be correlated with the size of the vegetative buttons and thongs. Cultures of sixteen species of the smaller marine algæ, including seven flagellates, were prepared by Mr. R. W. Butcher, whose paper is illustrated by coloured figures of all the species. Finally, the first number of Vol. 31 concludes with an interesting account by Dr. D. P. Wilson of the aquarium and sea-water circulatory system at the Plymouth Laboratory.

In the second number, Dr. H. G. Vevers describes improvements in his apparatus for photographing the sea floor, whereby the camera is set at 1 m. from the ground and records an area of 50 cm. × 50 cm., thus producing better definition. As the result of his surveys, Dr. Vevers estimates that near Looe there is a population of *Ophiothrix fragilis* at least two miles long and half a mile broad, at a density of 392,000 per acre. North-west of the Eddystone the population is even greater and reaches 1·3 million per acre. In both cases, tidal streams probably bring suspended food to the crowded beds, and the scavenging work of these brittle stars, whether of detritus or of sinking matter, must be considerable.

Dr. R. B. Pike has worked on the biology of the prawn *Pandalus bonnieri*, which is a diœcious species living in deep water. Breeding occurs from the end of October for from six to eight weeks, and the young leave the berried female from February to April in the following year, metamorphosing in June. Sexual maturity is reached in eighteen months. The maximum life-span is four years; but few live beyond three years in the Clyde area.

Dr. J. S. Alexandrowicz studied the muscle receptor organs in the Paguridæ, and Mr. Graham Hoyle the response mechanism in the Ascidians, *Phallusia mammillata* and *Ascidiella aspersa*. Prof. J. E. Harris has kept records of the breeding condition of dogfish supplied to the University of Bristol from the Ilfracombe area, and concludes that spawning starts in November and continues until July. A Fulbright scholar from Miami, Mr. R. F. Hutton, has named a cercaria from the cockle, *Cercaria fulbrighti*, and gives a full description of it and other parasites from this lamellibranch.

To the biological indicators of water movements in the English Channel (*Sagitta* and *Muggiæa* spp.), Dr. L. H. N. Cooper suggests adding the boar fish, *Capros aper* (L.), the occurrence of which coincides with that of *Muggiæa kochi*, indicating movement of water from the south-west area of the continental slope towards Plymouth, after a period of strong south-west winds succeeded by calm weather. Hydrographical observations are recorded by Dr. W. R. G. Atkins and Miss P. Jenkins, and on the reaction of marine animals to ultra-violet light in conjunction with echo sounders by R. E. Craig and I. G. Baxter, who hope that further work will produce results of practical importance to the fishing industry.

In their first paper in a series on the vitamin A and carotenoid content of invertebrates, Mr. L. R. Fisher and Drs. S. K. Kon and S. Y. Thompson describe an investigation of the various Crustacea from the British coasts, particularly the Euphausiids, *Meganyctiphanes norvegica* and *Euphausia superba*, the krill upon which some whales feed. These contained large quantities of vitamin A, 90 per cent of which was in their large eyes, together with a high proportion of their astaxanthin. No carotene was present. The vitamin A concentration was lower in decapods, absent in the copepod *Calanus finmarchicus*, amphipods, isopods and *Cladocera*. By consuming krill, a baleen whale may take in one ton of vitamin A, to be stored in the liver, which would yield about 2,000,000 I.U.

The volume ends with the report of the Council of the Marine Biological Association. It is pleasant to note that for the first time the Association will be able to have a vessel specially built as a research ship. Membership has increased by 47 to 659.

N. B. Eales

## PATTERNS OF SPRING MIGRATION

IN 1950 and 1951 the British bird observatories exchanged information about the occurrences of selected species of birds. A study of this collated information by R. K. Cornwallis appears to throw some light on the pattern of migration to and through the British Isles in spring (*British Birds*, 45, No. 9; September 1952).

The simple conception of this pattern of spring migration is one of a south-to-north movement. The birds, it is assumed, enter England at points along the south coast and proceed northwards until they either reach their breeding-grounds in Britain, or, if they do not remain to breed, strike north-west to Iceland or north-east to Scandinavia from our northern coasts. This is often assumed in ornithological writings to be what happens, though the subject is a neglected one.

Not all the facts, however, appear to fit this simple pattern. For example, certain birds which breed in Scandinavia and occur in Britain both as summer residents and as passage migrants were recorded on spring migration in 1950 in greater numbers at the more northerly bird observatories, the numbers decreasing regularly with each more southerly observatory in turn (pied flycatcher, garden warbler, lesser whitethroat, common redstart).

It is common, too, when waves of birds are recorded at the east-coast observatories, for these to occur on approximately the same date at all of them and not progressively later at the more northerly stations (redstarts, pied flycatchers, fieldfares and ring ouzels). Moreover, the greatest numbers of some birds are often observed, particularly at east-coast stations, on dates when British breeding birds of the same species have already started nesting, even when the breeding-ground lies farther north than the observatory.

A fourth fact is that at Gibraltar Point the direction of diurnal migration in the spring, as well as in the autumn, is almost invariably to the south-west. At Cley it is from east to west. In north Lincolnshire it is more orthodox, being north-west along the south bank of the Humber, but at Spurn both northward and southward movements are seen.

The most likely explanation of these facts seem to be that, as well as receiving migrants in accordance with the simple south–north pattern, the British Isles also receive "drift-migrants" which, aiming for their Scandinavian breeding-grounds, are drifted westwards across the North Sea by the wind.

It is likely that drift of this kind affects nocturnal migrants much more than it does diurnal ones, for they, presumably, must rely for navigation principally on "preferred direction" and not on coastal and other "guiding-lines", and are therefore more likely to be sent off-course by the invisible forces of wind-drift. The directions of diurnal migration at Cley and Gibraltar Point, however, seem to indicate that some diurnal migrants are also subject to drift of the same kind.

Drift-migration of this type explains the coincidence of dates on which "waves" of birds are recorded as reaching the east coast, and also explains the movements after British breeding birds are already nesting; these later movements are composed of quite different, probably Scandinavian, breeding populations.

T. H. HAWKINS

# AFFINITY: A NEW GENETIC PHENOMENON IN THE HOUSE MOUSE

## Evidence from Distant Crosses

IT is generally assumed that at the first meiotic division the orientation of each bivalent towards the poles of the cell is at random, and consequently that (apart from viability disturbances) genetic linkage is the basis of all departures from Mendel's Law of Independent Assortment. Exceptions to random orientation are known in, for example, *Sciara*[1,2], certain scale insects[3], the Ascomycete *Bombardia lunata*[4], and *Drosophila melanogaster*[5]. Analogous phenomena in Heteroptera have been described and discussed by Dr. C. D. Darlington[6].

In the last two cases, the region of the chromosome responsible for the preferential orientation was shown to be the neighbourhood of the centromere, as might in general be expected, since it is the centromere which normally directs the orientation and movement of the chromosome on the spindle.

If the respective centromeres of more than one chromosome simultaneously show non-random segregation, the loci lying on *different* chromosomes may appear to belong to the same linkage group. The strength of the apparent linkages will depend both on the degree of preferential orientation of the centromeres and on the strength of the true linkages between the loci concerned and their centromeres. Such quasi-linkages will not show the type of arithmetical regularities which characterize true linkage and which reflect the linear order of the linked loci on the same chromosome.

The purpose of this communication is to suggest an interpretation along these lines of anomalous segregation ratios which were obtained by various workers many years ago from distant crosses in the mouse. It is hoped that the hypothesis advanced here will, if confirmed, be of some genetic and evolutionary interest.

The main body of data to be considered resulted from a cross performed by Gates[7] between a male 'Japanese' waltzer (a domesticated variety of *Mus bactrianus*) and a female European laboratory mouse (*Mus musculus*). The phenotypic frequencies in the backcross progeny departed strikingly from Mendelian expectations, as can be seen from the accompanying table. In addition to the marked loci shown, segregation also occurred at the pink-eye locus. But since it made no contribution to the statistical disturbance, the data are presented here after combining the pink-eyed with the non-pink-eyed classes.

PHENOTYPIC RATIOS DERIVED BY GATES FROM AN *M. musculus* × *M. bactrianus* CROSS

First cross:
$♀\frac{pdb{+}{+}}{pdb{+}{+}} \times ♂\frac{{+}{+}{+}sv}{{+}{+}{+}sv}$
Backcross
$F_1♀♀\frac{pdb{+}{+}}{{+}{+}{+}sv} \times F_1♂♂\frac{pdbsv}{{+}dbsv}$

| Backcross progeny | | | | Comparison of observation with expectation calculated on the basis of 'polar' affinity. Complementary genotypes added | |
|---|---|---|---|---|---|
| | | | | Observed | Expected |
| ++*sv* | 117 | *db*++ | 86 | 203 | 199·7 |
| ++*s*+ | 77 | *db*+*v* | 85 | 162 | 176·6 |
| +++*v* | 85 | *dbs*+ | 83 | 168 | 172·8 |
| ++++ | 81 | *dbsv* | 88 | 169 | 162·9 |
| +*bsv* | 77 | *d*+++ | 90 | 167 | 167·0 |
| +*bs*+ | 73 | *d*++*v* | 86 | 159 | 147·7 |
| +*b*+*v* | 79 | *d*+*s*+ | 67 | 146 | 144·5 |
| +*b*++ | 59 | *d*+*sv* | 56 | 115 | 127·8 |
| | | | | 1,289 | 1,289·0 |

*d* = dilute, *b* = brown, *s* = pied, *v* = waltzing

The fit to expectation is very poor. $\chi^2_{(15)}$ is 36·170, and if we eliminate the eight degrees of freedom relating to the equivalence of complementary genotypes, we have $\chi^2_{(7)} = 26{\cdot}432$ ($P < 0{\cdot}001$). Gates noted that the ratios were disturbed and also that the single-factor ratios were good. He directed attention to the marked excess of the *bactrianus* combination of characters, and as an interpretation he postulated an "association system"—"a definite tendency on the part of the chromosomes to associate together according to parental grouping, thus distorting the theoretical proportions". His meaning is not entirely clear for the following reasons: (1) the parental chromosomes no longer exist as such after crossing-over; each chromosome enters a gamete as a patchwork of material derived from both parents; (2) he remarks, "The chromosomes of the female parent, as representative of the fancy mouse, do not seem to group together as strongly as those of the Japanese parent . . .". This casts doubt on whether he intended to refer to meiotic phenomena at all; and (3) earlier work to which he refers as exemplifying "association systems" in fact relates to superior viability of non-recombinant gametes in species hybrids, and not to the mode of gamete formation.

Gates's phrase 'association system' did, however, suggest the present hypothesis, which may, in fact, be no more than a development of his intended meaning. It is that, at the first meiotic division in the hybrid, *musculus* centromeres tend to go to one pole and *bactrianus* centromeres to the other. Sir Ronald Fisher has suggested to me that the term 'affinity' be adopted for this phenomenon. It could result from an attraction of centromeres of like origin either for each other (which I shall term 'mutual affinity'), or for some polar element of the cell ('polar affinity').

On the hypothesis of 'polar affinity', the best-fitting assumptions are that the segregation of *d* is completely polarized, and that *b*, *s* and *v* are polarized with intensities, calculable from their respective frequencies of segregating to the same pole as *d*, namely, 54·46 per cent, 53·61 per cent and 53·06 per cent. On the basis of other work[8], these loci have been assigned to separate linkage groups, and their mutual relations in Gates's data are incompatible with true linkage.

The expected numbers calculated on these assumptions are shown in the table. $\chi^2$ measuring goodness of fit is 14·013 and has eleven degrees of freedom, four having been used in the estimation of four parameters. If we eliminate the eight degrees of freedom corresponding to the equivalence of complementary genotypes, we have $\chi^2_{(3)} = 5{\cdot}274$ $(0{\cdot}2 > P > 0{\cdot}1)$. Hence the fit is judged to be satisfactory. An even closer concordance between observation and expectation can be attained if the affinity is assumed to be of the 'mutual' type. Indeed, a simplified model of mutual affinity can be devised which will reduce the $\chi^2_{(7)}$ of 26·432 $(P < 0{\cdot}001)$ to a $\chi^2_{(6)}$ of 2·406 $(P > 0{\cdot}8)$.

There are two other bodies of data derived from *M. musculus* × *M. bactrianus* crosses which are suitable for testing this hypothesis[9,10]. In both, the wild variety of *M. bactrianus* was used. Since Gates's data indicate that *d* is very close to its own centromere, the most relevant and informative quantities are the frequencies of recombination between *d* and the other segregating genes.

It turns out that the segregations of *d* with *a* and with sex are compatible with independent assortment; but, as expected, apparent linkage between *d* and *b* appears in these data too. The actual recombination frequencies, however, exhibit some remarkable incongruities. Female hybrids of the *M. musculus* × wild *M. bactrianus* cross show significantly more recombination (53·3 ± 2·3 per cent, from Green's data) both than female *M. musculus* × Japanese waltzer hybrids (45·5 ± 1·4 per cent, from Gates's data), and than their male *M. musculus* × wild *M. bactrianus* counterparts (40·8 ± 2·4 per cent, from Little's and Green's data combined). However, sex differences in crossing-over are not unusual in the mouse, and it is a commonplace that chiasma formation is suppressed in distant crosses to a greater or less extent according to the degree of genetic disparity between the parental forms. The Japanese waltzer has been split off from the wild form for many centuries, a period of time in which considerable genetic divergence between the two groups could occur.

Dr. C. D. Darlington has suggested to me a possible variant interpretation of these data according to which the Asiatic and European forms differ by a reciprocal translocation. But it is likely that such an interchange would be associated with substantially reduced fertility, at least in the female hybrids, in contrast with the exceptionally high fertility reported by both Gates and Green.

It is intended to publish in due course a full account of the theoretical deductions from the *M. musculus* × *M. bactrianus* crosses, together with a discussion of the evolutionary significance and possible physical basis of the phenomenon. In spite of repeated efforts, it has not yet been possible to obtain stocks from which to produce hybrid material suitable for applying cytological and further genetic tests to this theory.

I am indebted to many people for criticisms and suggestions, especially to Dr. A. R. G. Owen and Mr. N. T. J. Bailey for statistical help and advice, to Sir Ronald Fisher, Prof. J. B. S. Haldane and Dr. C. D. Darlington for helpful discussions, and to Dr. E. B. Ford for his continual interest and encouragement, and for his strenuous attempts, as yet unhappily unrewarded, to obtain live specimens of *M. bactrianus* for me. I am in receipt of a research training grant from the Medical Research Council, and I wish also to express my gratitude to the Agricultural Research Council for the provision of facilities.

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## Evidence from within Laboratory Stocks

OVER a period of a few years, I have observed, in data produced for other purposes, an association between *W* (dominant pied) on chromosome III, and *Sd* and *fi* (Danforth's short tail and fidget) on chromosome V of the house mouse. Sir Ronald Fisher, on receiving privately from Mr. Donald Michie, of the Genetics Laboratory, Oxford, his interpretation of the findings of Gates[1] and others, realized that here might lie an explanation of this association, and proposed the term 'affinity' for the phenomenon.

Affinity, or an effective attraction between like centromeres, is proposed by Michie as producing the quasi-linkages observed by Gates and others in backcross progeny from the $F_1$ of crosses between two sub-species of *Mus*. (It is not intended to discuss here whether this attraction is direct—between centromeres only, or indirect—between centromeres and differentiated poles of the dividing cell.) That such an attraction of centromeres might also operate within a colony of a species (namely, *Mus musculus*) now became apparent to Sir Ronald Fisher and myself. The principle of affinity within a species, if it can be established as of more or less general application among plants and animals, has some important aspects. One is that, without the use of sub-specific hybrids, which has several disadvantages, it facilitates both identification of centromere markers and calculation of the positions of centromeres on their chromosomes. Affinity observable within a species has, also, an evolutionary significance.

In order to establish this principle, I have planned a method of manipulating the genetic material available, involving chromosomes III and V, in order to show various kinds of segregation of their centromeres, and in order to calculate the position of the centromere on chromosome V. I have also searched for and found, from experiments designed for other purposes, data which appear to show segregation of centromeres in other chromosomes.

A satisfactory demonstration of affinity, from unprepared material, is not easily made. There are several reasons for this. One is the expected disappearance of quasi-linkage on inbreeding, or on using stocks of which the centromere genotype has not been tested or fixed by inbreeding. Another is the difficulty of distinguishing not only quasi-linkage of high recombination value from independence, but also of distinguishing these two from reversal of the linkage, which can theoretically occur; from unprepared material it is not always possible to calculate which of these kinds of quasi-linkage will occur, or to calculate exactly their expected frequencies. Reversal can be defined (in the terms of real linkage) as the segregation in one linkage phase of centromere markers known to be ancestrally in the opposite phase. It gives a formal linkage value greater than 50 per cent. This value is always $1-y$, where $y$ is observed in the absence of reversal. An example is given below. A third reason is the difficulty of repeating striking results.

It is obviously desirable to have material from which repetitions can be made by workers who may wish to confirm my results. The best material, namely, segregating inbred lines and linkage groups, is fortunately available or is being constructed in this department as part of Sir Ronald Fisher's plan for the systematic detection of linkage and for accurate mapping. At his suggestion I have made up crosses between inbred lines and backcrossed to multiple recessives, in order both to discover new quasi-linkages, and to recognize them in material from which they can at any time be reproduced. As a result of this work, which is still in progress, a quasi-linkage has been obtained sufficiently striking to seem worthy of publication. Using the convention of real linkage, this may be represented as follows:

*Sd* ex line 4 × *Ca* (Caracul) ex line 10

One $\frac{Sd\ +}{+\ Ca}$ male × several $\frac{++}{++}$ females

| | ++ | *Ca* | *Sd* | *CaSd* | Total | Recomb. value | Linkage $\chi^2$ |
|---|---|---|---|---|---|---|---|
| *fz* | 18 | 10 | 6 | 13 | 47 | 65·96% | 4·7872 |
| + | 23 | 10 | 8 | 13 | 54 | 66·67% | 6·0000 |
| Total | 41 | 20 | 14 | 26 | 101 | 66·34% | 10·7872 |

The datum is divided into *fz* (fuzzy) and 'not *fz*', because this factor is also segregating as a backcross and, although fuzzy itself is quite unmistakable, *Ca* presents some difficulty of classification in the presence of *fz*. However, the two sets of data manifestly agree well.

A new cross between lines 4 and 10 has been set up in the hope that these lines are sufficiently inbred to allow repetition of these results.

It is encouraging, although not unexpected, that similar, if less striking, data have already been reported. Dunn, Gluecksohn-Schoenheimer and Bryson[2] give the following table:

| Cross | ++ | *Ca* | *Sd* | *CaSd* |
|---|---|---|---|---|
| +/*Sd* +/*Ca* × ++ | 50 | 33 | 35 | 43 |

The authors do not say from which parent the dominants of the double heterozygote came, but it seems probable that they were in repulsion, since *Sd* (which is here described for the first time) is not stated as occurring in a Caracul stock. The recombination value calculable on these data is 57·76 per cent, and the linkage $\chi^2$ is formally just significant at 3·8820. Dunn and his associates draw no conclusion from the data other than that "It (*Sd*) is probably not linked with Caracul (*Ca*)".

That the association between *Sd* and *Ca* apparent in these two bodies of data is not easily interpreted as real linkage, even on the basis of unusually strong interference, is indicated by the fact that another, comparatively large, body of repulsion data from this department shows almost perfect independence of *Sd* and *Ca*:

| Cross | ++ | *Ca* | *Sd* | *CaSd* | Total | Recomb. value | Linkage $\chi^2$ |
|---|---|---|---|---|---|---|---|
| $\frac{Sd\ +}{+\ Ca}$ × ++ | 60 | 65 | 56 | 62 | 243 | 50·21% | 0·0029 |

These results are in good accord with the theory of affinity.

A fuller account of observation and theory will be submitted later to *Heredity*.

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# ENZYMATIC BREAKDOWN AND SYNTHESIS OF ACETOACETATE

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ACETOACETATE and other β-keto-acids can contribute acetyl groups for citrate synthesis or sulphanilamide acetylation. Thus, cleavage of the β-keto-acid must yield acetyl coenzyme A. In pigeon liver[1] and yeast extracts[2] the reaction requires the presence of adenosine triphosphate and coenzyme A (CoA).

The formation of acetyl coenzyme A has now been directly demonstrated in extracts of pig kidney incubated with acetoacetate, adenosine triphosphate, and coenzyme A, in the presence of magnesium ions ($Mg^{++}$) and reduced glutathione. In all these cases, acetyl coenzyme A may be formed via the following reactions:

Acetoacetate + CoA + ATP ⇌ acetoacetyl CoA + adenosine-5-phosphate + pyrophosphate (1)

Acetoacetyl CoA + CoA ⇌ 2 acetyl CoA (2)

Reaction 1 would be analogous to the adenosine triphosphate–coenzyme A–acetate reaction, the mechanism of which has recently been elucidated by Lipmann and his collaborators[3].

As pigeon liver extracts can also catalyse the synthesis of acetoacetate[4] by a reaction involving two molecules of acetyl coenzyme A[5], it is possible that such synthesis in liver occurs by a reversal of reaction 2 (cf. Lynen *et al.*[6]) coupled with the action of a specific acetoacetyl coenzyme A deacylase (reaction 3):

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$$\text{Acetoacetyl CoA} + H_2O \rightarrow \text{acetoacetate} + \text{CoA} \qquad (3)$$

The acetoacetate synthesizing system has been purified seven-fold from ox liver extract using an assay (cf. Table 3) with acetyl phosphate, coenzyme A, and phosphotransacetylase as a source of acetyl coenzyme A[6]. The partially purified system synthesizes acetoacetate from acetyl coenzyme A (Table 1). It does not, however, cleave acetoacetate, in the presence of adenosine triphosphate and coenzyme A, to acetyl coenzyme A, and hence does not catalyse reaction (1)

TABLE 1. ACETOACETATE SYNTHESIS FROM ACETYL COENZYME A

The complete system contained tris(hydroxymethyl)aminomethane–hydrochloric acid buffer, pH 8·1, 30 micromoles; magnesium chloride, 8 micromoles; acetyl coenzyme A, 2·9 micromoles; ox liver ethanol fraction (27 mgm. protein). Volume, 3 0 ml.; temperature, 25°. The yield of acetoacetate is only 40 per cent of that expected from the liberation of sulphydryl (that is, coenzyme A), presumably as a result of acetyl coenzyme A deacylase activity. Acetyl coenzyme A was prepared chemically by the method of Wilson (ref. 7)

| Time (min.) | Sulphydryl liberation (micromoles) | Acetoacetate synthesis (micromoles) |
|---|---|---|
| 0 | 0 | 0 |
| 40 | 3·20 | 0·64 |

Another mechanism of formation of acetoacetyl coenzyme A has been suggested by experiments with enzyme preparations obtained from pig heart extracts by fractionation with ammonium sulphate and ethanol. These experiments, in which the formation of acetyl coenzyme A was followed through its reaction with oxalacetate to form citrate in the presence of an excess of condensing enzyme[8], support the occurrence in heart of the following sequence of reactions. (Similar reactions have been postulated independently by D. E. Green and co-workers[9].)

$$\text{Succinate} + \text{CoA} + \text{ATP} \rightleftharpoons \text{succinyl CoA} + \text{ADP} + \text{P} \qquad (4a)$$

$$\text{or}\quad \alpha\text{-Ketoglutarate} + \text{CoA} + \text{DPN}^+ \rightarrow \text{succinyl CoA} + CO_2 + \text{DPNH} + \text{H}^+ \qquad (4b)$$

$$\text{Succinyl CoA} + \text{acetoacetate} \rightleftharpoons \text{succinate} + \text{acetoacetyl CoA} \qquad (5)$$

$$\text{Acetoacetyl CoA} + \text{CoA} \rightleftharpoons 2\ \text{acetyl CoA} \qquad (6)$$

$$2\ \text{Acetyl CoA} + 2\ \text{oxalacetate} \rightleftharpoons 2\ \text{citrate} + 2\ \text{CoA} \qquad (7)$$

The basic observation is that heart extracts, or the enzyme fractions therefrom, synthesize little or no citrate from acetoacetate, coenzyme A, adenosine triphosphate, and oxalacetate, unless succinate is also present. Table 2 *A* shows that, in addition to succinate, citrate synthesis from acetoacetate and oxalacetate requires coenzyme A, adenosine triphosphate, and magnesium ions. The condensing enzyme was not limiting in the enzyme fractions employed. As previously observed by others[10], it has been found that two molecules of citrate are formed for each molecule of acetoacetate disappearing. Acetoacetate can be replaced by β-ketovalerate, β-ketohexanoate and β-ketoisohexanoate, in order of decreasing activity, but not by β-ketooctanoate or β-ketoadipate (Table 2 *B*). β-Hydroxybutyrate, butyrate, hexanoate and octanoate (tested with coenzyme I and II as hydrogen acceptors) and acetate are not active in this system.

TABLE 2. CITRATE SYNTHESIS FROM ACETOACETATE AND OTHER β-KETO ACIDS

(*A*) The complete system contained tris(hydroxymethyl)aminomethane–hydrochloric acid buffer, pH 7·5, 100 micromoles; potassium adenosine triphosphate, 10 micromoles; coenzyme A (85 per cent pure, obtained from the Pabst Laboratories, Milwaukee, Wisconsin, through the courtesy of Dr. A. Frieden), 0·1 mgm. (about 0·1 micromole of pure coenzyme A); magnesium chloride, 8 micromoles, reduced glutathione, 10 micromoles; potassium acetoacetate, 100 micromoles; potassium succinate, 100 micromoles; potassium oxalacetate, 20 micromoles; crystalline condensing enzyme, 5 units; 1ig heart enzyme fraction (6 mgm. protein) obtained by fractionation with ammonium sulphate and ethanol. Volume, 1·66 ml., incubation, 60 min. at 38°

(*B*) The complete system was the same as in (*A*) except that 100 micromoles of each β-keto-acid was added as indicated. The heart-enzyme fraction was similar to that used in (*A*) and contained 14 6 mgm. of protein

| *A* | | *B* | |
|---|---|---|---|
| Components | Citrate synthesis (micromoles) | Acetyl donor | Citrate synthesis (micromoles) |
| Complete system | 3·18 | None | 0 |
| No acetoacetate | 0 | Acetoacetate | 5·41 |
| No succinate | 0·03 | β-Ketovalerate | 1·66 |
| No adenosine triphosphate | 0·05 | β-Ketohexanoate | 0·93 |
| No coenzyme A | 0 05 | β-Ketoisohexanoate | 0·26 |
| No magnesium ions | 0·04 | β-Ketooctanoate | 0·02 |
| No oxalacetate | 0 | β-Ketoadipate | 0 |
| No condensing enzyme | 3·22 | | |

In the absence of oxalacetate, addition of stoichiometric amounts of acetoacetate, coenzyme A and adenosine triphosphate, together with magnesium ions and a reducing agent (glutathione or hydrogen sulphide), to the heart enzyme fractions results in the accumulation of acetyl coenzyme A provided succinate is also present. The acetyl coenzyme A was identified after deproteinization by its reaction with oxalacetate, in the presence of crystalline condensing enzyme, to form citrate and by paper chromatography[11]. Also, when β-ketovalerate (or β-ketohexanoate) is incubated with the heart fractions in the presence of the complete system minus oxalacetate, and neutral hydroxylamine is added later to trap thiol esters, the formation of acetohydroxamic and propionohydroxamic acids (or acetohydroxamic and butyrohydroxamic acids) can be demonstrated by chromatographic methods[12].

Reaction *4a* is catalysed by the system discovered by Kaufman[13] which is present in the heart fractions employed in this work. In heart acetone powder extracts, which do not contain α-ketoglutaric dehydrogenase, the succinate – coenzyme A – adenosine triphosphate system can be replaced by α-ketoglutarate, coenzyme A, and coenzyme I, in activating acetoacetate breakdown to acetyl coenzyme A, provided a purified α-ketoglutaric dehydrogenase fraction is added. α-Ketoglutaric dehydrogenase catalyses reaction *4b*[14].

Unlike liver, heart extracts do not synthesize acetoacetate in the presence of the acetoacetate assay system. However, they synthesize appreciable amounts of acetoacetate when succinate is added (Table 3). This synthesis apparently proceeds by reversal of reactions (6) and (5) coupled with the action of a succinyl coenzyme A deacylase (reaction 8[15]) present in the extract, thereby regenerating coenzyme A and allowing it to function catalytically.

$$\text{Succinyl CoA} + H_2O \rightarrow \text{succinate} + \text{CoA} \qquad (8)$$

In some heart fractions, the yield of acetoacetate in the presence of succinate is further increased by the addition of a purified succinyl coenzyme A deacylase from heart. Indeed, succinyl coenzyme A deacylase activity is so limiting in heart fraction III (Table 3) that both succinate and deacylase fraction are required for acetoacetate synthesis.

The free energy change of reaction (6) can be estimated from the energy content of the acyl

TABLE 3. ACETOACETATE SYNTHESIS WITH HEART ENZYMES
The acetoacetate assay system contained tris(hydroxymethyl)ammomethane–hydrochloric acid buffer, pH 8·1, 150 micromoles; magnesium chloride, 4 micromoles; potassium chloride, 50 micromoles; coenzyme A, 0 1 mgm., obtained from the Pabst Laboratories, Milwaukee, Wisconsin, through the courtesy of Dr A. Frieden (about 0·1 micromole of pure coenzyme A); lithium acetyl phosphate, 50 micromoles, L-cysteine, 20 micromoles; and 10 units of a partially purified phosphotransacetylase preparation from *Strep. haemolyticus*. Potassium succinate (100 micromoles) and a purified succinyl coenzyme A deacylase preparation (1·1 mgm. protein) from pig heart were added as indicated. The heart extract (5·6 mgm. protein) was made from pig heart acetone powder. Fraction 1 (11·8 mgm. protein) was an ammonium sulphate fraction (0 4–0 6 saturation) of the heart extract Fraction 2 (9·2 mgm. protein) was obtained from fraction 1 by precipitation with ethanol (20–40 per cent) at – 15°. Fraction 3 (6·1 mgm. protein) was equivalent to fraction 2 but made from an extract of fresh heart. Volume, 2·0 ml.; incubation, 60 min. at 38° (25° for fraction 3)

| Additions to assay system | Micromoles of acetoacetate formed | | | |
|---|---|---|---|---|
| | Heart extract | Fraction 1 | Fraction 2 | Fraction 3 |
| None | 0 (0)* | 0 06 | 0·22 | 0 |
| Succinate | 0·39 | 0·77 | 0·90 | 0 |
| Deacylase | 0·05 | 0·14 | 0·12 | |
| Succinate + deacylase | 0 47 (0·27) | 1·51 | 1·60 | 0·54 |

* Values in parentheses are for pig kidney extract

mercaptide bond of acetyl coenzyme A[8] (approximately 12,000 calories) and the calculated free energy of hydrolysis of acetoacetate[14] (16,000 calories). For the synthesis of acetoacetyl coenzyme A, $\Delta F \simeq 28{,}000 - 24{,}000 = +\ 4{,}000$ calories. This corresponds to an equilibrium constant of about $10^{-3}$. In heart, the equilibrium of reaction (6) can be shifted in favour of synthesis through coupling with reactions (5) and (8) when succinate is present. In liver, which does not catalyse reaction (5), this shift of equilibrium may be accomplished by the action of a specific acetoacetyl coenzyme A deacylase.

The occurrence of a reversible coenzyme A transfer from succinyl coenzyme A to acetoacetate (reaction 5) has important implications. If, as seems likely, acetoacetyl coenzyme A is generated by fatty acid oxidation, this process would result in phosphorylation at the substrate-level by reversal of reactions (5) and (4*a*).

We wish to thank Prof. Severo Ochoa for his interest in this work. We are indebted to Dr. S. Kaufman and Dr. C. Gilvarg for purified preparations of α-ketoglutaric dehydrogenase and succinyl coenzyme A deacylase from pig heart. The work was supported by grants from the United States Public Health Service, the American Cancer Society (recommended by the National Research Council Committee on Growth), the Williams–Waterman Fund of the Research Corporation, and by a contract between the Office of Naval Research and New York University College of Medicine.

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# ELECTRON MICROSCOPY OF MITOCHONDRIA AND CYTOPLASMIC DOUBLE MEMBRANES

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## Ultra-Structure of Rod-shaped Mitochondria

BY means of an improved technique using a modified Spencer No. 820 rotary microtome[1] and specially polished razor blades[2], it has been possible to obtain tissue sections sufficiently thin to study the structure of tissue cells in sections at a resolution of better than 30 A.

A second factor of importance in this connexion is the improvement of the osmium fixation technique through the modifications recommended for electron microscopy by Pallade[3].

A third factor is represented by the demonstration by Hillier[4] of the deteriorating effect of removing the embedding medium by solvents exhibiting considerable surface forces when evaporating. To study the structure of the cells at a high resolution it is therefore necessary to avoid the removal of the embedding medium, although this means subjecting the sections to a high beam intensity.

The mitochondria have been studied at a resolution of about 30 A. in the retinal rods of the guinea pig eye, in the excretory cells of the mouse pancreas and (in collaboration with J. Rhodin) in the proximal convoluted tubules of the mouse kidney[5].

A similar structure has been revealed in all these cases, and the presumed identification of certain structural components as mitochondria in the retinal rods was based on the characteristic ultra-structure and was later confirmed by supravital staining with janus green *B*[6].

In all three kinds of cells the mitochondria are rod-shaped and lined by an outer double membrane. In the interior of the mitochondria there is a great number of transversally oriented inner double membranes with different spacings in the different types of cells studied. The outlines of these double membranes also differ in cells of different tissues, being rather irregular in the rod inner segment mitochondria. Fig. 1 illustrates the tubular cell mitochondria of the mouse kidney and Fig. 2 the rather similar appearance of the retinal rod mitochondria in the rod inner segment from the guinea pig.

The dimensions of the outer and the inner membranes are identical as measured in the electron micrographs. For the mitochondria of the proximal convoluted tubule cells, the mean total thickness is 160 A. This figure is the mean value of 1,200 measurements on twenty-five different mitochondria. The thickness of the two constituent single membranes is 45 A., and the space in between the single membranes measures 70 A.

The mitochondria of the retinal rods are located in the inner segment, where the long slender mitochondria are tightly packed, and the whole aggregation of mitochondria forms the so-called ellipsoid.

The double character of the membranes observed in the mitochondria does not depend upon a diffraction phenomenon, as the pictures represent close-to-focus pictures in through-focus series, and the two constituent single membranes exhibit

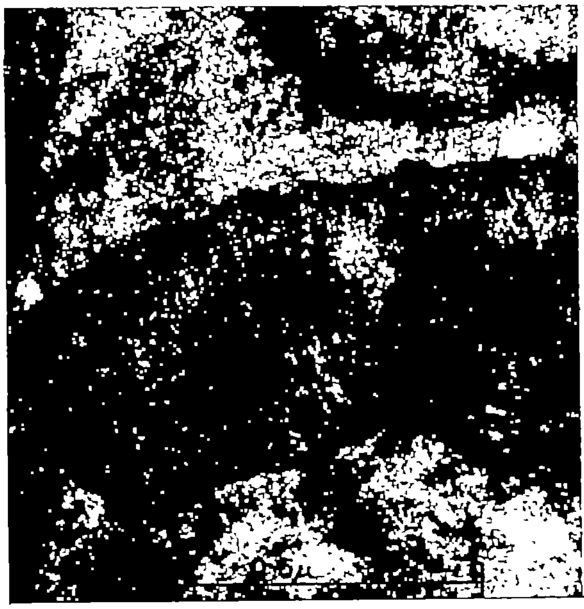

Fig. 1

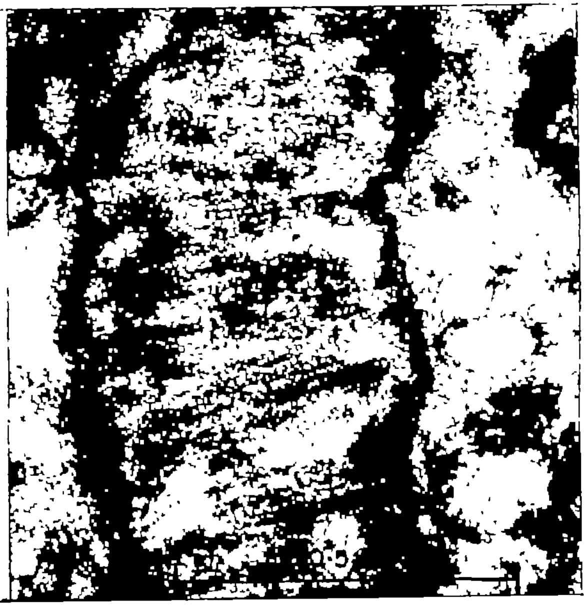

Fig. 2

Fig. 1. Part of a rod-shaped mitochondrion from the proximal convoluted tubule of mouse kidney; in the upper right corner a part of a cell nucleus with the double nuclear membrane and in the upper left corner a part of a cell granule. Along the lower side of the mitochondrion some intracellular cytoplasmic membranes are seen. Ultra-thin section. Magnification, × 97,000

Fig. 2. Part of a mitochondrion from the inner segment of retinal rod of a guinea pig eye. The transversally oriented double membranes are more irregularly arranged than in the tubular cells, due to the more irregular outlines when observed in a direction parallel to the long axis of the mitochondrion. Ultra-thin section. Magnification, × 90,000

sufficient deviations from a parallel course to demonstrate a certain mutual independence. On the other hand, the variations regarding the spacing are sufficiently small to justify considering the two membranes as parts of the same structural element.

Another possibility would be that the double appearance was due to a single membrane oriented obliquely to the direction of the electron beam and with an enhanced contrast along the cut margins of the membrane in the upper and the lower surfaces of the section. This is excluded by, among other conditions, the fact that the spacing is independent of the thickness of the sections.

Experience with osmium fixation shows that it is an excellent electron stain for protein membranes[7].

It has tentatively been assumed that the double membranes represent two membranes of mainly protein character separated by a double layer of lipid molecules. This assumption is supported by the dimensions measured, 45 A. representing a reasonable thickness for a protein membrane and 70 A. corresponding to the thickness of a double layer of, for example, mixed myelin sheath lipids[8]. [Aug. 11.

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## Systems of Double Membranes in the Cytoplasm of Certain Tissue Cells

Recent developments of the technique for making ultra-thin sections for electron microscopy[1] have made it possible to study the ultra-structure of tissue cells at high resolution (better than 30 A.) with the topography of the structural elements preserved.

A rather highly developed system of double membranes was first observed in the cytoplasm of the excretory cells of the mouse pancreas preserved by freeze-drying and embedded directly after drying in *n*-butyl-methacrylate (Fig. 3). Suspecting that the striking organization might be an artefact due to a stepwise advance of freezing through the cell, osmium-fixed material was analysed. The same systems of double membranes were observed in this material (Fig. 4). These circumstances constitute good evidence that the double membranes are real structures and do not represent fixation artefacts, the osmium fixation and the freeze-drying acting according to quite different principles.

The double membranes are oriented mainly parallel to the cell membrane, and up to about forty double membranes may be observed in the space between the cell membrane and the nucleus.

Such a structure might produce an anisotropy of the cytoplasm. A preliminary polarization optical analysis of the living pancreas cells in the living mouse has revealed an anisotropy of the cytoplasm, negative with respect to a direction perpendicular to the cell surface and with the optical axis parallel to this direction. This anisotropy might well correspond to a system of membranes oriented parallel to the cell surface. The polarization optical analysis is still incomplete.

The electron microscopic observations on freeze-dried and osmium-fixed material thus seem to be confirmed by the polarization optical analysis on living cells.

The mean total thickness of the double membranes is 530 A. when measured on frozen-dried material and 600 A. when measured on osmium-fixed material. The mean distance between the centres of the two constituent single membranes is 370 A. and 360 A.

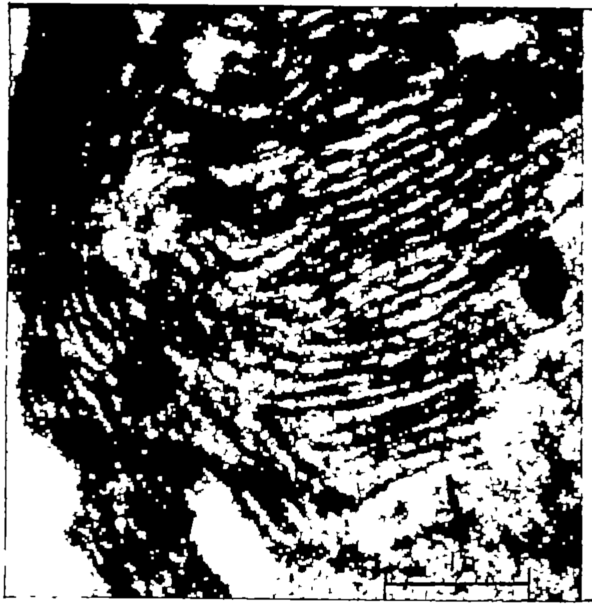

Fig. 3

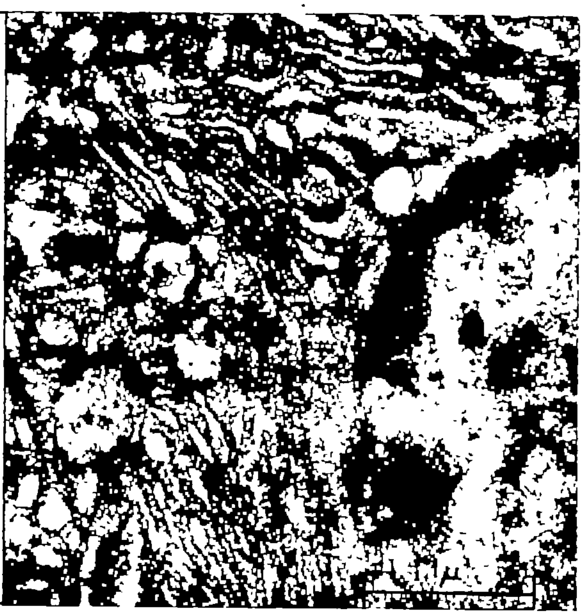

Fig. 4

Fig. 3. Cytoplasm of mouse pancreas excretory cell; fixation by freeze-drying. A characteristic pattern of double membranes. Thin section. Magnification, × 18,000

Fig. 4. Cytoplasm and part of the nucleus of a mouse pancreas excretory cell; buffered osmium fixation. A system of double membranes similar to those in Fig. 3 is shown. In the upper part of the picture several double membranes with wide spaces separating the two constituent single membranes are seen. Thin section. Magnification, × 22,000

for frozen-dried and osmium-fixed material, respectively. The calculated mean thickness of the single membranes is 160 A. (frozen-dried) and 240 A. (osmium-fixed), and the width of the space between the two membranes of the double membrane is 210 A. (frozen-dried) and 120 A. (osmium-fixed). These figures are preliminary, as each is based on only sixty to eighty measurements.

The double membranes appear coarser after osmium fixation than after freeze-drying, presumably due to osmium-stained components with a close topographical relation to the membranes or to the precipitation of proteins at the membranes.

Intracellular double membranes have also been observed in the cells of the proximal convoluted tubules of mouse kidney[2], and in the epithelium of mouse intestines. In the kidney tubular cells the intracellular membranes occur in the basal cell zone and divide the cytoplasm into compartments containing the mitochondria. The total mean thickness of these double membranes is 270 A. (mean value of 600 measurements on twenty-five membranes), the thickness of the constituent single membranes 80 A., and the width of the space between the single membranes 110 A.

These figures show a distinct difference in dimensions between the intracellular cytoplasmic membranes of the pancreas and of the kidney cells. They also differ in regard to the effect caused by the osmium fixation. The double membranes of osmium-fixed pancreas cells often appear deformed, with the two constituent single membranes separated by more-or-less wide spaces. The double membranes may even appear as wide tubules. As the double membranes do not show this appearance in frozen-dried material, it seems reasonable to assume that the wide spaces are due to the osmium fixation causing a swelling of the double membranes.

The double membranes of the tubular cells of the kidney and of the epithelial cells of the intestines have not been observed to exhibit that deformed pattern. On the contrary, the distance between the constituent single membranes of these double membranes is fairly constant.

The double membranes of the pancreas cells thus differ considerably from the double membranes in the kidney and intestinal cells both in dimensions and variability of the spacing. It therefore seems justified to assume that we are dealing with rather different intracellular double-membrane structures.

The intracellular cytoplasmic membranes seem to correspond to the coarse cytoplasmic fibrils first observed by J. Hillier[3] in liver cells in connexion with his work on improving the sectioning technique and recently described by Bernhard, Gautier and Oberling[4] in liver, pancreas and salivary gland cells.

Double-membrane structures have also been observed as an important structural element of the mitochondria[5] and in the outer segments of the retinal rods of guinea pig and perch eyes[1].

The following interpretation of the observations is proposed. The two constituent single membranes represent membranes of mainly protein nature and the space between represents a multilayer of lipid molecules, partially dissolved during the embedding. This tentative interpretation seems justified, at least for the intracellular double membranes of kidney and intestinal cells. The structural organization of the double membranes of the pancreas cells, on the other hand, may well be more complex.

The intracellular cytoplasmic membranes may represent a fundamental principle of organization of the cytoplasm. [Aug. 22.

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# LETTERS TO THE EDITORS

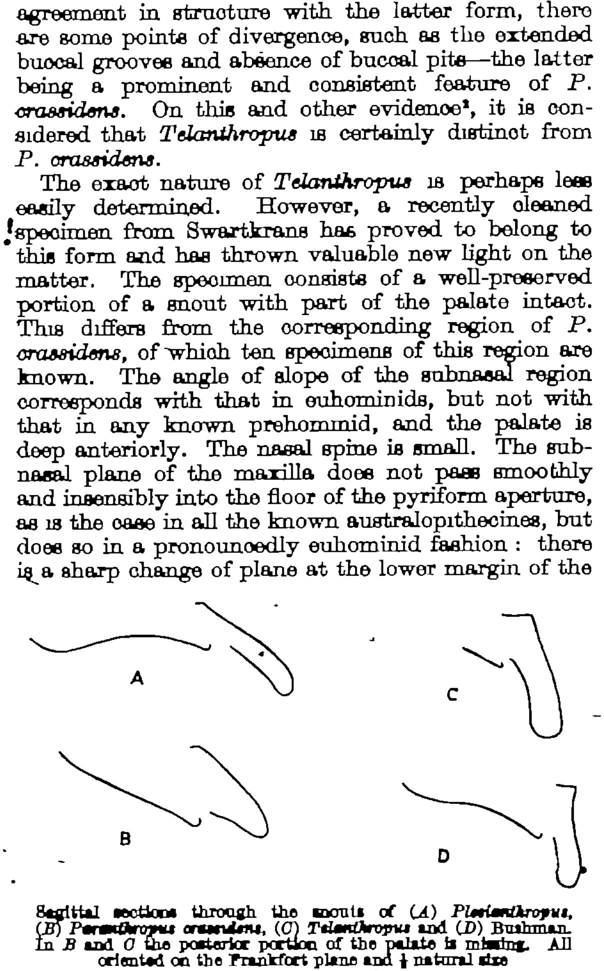
*The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications*

## The Nature of *Telanthropus capensis*

THE type mandible of *Telanthropus capensis* was found in the Swartkrans excavation in April 1949 by me. Dr. R. Broom and I published a preliminary description in this journal[1]. In this note the opinion was expressed that this form is "intermediate between one of the ape-men and true man". This conclusion has been somewhat sceptically received by most workers, who consider, in view of the fact that the same excavation has yielded numerous remains of the ape-man *Paranthropus crassidens*, that the specimen is more likely to be a small and slightly aberrant *P. crassidens* than a new type of man.

Hitherto the known specimens of this form comprised only the almost complete mandible containing five molars, $P_3$ belonging to the left side of the same mandible and the proximal end of a radius. The teeth are small compared to the *P. crassidens* homologues—especially $M_1$. The length and breadth values for $M_1$, respectively, fall 5·4 and 3·8 standard deviations from the corresponding means for $M_1$ of *P. crassidens*. The ascending ramus and corpus mandibulæ heights are appreciably lower than those of *P. crassidens*. Although the molars show general agreement in structure with the latter form, there are some points of divergence, such as the extended buccal grooves and absence of buccal pits—the latter being a prominent and consistent feature of *P. crassidens*. On this and other evidence[2], it is considered that *Telanthropus* is certainly distinct from *P. crassidens*.

The exact nature of *Telanthropus* is perhaps less easily determined. However, a recently cleaned specimen from Swartkrans has proved to belong to this form and has thrown valuable new light on the matter. The specimen consists of a well-preserved portion of a snout with part of the palate intact. This differs from the corresponding region of *P. crassidens*, of which ten specimens of this region are known. The angle of slope of the subnasal region corresponds with that in euhominids, but not with that in any known prehominid, and the palate is deep anteriorly. The nasal spine is small. The subnasal plane of the maxilla does not pass smoothly and insensibly into the floor of the pyriform aperture, as is the case in all the known australopithecines, but does so in a pronouncedly euhominid fashion: there is a sharp change of plane at the lower margin of the pyriform aperture. The bony plate inside the nasal aperture is almost at right-angles to the subnasal plane. The left canine socket is intact except for the outer wall and is too small to accommodate even the smallest lower canine root of *P. crassidens*. The smallest upper canine root of the latter form is much too large for this socket. This probably means that in *Telanthropus* both the crown and root of the canines were reduced in size, whereas in *P. crassidens* the crown had been reduced but not the root. From the various fragments of $P^3$ preserved on both sides, it seems that this tooth was still three-rooted; which condition is also found in the australopithecines.



Sagittal sections through the snouts of (*A*) *Plesianthropus*, (*B*) *Paranthropus crassidens*, (*C*) *Telanthropus* and (*D*) Bushman. In *B* and *C* the posterior portion of the palate is missing. All oriented on the Frankfort plane and ½ natural size

This snout differs, therefore, in a number of important features from those of the australopithecines and approaches the condition in the earliest known euhominids very closely. In conjunction with the characters of the mandible, there seems little doubt that *Telanthropus* is a very primitive euhominid. There are some australopithecine affinities, and it is therefore difficult to avoid the conclusion that this form had recently passed from australopithecine to euhominid status.

Recent geological and faunal evidence[3] strongly suggests that the Swartkrans site is Upper Pliocene in age and that it is all a uniform deposit, that is, that the *Telanthropus* and *P. crassidens* remains are coeval. *Telanthropus* is therefore of very great interest and significance for studies on hominid phylogenesis. It demonstrates the very close relationship between australopithecines and man, and is almost certainly the oldest euhominid so far known. A fuller account is being published elsewhere.

J. T. ROBINSON

Transvaal Museum,
Pretoria.
Nov. 25.

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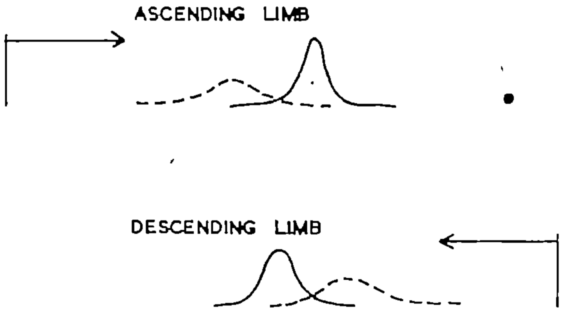
## Separation of an Inhibitor of Influenza Virus Hæmagglutination from Human Sputum

A SIMILARITY exists between the action of the influenza virus enzyme on the surface of the erythrocyte or cells of the respiratory tract and its action in destroying the inhibitory properties for virus hæmagglutination possessed by certain soluble mucins. This has stimulated much interest in the biological function of the mucins in relation to influenza virus infection and particularly in their chemistry as substrates for influenza virus enzyme action[1]. Although studies since 1948 have dealt with influenza virus action on a variety of inhibitors, ranging from those obtainable from serum and urine to those from egg-white, sheep salivary gland and human ovarian cyst, relatively little attention has been paid to the inhibitors present in the secretions actually at the site of influenza virus infection, namely, those in the human nasal and bronchial mucus. Fazekas[2] has described the change in 'inhibitor profile' for certain influenza viruses which takes place in human nasal mucus during influenza. Rose[3] has reported that sputum contains factors which inhibit both infectivity (in eggs and mice) and hæmagglutination by influenza virus.



Electrophoresis of sputum inhibitor in potassium phosphate buffer (pH 7·0, $\mu$ = 0·1) at 3·2 volt/cm. for 14,400 sec. Concentration approximately 0·4 per cent. Before (———) and after (– – – – –) treatment with receptor-destroying enzyme

Preliminary experiments carried out by us to extend the observations of Rose have shown that the factor present in some sputa which inhibits the growth of influenza virus *in ovo* seems to be distinct from the factor constantly present in all sputa which inhibits hæmagglutination *in vitro* by both enzymically active and 'indicator' viruses. It has been possible to extract from sputum an inhibitor of hæmagglutination which appears to be a single substance. The purification and properties of this inhibitor are described in this communication.

Samples of sputum, from patients with chronic bronchitis, were homogenized for five minutes in a Waring blendor in ten times their volume of physiological saline. The solution was centrifuged (5,000 *g*, 20 min.) to remove bacteria and cell debris. The supernatant was centrifuged (20,000 *g*, 25 min.) to remove an aggregated mucinous component. The inhibitor was precipitated from this supernatant by the addition of an equal volume of acetate buffer ($p$H 3·6, ionic strength ($\mu$) = 1·0, containing 0·02 *N* calcium chloride). The presence of calcium ions was found necessary for satisfactory precipitation. The precipitate was recovered by centrifugation (3,000 *g*, 10 min.) and dissolved in a minimum volume of phosphate buffer ($p$H 7·0, $\mu$ = 1·0). The resulting slight precipitate of calcium phosphate was removed by centrifugation (2,000 *g*, 15 min.). The supernatant was submitted to electrophoresis in phosphate buffer ($p$H 7·0, $\mu$ = 0·1). A single component migrating towards the anode with a mobility of $6 \cdot 7 \times 10^{-5}$ cm.$^2$ sec.$^{-1}$ volt$^{-1}$ was found (see diagram). After treatment with a purified preparation[4] of the receptor-destroying enzyme of *Vibrio choleræ* the mobility of this component was reduced to $4 \cdot 9 \times 10^{-5}$ cm.$^2$ sec.$^{-1}$ volt$^{-1}$. This reduction in mobility after the action of the receptor-destroying enzyme has been found to be general for inhibitors and gives an indication of the uniformity of the substance as an inhibitor[5].

The inhibitory titres of the samples submitted to electrophoresis were estimated according to the method of Stone[6], using the viruses shown in the table.

| | Active viruses | | | Indicator viruses | | |
|---|---|---|---|---|---|---|
| | Mel | Lee | WSE | Mel | Lee | WSE |
| Untreated sputum inhibitor | 200 | 80 | 1,000 | 9,000 | 4,000 | 8,000 |
| Sputum inhibitor treated with receptor-destroying enzyme | 10 | 10 | 10 | 10 | 10 | 10 |

Details of this work will be published elsewhere.

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## Aureomycin in *Theileria parva* Infection

Recognition of the selective action of quinine, atebrin and chloroquine on the hæmotropic trophozoites of certain *Plasmodium* species, and that of plasmoquine on the exoerythrocytic trophozoites as well as on the gametocytes, forms the bases of modern chemotherapy of malaria in laboratory animals and in man.

Application of this conception of selective chemotherapeutic action to other diseases caused by protozoa, the life-cycle of which is similar to that of the malarial parasite, notably the *Theileria* spp., appeared to be indicated. Neitz[1] reported that the 8-aminoquinoline preparation plasmoquine has a selective action on the hæmotropic forms of *Theileria parva*, while leaving the schizont phase unaffected. Therefore the drug had no curative value. The investigation was extended to include other drugs, among which was aureomycin. The antibiotic, administered intravenously in repeated large doses during the incubation period of infection, has been found to exert a marked effect upon the schizonts of *Theileria parva*. In fact, in each of seven cases of sporozoite-induced theileriasis, disappearance of schizonts was followed by recovery and the development of a solid immunity.

For these tests, nine cattle were used, of which two served as untreated controls. In each case the disease was induced by feeding infective *Rhipicephalus appendiculatus* nymphæ on the left ear. Treatment was commenced 24 hr. later by the injection of aureomycin in a dose of 10 mgm. per kgm. body-weight. The same dose was repeated at arbitrary irregular intervals as indicated in the accompanying table, until a decrease in the number of schizonts in lymph gland smears became evident. In each case from this stage the number of schizonts continued to decrease rapidly until they could no longer be found after prolonged search. Hæmotropic forms of the parasite persisted from one to five days after disappearance of the schizonts. Apart from an exceedingly mild febrile reaction and swelling of the superficial lymph glands, the animals showed no clinical evidence of the disease. After complete recovery, it was shown that a solid immunity to re-infection had been induced in one animal tested four weeks after disappearance of the schizonts. The immunity of the remaining six survivors will be tested after longer intervals.

In the untreated controls the normal fulminating form of the disease was produced, followed by death not later than the twenty-fourth day after attachment of the ticks.

| Days | Treated animals | | | | | | | Untreated animals | |
|---|---|---|---|---|---|---|---|---|---|
| | 5085 | 5430 | 5438 | 5483 | 5614 | 5436 | 5444 | 5700 | 5704 |
| 1 | X | X | X | X | X | ● X | X | | |
| 2 | | | | X | X | X | X | | |
| 3 | X | X | X | X | X | X | X | | |
| 4 | | X | X | | | | | | |
| 5 | X | | | X | X | | | | |
| 6 | | X | X | | | X | X | | |
| 7 | X | | | X | X | | | | |
| 8 | | X | X | | | | | | |
| 9 | | | | X | X S+ | X S+ | X S+ | | |
| 10 | X | X | X | S+ | S+ | S+ | S+ | | S+ |
| 11 | | S+ | | X S+ | X S+ | X S2+ | X S2+ | S+ | S2+ |
| 12 | X S+ | X S+ | X | S+ | S3+ | S2+ | S2+ | S+ | S3+ |
| 13 | S+ | S+ | S+ | X S2+ | X S3+ | X S3+ | X S3+ | S2+ | S3+ |
| 14 | X S2+ | X S+ | X S+ | S2+ | S2+ | S3+ P+ | S4+ P+ | S2+ | S4+ P+ |
| 15 | S2+ | S+ | S2+ | S+ | S2+ | X S3+ P2+ | X S4+ P2+ | S3+ P+ | S4+ P+ |
| 16 | S2+ | X S+ | X S2+ | S+ | S2+ | X S4+ P3+ | X S4+ P2+ | S3+ P+ | S4+ P+ |
| 17 | X S2+ | S+ | S+ | S+ P+ | S+ P+ | S4+ P3+ | S3+ P3+ | S4+ P2+ | S4+ P4+ |
| 18 | S3+ | X | X S+ | P+ | P+ | X S4+ P3+ | X S3+ P3+ | S4+ P3+ | S5+ P4+ |
| 19 | S2+ | P+ | | | P+ | X S4+ P3+ | S3+ P4+ | S5+ P4+ | S5+ P4+ |
| 20 | S2+ P+ | P+ | P+ | | P+ | X S4+ P4+ | S2+ P4+ | S5+ P5+ | S5+ P5+ |
| 21 | P+ | | P+ | | P+ | S3+ P4+ | S+ P4+ | S5+ P5+ | S5+ P5+ |
| 22 | P+ | | P+ | | | S3+ P3+ | S+ P3+ | S5+ P5+ | S5+ P5+ |
| 23 | P+ | | P+ | | | S2+ P3+ | P3+ | S5+ P5+ | S5+ P5+ |
| 24 | | | | | | S+ P3+ | P2+ | S5+ P5+ | S5+ P5+ |
| 25 | | | | | | P+ | P+ | | |

X, treatment with aureomycin; S2+, schizonts 2+ present in smears; P+, hæmotropic parasites present; + very rare; 2+, rare; 3+, fairly frequent; 4+, frequent; 5+, numerous

Thus aureomycin in a dose of 10 mgm. kgm. body-weight administered in repeated doses during the incubation period of *Theileria parva* infection is a schizonticide which acts on the early schizonts by suppressing nuclear division. This in turn suppresses the formation of merozoites, which invade either the lymphocytes or erythrocytes. The drug appears to have no effect upon the hæmotropic parasites. The result is that completion of the cyclical development of sporozoite-induced infection is inhibited and the clinical disease fails to develop. Nevertheless, a solid immunity is produced.

There remains to be determined the minimum effective dosage and the effect possibly in combination with a drug affecting the hæmotropic parasites, for example, plasmoquine administered at a later stage of parasite development.

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## A New Technique for Microscopic Preparations of Small Marine Animals

During a recent study of the platyctenid ctenophores of Jamaica, the following technique was devised to allow even the most delicate and minute platyctenid to be immobilized, fixed, stained and embedded in any desired position with the minimum distortion. As this method has since been used successfully with rhabdocœl turbellaria, it is felt that its usefulness might well be extended to a wider range of invertebrates.

The chief difficulty in obtaining flat, uncontracted specimens of these delicate animals is their marked intolerance of usual anæsthetics such as menthol, magnesium sulphate, urethane or chloral hydrate. Treatment with warm fixative is also very often unsuccessful, as the animals begin to contract as soon as the fumes of the fixative reach them before the liquid can be applied. The usual refrigerator 'freezing and thawing in fixative' method is also of no use as the animals either dissolve while in the ice cube, or become only partially fixed, or become fixed in an unnatural position. These difficulties have been overcome by the following method.

(*a*) *Immobilization and Fixation.* The platyctenid is allowed to take up either its normal 'sitting' position in a drop of sea water on a coverslip (preferably No. 1 thickness) or is allowed to flatten itself under the surface film of the drop. The coverslip is then gently transferred to the stage of a freezing microtome. The animal is given a moment or two to recover from any jarring, and then the supply of carbon dioxide from the cylinder is turned on. The sea water drop is carefully watched until it just becomes opaque, then the carbon dioxide is turned off. The drop continues to freeze for a few moments, and it is during this interval that the fixative is added drop by drop. After the fourth or fifth drop of fixative the sea water begins to thaw, but the animal remains motionless and the requisite amount of fixative may be poured on. Fixatives which can be recommended are, in order of preference, (1) Komai's[1] modification of Carnoy–Lebrun, consisting of 70 parts saturated aqueous sublimate solution, 30 parts 95 per cent alcohol, and 1·5 parts glacial acetic acid; and (2) Duboscq–Brasil.

(*b*) *Staining for Whole Mounts.* The animal remains attached to the coverslip after freezing with carbon dioxide, and staining may therefore be carried out by the gentle removal of the coverslip with the animal from one Petri dish to another. The final mount is obtained by inverting a slide over the animal in a drop of mountant on the original coverslip. The staining process should be as rapid as possible because of the fragile nature of the specimen. A progressive stain such as aceto-carmine usually gives good results and makes the addition of a differentiator to the list of staining solutions unnecessary.

(c) *Embedding*. The animals may be prepared for embedding in paraffin, ester wax[2] or in celloidin by a very simple modification of the above technique. A small square of thin 'Cellophane' is placed on the coverslip and held in position by a drop of sea water. A further drop is then placed on the upper surface of the 'Cellophane' and the animal transferred from the aquarium to this drop. Upon freezing as in section (a), the animal will now adhere to the 'Cellophane' instead of to the coverslip. After fixation and thawing, the coverslip with the 'Cellophane' and animal is transferred to 70 per cent alcohol and is then taken through the usual solutions for either wax or celloidin embedding.

For ease of handling of the coverslip, especially in celloidin solutions, a cradle made of fine copper wire and suspended from the cork by thread will be found to be helpful. In the actual embedding process, the coverslip, which merely acts as a stiffening support, is removed, but the 'Cellophane' is embedded along with the animal and may then be stripped off just prior to cutting.

Clearly this method of fixation owes much of its success to controlling the degree of freezing, which necessitates keeping the animal under observation from start to finish of the process. This can easily be tested in two simple experiments. First, if platyctenids are frozen into a hard block of ice and then allowed to thaw (without fixation), they will disintegrate, chiefly because the character of the mesoglœa appears to be altered, so that it is no longer capable of holding the animal together. This may perhaps be related to the high water content of the animal. Secondly, if the animals are frozen only slightly, as suggested in section (a) (without fixation), they will recover completely, and their normal movements may again be studied under the microscope.

The possibility that the carbon dioxide may have a gentle anæsthetizing effect cannot be entirely ruled out; but further experimentation would be required to elucidate this point.

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## X-Ray Evidence for Metal-to-Metal Bonds in Cupric and Chromous Acetate

As a preliminary to the structural determination of chromous acetate, it was decided to study the much more stable cupric acetate $Cu(CH_3COO)_2.H_2O$ during the early X-ray investigations. Both these compounds are monoclinic with space group $C2/c$, and their unit-cell dimensions, determined from X-ray measurements and given herewith, are almost identical.

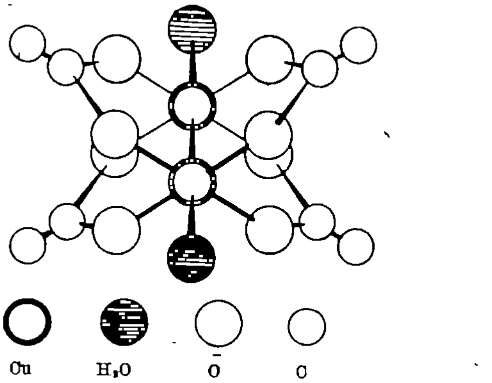
| | *a* | *b* | *c* | *β* |
|---|---|---|---|---|
| Cupric acetate | 13·15 | 8·52 | 13·90 A. | 117° 0′ |
| Chromous acetate | 13·15 | 8·55 | 13·94 A. | 117° 0′ |

The values for cupric acetate are in good agreement with those found by Hull and given in the "Handbook of Chemistry and Physics" (13th edit., p. 2060).

The close resemblance between these two acetates suggests that they are structurally isotypes, so that it appeared likely that an X-ray examination of cupric acetate might give information as regards the structure of the unstable chromous acetate.

Assuming eight $Cu(CH_3COO)_2.H_2O$ formula units in a cell with the above dimensions, the calculated density is 1·92 gm.cm.$^{-3}$, which is the same as the value determined experimentally by the method of flotation. Patterson projections, Harker sections and Fourier projections of the structure on three crystallographic planes show that the true repeat unit is $Cu_2(CH_3COO)_4.2H_2O$. It was further found that the symmetry centre of this dimeric molecule coincides with a symmetry centre of the $C2/c$ space group. The unit cell therefore contains only four molecules.

The accompanying diagram is of the cupric acetate molecule, obtained by calculating bond-lengths and angles from the projections. The nearest six neighbours of a copper atom are comprised of four oxygen atoms belonging to four different acetate groups, a copper atom and a water molecule. These six atoms form a distorted octahedral configuration about each of the two copper atoms in the molecule. The Cu–O distances all approach the value 1·97 A., which is in good agreement with the normal Cu–O [1] and Cr–O [2] distances found in other compounds. The four acetate groups are separately planar and their dimensions conform to previously determined bond-lengths and angles. The Cu–$H_2O$ distance is 2·20 A. The Cu–Cu distance is 2·64 A., and is only slightly longer than the value 2·56 A. found in metallic copper.



The ability of acetate groups to bridge two metal atoms in a complex has been predicted by Werner[3] from chemical reasoning. The cage-like structure of cupric acetate clearly illustrates this point. An unusual feature of this structure is the fact that, in addition to each copper atom forming four covalent bonds to four oxygen atoms, there also appears to be a fifth bond between the two copper atoms in a molecule. The nature of this metal-to-metal bond is at present being investigated by making an X-ray study of the acetates of the transition elements.

Experiments now in progress suggest very strongly that cupric acetate and chromous acetate are, in fact, structurally isotypes, and that similar bond-distances accordingly exist in the latter.

A detailed account of this work will shortly be published elsewhere. This communication is published by permission of the South African Council for Scientific and Industrial Research.

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## Surface Free-Energy of Solid Paraffin Wax

As part of a programme of research on the surface free-energy of solids, we have lately been working on paraffin wax. The method used is the one proposed by Bergren[1] and consists in measuring the rates of elongation or contraction of thin filaments of different lengths hanging under their own weights. The change in length results from two opposing forces: one which tends to shorten the filament so that its surface free-energy is decreased, and the other tending to lengthen the filament because of its weight. A critical filament-length, $l_0$, is determined at which the elongation of the upper part of the filament is equal to the contraction of the lower part, so that the length remains constant. Assuming that the solid near the melting point behaves as a viscous liquid, that is, the rate of deformation is proportional to the applied stress, the surface free-energy of the solid can be calculated from the critical length $l_0$ using the equation:

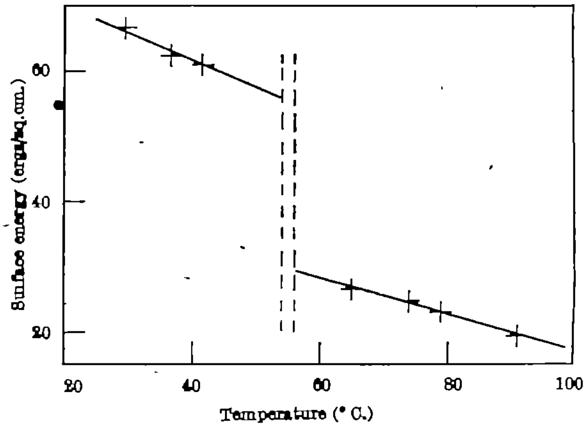
$$\gamma = \tfrac{1}{2}\rho g r l_0,$$

where $\gamma$ is surface free-energy, $\rho$ is density of solid at temperature of experiment, $g$ is acceleration due to gravity, and $r$ is radius of wire.

In our experiments, filaments of 0·01088 cm. radius were produced by extrusion of the paraffin wax (melting range 54–56° C.) through a tungsten carbide die at room temperature into a constant temperature ($\pm$ 0·1° C.) enclosure. The observations were then made on the filament hanging from the die. The change in length was measured at intervals by means of a cathetometer, and $\Delta l/l\Delta t$ (positive or negative) plotted against the original length of the filament. This should be a straight line according to theory, and $l_0$ was obtained by interpolation as intercept on the length axis.

Measurements were carried out at 29·5°, 36·7° and 41·5° C., and the surface free-energy calculated using $\rho_{20^\circ\text{C.}} = 0\cdot8857$ gm./cm.$^3$, the change in density being negligible over the temperature-range concerned. The results are plotted in the accompanying graph, together with values for the same specimen of paraffin wax in the liquid state determined by the ring tensiometer method and corrected by the method of Harkins and Jordan[2].

The results indicate a discontinuity in the surface free-energy on melting. On the other hand, the temperature coefficient of the surface free-energy does not alter appreciably.



Surface free-energy of solid and liquid paraffin wax

The same method has been used for measuring the surface free-energy of tin (99·99 per cent pure) *in vacuo* at 215° C. (17° below melting point). Polycrystalline wires with transverse grain boundaries (1/25 cm. average longitudinal grain-size) were extruded from the electrically heated die directly into the evacuated constant-temperature chamber. After correcting for the grain boundary energy according to Udin[3], the surface free-energy at 215° C. was found to be 685 ergs/cm.$^2$.

Further work on the surface free-energy of tin and other low-melting metals at different temperatures is in progress. A detailed account of this will be published later.

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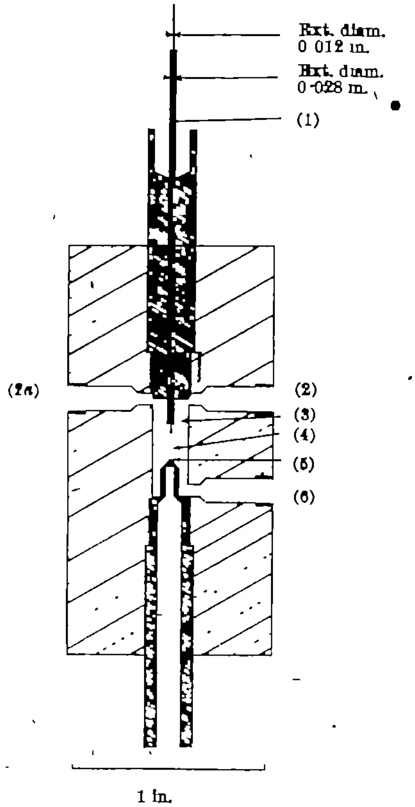
## A Device for Counting Small Particles suspended in a Fluid through a Tube

ATTEMPTS to count small particles suspended in fluid flowing through a tube have not hitherto been very successful. With particles such as red blood cells the experimenter must choose between a wide tube which allows particles to pass two or more abreast across a particular section, or a narrow tube which makes microscopical observation of the contents of the tube difficult due to the different refractive indices of the tube and the suspending fluid. In addition, narrow tubes tend to block easily.

These difficulties can be overcome by slowly injecting a suspension of the particles into a faster stream of fluid flowing in the same direction. Provided there is no turbulence, the wide column of particles will then be accelerated to form a narrow column surrounded by fluid of the same refractive index, which in turn is enclosed in a tube which will not interfere with observation of its axial contents.

This principle has been applied to the alignment of red blood cells preparatory to electronic counting. The constructional details of the apparatus in use are shown in the diagram.



(1) Needle in holder; (2) and (2a) inflow tubes; (3) wide-bore tube; (4) observation area for (3), (5) vortex; (6) flushing tube

The whole apparatus is filled with gas-free distilled water which is allowed to flow via tubes 2 and 2*a* into the wide tube 4 and into the vortex 5. Tube 6 is normally closed. The suspension of cells is then passed into the needle (1). As the stream of cells emerges from the tapered tip of the needle it is narrowed by the faster peripheral stream in 3, and as the vortex is approached the stream of cells narrows further as the velocity increases.

To be robust and serviceable, the chamber is made of a solid brass block, drilled and tapped so that all the five tubes can be removed for cleaning or replacement. Three side tubes are used. By using tubes 2 and 2*a* for water to enter the chamber, the stream of cells passing from the needle to the vortex loses its tendency to curve which occurs if water enters from one side only.

Tube 6 is connected to a source of negative pressure. It is normally closed; but it is useful for flushing air or foreign material from the chamber.

Tube 3, which is circular in cross-section, approaches a square cross-section at the observation area (4). Here the walls are cut away and replaced with flat glass cover-slips sealed to the brass with wax compound. Ideally, tube 3 should be tapered and, from the point of view of accelerating the cells, rather narrower than it is. The needle and vortex are aligned as accurately as possible to be central to the wide bore.

The needle should be wide enough not to block easily but, provided it does not block, should be as narrow as possible to enable the velocity of cells passing through the needle to be substantially greater than the sedimentation effect of gravity. A further reason for a narrow needle is that if a constant flow-rate is used as a measure of the volume of cell suspension to be counted, the fluctuations of flow in a wide-bore needle will be greater for the same minute changes of pressure. A bore of about 125 μ has been found suitable. The needle is made of stainless steel.

The vortex tube has a small hole of 0·16 mm. diameter at its tip, the walls of which are tapered to 45° to reduce their optical interference when observing cells entering the tube. This tip is made of platinum to avoid corrosion. A negative pressure of 25 cm. of mercury is applied to the vortex. Poiseuille's formula and its derivatives and corrections cannot usefully be applied to flow in the chamber because the flow approaching the vortex has a radial component and also on account of cells interrupting the smooth gradient of pressure from the periphery to the centre.

The chamber at present in use functions moderately well. Dark-ground illumination is used, and a thin luminous stream of cells less than 10 μ wide, wavering slightly (not more than 5 μ to either side), is seen approaching the vortex but cannot be seen as it enters. The speed has been estimated as being between 3 and 6 cm./sec. as judged by oscilloscope measurements of the cells crossing a field of about 5 μ. It is hoped that this speed will be increased by redesigning the chamber with decreased diameter of the observation area, which at present is 3/16 in.

I am indebted to Dr. J. Cox for the construction of the apparatus, and to Messrs. Accles and Pollock. Ltd., who supplied the steel tubes.

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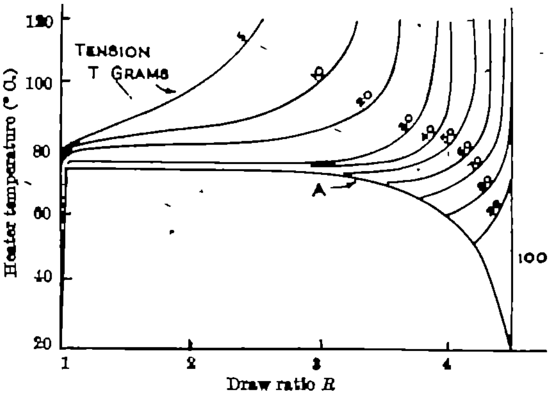
## Drawing Synthetic Fibres

THERE are two aspects of the drawing of synthetic fibres which have not so far been treated very fully in the literature. These are, respectively, the behaviour of the fibre during continuous drawing on the machine (as opposed to simple stretching on a tensometer) and the formation and maintenance of a 'neck' during drawing[1]. These two problems are intimately related to one another, since a continuous drawing machine, operating as a steady-state tensometer, is a particularly suitable tool for examining 'necking'.

The starting point was to consider continuous machine drawing in terms of a three-dimensional load–extension–temperature surface characteristic of the material, which during most of our investigation has been polyethylene terephthalate ('Terylene'). A 'contour map' for such a surface for this material is shown in the accompanying graph.

It has been found that during continuous drawing between two rolls, with a heater mounted between, the extensions occurring in the yarn at all points in the thread-line can be explained in terms of this surface, whenever the yarn tension is less than that required to form a 'neck' in the cold fibre. Most of this region lies above the second-order transition tem-



Denier, 280; heater, 4 in. hot plate; speed, 7·5 cm./sec.

perature of the polymer, and drawing is then always uniform at all machine ratios.

Outside this region, where the tensions mount very rapidly, the material 'necks' at a ratio independent of the machine setting, but dependent on the diameter and initial molecular orientation of the specimen and upon the absolute speed of the machine. This is the normally observed 'cold-drawing' of the fibre. Under these conditions, the neck advances or retreats along the thread-line at a steady velocity which can be measured and used to calculate the natural draw ratio in the neck. In the graph the natural draw ratio thus calculated, for fibres of polyethylene terephthalate, is shown by the line $A$.

The natural draw ratio drops to unity at about 80° C. in the range of the second-order transition of the polymer[2].

Consideration of the phenomenon in the terms of the surface suggests strongly to us that it is due to self-heating of the specimen to a point where the effective load-extension curve becomes horizontal; that is, to where the extension occurs at constant load but rising temperature, rather than constant temperature and rising load. Conditions for this to happen can readily be calculated for model substances having simple load-extension temperature properties, when the essential criteria for 'necking' to occur appear to be: (1) a modulus which falls with increasing temperature; (2) a sufficient rise in temperature of the material caused by the work of stretching. This in turn implies: (*a*) poor conductivity; (*b*) that the work done appears as heat rather than elastic potential energy; (*c*) that heat losses must be small. Crystallinity in the material does not appear to be essential.

Parallel observations on such substances as nylons, polyethylene, gutta percha and polymethylmethacrylate, which is amorphous, appear to support these conclusions.

We hope to publish this work elsewhere at greater length.

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## Resolution of Racemic Mixtures by Symmetrical Agents

THE recent communication by H. M. Powell[1] on new procedures for resolution of racemic substances by means of perfectly symmetrical agents prompts me to describe my own researches on the same subject. A full account of our results, including experimental details, is to be published in the *Anais Soc. Biol. Pernambuco*[2]. Although the method outlined below is very simple, apparently it has not been mentioned in the literature[3].

The proposed method is based upon the following assumptions: it is well known that optically active adsorbents preferentially adsorb one of the enantiomorphs from a racemic mixture[4,5]. When a crystalline racemic substance is precipitated from its solution, a crystallization nucleus is first developed. Since this nucleus contains a relatively small number of molecules there is more than an even chance that it will contain an excess of one enantiomorph or the other. Supposing that the forces acting in the growth of a crystal are of the same kind as those responsible for adsorption, this nucleus will grow preferentially, collecting one of the optical antipodes at the expense of the other, which will remain in the solution. Usually in a macro-crystal of dissymmetrical molecules obtained under perfectly symmetrical conditions the antipodal forms are so nearly equivalent in number that it is impossible by experimental means to prove the existence of an excess of one of the enantiomorphs, but this numerical equality only represents a statistical mean. It is possible, however, to increase the statistical fluctuations so that resolution can be shown.

In our experiments a racemic alkaloid, prepared synthetically (such as DL-narcotine or DL-laudonosine), insoluble in water, is first dissolved in hydrochloric acid, and a symmetrical organic base (pyridine) is then slowly poured into the solution, causing the re-precipitation of the alkaloid:

$$\text{pyridine} + [B\text{H}]^{+}\text{Cl}^{-} \rightarrow [\text{pyridine.H}]^{+}\text{Cl}^{-} + B.$$

After a small precipitate has formed, it is filtered off and the solution tested for optical activity. In our experiments with DL-narcotine and DL-laudonosine, resolutions ranging from 1 up to 2·5 per cent were achieved. The method can be applied to many other substances, and experiments are in progress on the resolution of DL-cystine and DL-tyrosine.

Finally, we wish to stress the implications of these findings (as well as those of Powell) on the problem of the origin of molecular dissymmetry in living matter. Processes such as those recently described are probably more likely to have occurred in the past than the activation of reactive racemic mixtures by naturally polarized light, even if they lead to a spontaneous decrease in the entropy of the system.

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[2] Paper presented on July 10, 1952.

[3] See, for example, the exhaustive review by Ritchie, P. D., "Advances in Enzymol.", **7**, 65 (1947).

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## Emission of Molecular Complexes of Nitro-compounds

Lewis and Kasha[1] have directed attention to the phosphorescence induced by ultra-violet light on a number of organic compounds, particularly nitro-compounds, dissolved in the 'glass' produced when their solutions in suitable solvent mixtures are cooled to liquid-air temperature. They attribute this phenomenon to the formation of triplet-levels from the original excited singlets, the phosphorescence resulting from the triplet – ground-level change being unquenched owing to the greatly diminished thermal agitation at low temperatures in the glass.

We have found that even at ordinary temperatures an intense brick-red fluorescence is produced in ultra-violet light when an acetone solution of *s*-trinitrobenzene is shaken with a few crystals of potassium cyanide. In a mixture of methyl and ethyl alcohols (1 : 5), the fluorescence is orange-red; when this is frozen to a glass in liquid air, it exhibits a short-lived orange phosphorescence (with very dilute solutions the phosphorescence is green). We have examined other systems, not all of which show fluorescence at ordinary temperatures, but all of which emit radiations at liquid-air temperature. Our preliminary observations are recorded in the accompanying table.

| In solution in methanol/ethanol (1 : 5) | Fluorescent colour at room temperature | Phosphorescent colour at liquid-air temperature |
|---|---|---|
| Sodium nitrite/*sym*-trinitrobenzene | — | blue |
| " " /chloranil | — | blue |
| " cyanide/*o*-dinitrobenzene | green | blue-green |
| " " /*m*- " | green | pale-blue |
| " " /*p*- " | greenish-brown | green |
| " " /*sym*-trinitrotoluene | — | red (green on dilution) |
| " " /chloranil | green | blue |
| " acetate/*sym*-trinitrobenzene | orange-red | yellow-green |
| Methylamine/*sym*-trinitrobenzene | red | orange |

We believe that in these systems there is immediate complex formation, involving some donor–acceptor mechanism whereby a transition between molecular levels, originally forbidden, becomes permitted in the complex. Whether this level, distorted by the proximity of the donor molecule, corresponds to a level in the acceptor molecule or its ion, we cannot at present say.

We are grateful to Dr. E. J. Bowen for his suggestions and discussion.

*Note added in proof.* It may be mentioned that, since this letter was submitted, Reid[2] has described the emission spectra of certain hydrocarbon – aromatic nitrocompound complexes. He arrives at similar conclusions concerning the nature of the transitions involved.

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[2] Reid, *J. Chem. Phys.*, 20, 1212, 1214 (1952).

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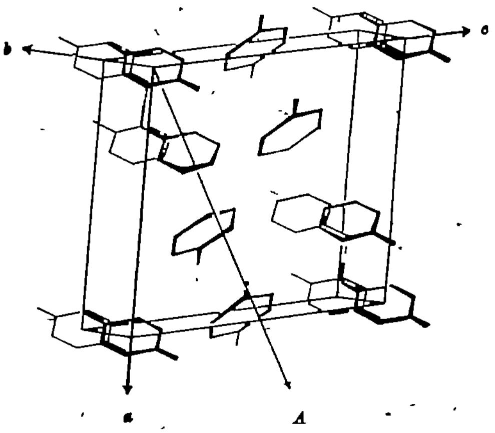
## Molecular Compounds of the Quinhydrone Type

THE nature of the molecular interaction in the formation of crystalline quinhydrones has been discussed previously by Anderson[1]. By comparison of preliminary crystallographic data for a number of quinhydrones, he came to the conclusion that the molecules are held together by the interaction of polar groups and polarizable aromatic substances, and that hydrogen-bond formation is not an essential structural feature, though it is not necessarily excluded. We have now been able to confirm these conclusions by a detailed structure determination of phenoquinone (which will be reported in full elsewhere), and by comparison with further preliminary data for quinhydrone and other molecular compounds of this type.

The arrangement of molecules in the unit cell of phenoquinone is shown in the accompanying diagram. Each quinone molecule, such as that at 000, is sandwiched between a pair of centrosymmetrically related phenol molecules, for example, those at $\frac{1}{4}$ 0 $\frac{1}{4}$ and $\frac{3}{4}$ 0 $\frac{3}{4}$. This results in the structure being built up of sets of three molecules arranged in columns parallel to the direction marked *A* in the diagram. In each set the plane of the quinone molecule is parallel to those of its two adjacent phenol molecules and is separated from them by a distance of 3·33 A. Each phenolic hydroxyl group forms a hydrogen-bond of length 2·64 A. with a quinone molecule in an adjacent column, two such hydrogen-bonds being indicated in the diagram by broken lines.



In order to compare this structure with that of quinhydrone, we must take into consideration the fact that, in the latter structure, the molecules must lie in special positions, since there are only two of each type of molecule in a cell of space-group $P2_1/c$. Further, on X-ray photographs taken with the crystal oscillating about its *a*-axis, the extremely low intensity of reflexions on layer lines of odd order indicates an almost exact repetition of the structure at intervals of $a/2$ parallel to the *a*-axis. The only choice of special positions which makes this arrangement possible necessitates the stacking of quinone and quinol molecules alternately, in continuous columns along the *a*-axis. This means that the unit cell of quinhydrone must be compared with the cell formed by the *A*-, *b*- and *c*-axes of phenoquinone as shown below.

| Quinhydrone | Phenoquinone |
|---|---|
| $a_0$ = 7·55 A. | $A_0$ = 11·62 A. |
| $b_0$ = 6·05 A. | $b_0$ = 5·97 A. |
| $c_0$ = 11·55 A. | $c_0$ = 11·48 A. |
| $\beta$ = 110° | $\beta$ = 109° |

It may be seen that there is a close similarity between the two sets of cell dimensions, except that the $a$-dimension of quinhydrone is approximately equal to two-thirds of the $A$-dimension of phenoquinone. This factor of two-thirds relating the two dimensions is to be expected in view of the change in stoichiometric composition from 1 quinone/2 phenol to 1 quinone/1 quinol. When this is taken into consideration, it follows that the arrangement and orientation of the molecules must be very similar in the two structures. It therefore appears that the essential structural feature in this type of molecular compound is the plane-to-plane stacking of alternate polarizing and polarizable molecules. Where hydrogen-bonding is possible, as in these two complexes, it must also be of importance in determining the structural arrangement, since it is to realize the full hydrogen-bonding potentialities of the molecules that the change in stoichiometric composition occurs.

In order to investigate the extent to which the principle of plane-to-plane stacking of alternate component molecules determines the structure of molecular compounds, an X-ray crystallographic survey is being made of such series of complexes as those formed by quinones and by aromatic nitro compounds. For all those so far investigated (complexes between hexamethyl-benzene and chloranil, trinitrobenzene and anthracene, trinitrobenzene and naphthalene), it has been possible to propose trial structures based on this principle. The only detailed structure determination which has so far been carried out for a molecular compound formed by trinitrobenzene, namely, with $p$-iodoaniline[2], also shows this same type of molecular arrangement.

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## Simultaneous Sulphonation and Nitration in an Aromatic Nucleus

FROM the literature[1,2], when β-naphthylamine is nitrated by either: (1) the addition of potassium nitrate to a cooled solution of β-naphthylamine in concentrated sulphuric acid; or (2) the addition of β-naphthylamine nitrate to concentrated sulphuric acid, the products are 5-nitro and 8-nitro 2-naphthylamine.

If, however, β-naphthylamine is nitrated by the addition of a mixture of nitric and sulphuric acids to a solution of the amine in sulphuric acid at − 25°, or by the addition of β-naphthylamine sulphate to a mixture of nitric and sulphuric acids, the product is a mixture of two isomeric nitro aminonaphthalene sulphonic acids in the approximate ratio of 70 : 30, the main product being 1-nitro 2-aminonaphthalene 6-sulphonic acid. (The structure of the other isomer is not yet known.)

This reaction is peculiar in four respects: (*a*) it is the first case known to us of simultaneous sulphonation and nitration in an aromatic nucleus; (*b*) the main product is the result of *ortho–para* direction; (*c*) a remarkable difference in reaction mechanism is produced by comparatively small changes in experimental technique; (*d*) this anomalous behaviour is not shown by α-naphthylamine.

Details of this work will be published elsewhere.

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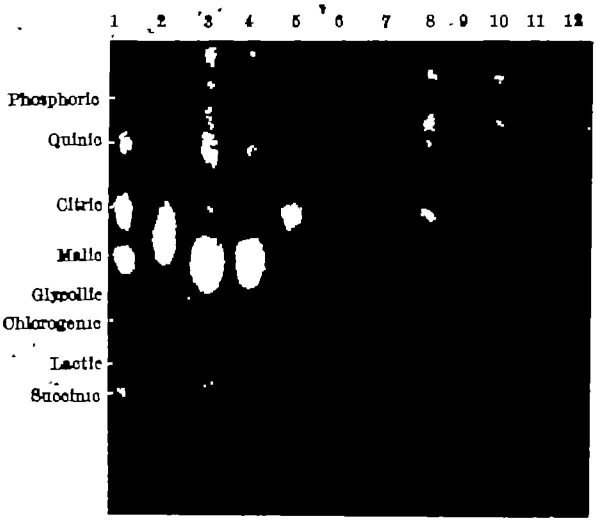
## Degradation of Sugars on Ion-Exchange Columns of 'Amberlite IRA 400 (OH′)'

IT has recently been suggested by Roseman *et al.*[1] that columns of 'Amberlite IRA 400 (OH′)' might be used for the separation of certain reducing and non-reducing carbohydrates. Our own experience with this resin suggests that very carefully controlled conditions would be necessary if reliable quantitative results are to be obtained. During an investigation of the non-volatile organic acid components of apple juice and cider, it has been found that sugars are extensively degraded by 'Amberlite IRA 400' used in the OH′ form, organic acids being the main products of degradation.

Paper chromatography was used for the separation of the acids following the technique of Lugg and Overell[2]. Interfering cations, sugars and other non-acidic materials were removed by the use of ion-exchange resins, 50-ml. samples of juice or cider being given the following treatments: (i) cation removal on 'Amberlite IR 120', (ii) anion removal on 'Amberlite IRA 400' and elution with $N$ ammonium carbonate, (iii) removal of excess ammonium carbonate by evaporation on the water-bath, and (iv) removal of remaining ammonium ions by treatment with 'Amberlite IR 120'. 10-gm. quantities of resin retained in glass tubes of 0·8 cm. diameter were used throughout with a flow-rate of 1 ml./min.

Initially, the 'IRA 400' resin was used in the OH′ form, and it was found that a number of acid spots were apparent on the chromatograms of treated samples which were not found on those of samples before treatment or after stage (i) in the above procedure (compare chromatograms 2 and 3). Malic, quinic[3], chlorogenic[4] and phosphoric acids were identified as present in the juices; ciders contained succinic acid in addition. After ion-exchange treatment, chromatograms revealed five additional spots, two being identified as due to lactic and glycollic acids. Titration of samples after stages (i) and (iv) showed that the anion-exchange treatment resulted in increases of acidity, the extent varying according to the time of contact with the resin. Increases, expressed as malic acid, ranged from 0·05 per cent (in 2 hr.) to 0·40 per cent (in 17 hr.). Solutions containing a mixture of pure acids, when subjected to the above treatments, showed no change in acidity and the chromatograms showed no additional spots.

An average cider-apple juice contains sugars in the proportions fructose 10, sucrose 2 and glucose 1·5 per cent[5]. A neutral solution of sugars of this composition was passed through a column of 'IRA 400 (OH′)', the column washed thoroughly with distilled water and



Chromatograms developed in benzyl alcohol (3 vol.), tert. butyl alcohol (1 vol.), *iso* propyl alcohol (1 vol.), water (1 vol.) and formic acid 2 per cent (see ref. 8) and run at laboratory temperature. Papers sprayed with 0·08 per cent bromo cresol green in 95 per cent aq. ethanol.

1, Standard mixture of malic, quinic, succinic, lactic and citric acids; 2, untreated cider (S.G. 1010); 3, cider-acid extract using 'IRA 400 (OH′)'; 4, cider-acid extract using 'IRA 400 ($CO_3''$)'; 5, sugar solution (fructose, glucose and sucrose) after 'IRA 400 (OH′)' treatment; 6, sugar solution (fructose, glucose and sucrose) after 'IRA 400 ($CO_3''$)' treatment; 7, untreated fructose solution; 8, fructose solution after 'IRA 400 (OH′)' treatment; 9, untreated glucose solution; 10, glucose solution after 'IRA 400 (OH′)' treatment; 11, untreated sucrose solution; 12, sucrose solution after 'IRA 400 (OH′)' treatment

left overnight (17 hr.) before elution. An increase in acidity of 0·76 per cent was recorded, and the chromatogram showed that this increase was represented by the additional acid spots previously found in treated juices (chromatogram 5).

To determine the differential effect of the treatment on these three sugars, corresponding concentrations of each sugar were submitted separately to the resin treatment, the columns being left overnight before elution. The results are summarized in the accompanying table, sugars being estimated by the method of Somogyi[6].

From the table it can be seen that (1) there is no retention of any of the three sugars by 'Amberlite IR 120', (2) all three sugars are retained by 'IRA 400 (OH′)', (3) there is considerable degradation of fructose and glucose with the production of organic acids, (4) sucrose, a non-reducing sugar, is relatively little attacked by the resin, (5) sugars which have not been degraded can be removed from the column by elution with *N* ammonium carbonate. Chromatograms 7–8, 9–10 and 11–12 show the acids produced by degradation of the sugars.

| | Weight of sugar (gm.) | | |
|---|---|---|---|
| | Fructose | Sucrose | Glucose |
| (*a*) Entering 'IRA 400 (OH′)' column (50 ml of solution) | 4·04 | 0 85 | 0·61 |
| (*b*) Present in effluent and water washings | 2·8 | 0 005 | nil |
| (*c*) Retained on 'IRA 400 (OH′)' | 1·24 | 0·845 | 0 61 |
| (*d*) Eluted by ammonium carbonate | 0·53 | 0 80 | 0·32 |
| (*e*) Present after 'IR 120' treatment (stage iv) | 0·52 | 0·80 | 0·32 |
| (*f*) Percentage of retained sugar (*c*) degraded in 17 hr. | 57·3 | 0·05 | 47·6 |
| (*g*) Acidity of final solution (50 ml.) as per cent malic | 1·055 | 0·08 | 0·60 |

By using 'Amberlite IRA 400' resin in the $CO_3''$ form, as described by Bryant and Overell[7], it is possible to obtain practically sugar-free extracts of apple juice or cider showing no increases in acidity (chromatogram 4). Very little sugar is retained by the resin and there is no degradation even after a considerable period of contact (chromatogram 6).

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## Filter-Paper Disk Chromatography

As a corollary to our comparative studies of the amino-acid metabolism of bacteria[1], it was necessary to develop a simple chromatographic technique suitable for routine use in the laboratory. Such a technique using filter-paper disks was developed and fully described[2]. Recent publications in *Nature*[3,4] and elsewhere[5] describing almost identical methods would suggest that our publication has escaped notice.

Our experience with paper disk chromatography in the past three years shows that, although the method is admirable for the separation of two or three substances, it is not a satisfactory substitute for large-scale paper chromatography in the separation of more complex mixtures such as protein hydrolysates.

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## Paper Partition Chromatography of Natural Œstrogens

The paper chromatography of steroids, for example, cortical steroids, has already been investigated by Zaffaroni *et al.*[1] and by Bush[2]. Although the separation on paper of the natural œstrogens free or in compounds has already been investigated by Bush[3], Heftmann[4], Nyc *et al.*[5] and Boscott[6], a satisfactory separation of the three natural steroids on non-treated paper has, to our knowledge, not yet been published. The method described below gives excellent results. It has been especially devised for separating and purifying the small amounts of œstrogens normally present in biological fluids.

The detection of quantities of œstrogens weighing about 1–5 μgm. on paper chromatograms is very successful after grinding a solution of 10 per cent antimony chloride in chloroform and heating it for 5 min. at 90–100° C. Spots of different colours are obtained with the three steroids: brown for œstrone, yellow for œstradiol and pink for œstriol. The limit of sensitivity is about a microgram. Examination under ultra-violet light increases the sensitivity of detection for œstradiol (0·2 μgm.) and œstriol (0·5 μgm.). This reaction is generally satisfactory. The spotting of œstrogens on paper can also be realized after treatment with Folin's, Pauly's and other diazo-reagents, and after drying and subjection to ammoniacal vapours. However, these diazo reactions are not so useful in practice.

One solvent—water—and the ascending method was first tried for the separation of the three phenolic steroids on paper. Because of their different dissociation constants, some alkaline solutions give different $R_F$ values for the three hormones. With $N/20$ sodium hydroxide, for example, the results obtained are 0·04–0·21 and 0·5 respectively for œstrone, œstradiol and œstriol. Organic bases also give good results (15 per cent pyridine). However, in the light of our experiments, we consider that the utilization of aqueous solvents for clear separations is not advisable when steroids exceed 20–30 μgm., because of the streaky movements. Furthermore, when mixed with biological extracts, œstrogens do not always show the same $R_F$ values as in pure solutions. In fact, the separation of œstrone from œstriol was the only one we could achieve, this being effected with $N/20$ sodium hydroxide or 33 per cent methanol.

A very satisfactory separation of the three natural œstrogens on paper can be obtained with the use of non-miscible liquids. Our method involved the use of glass cylinders (15 cm. in diameter and 40–50 cm. long) closed by means of two glass plates, and Whatman No. 1 filter paper. The descending method is normally employed. Saturation of the paper is first completed with $N/2$ ammonium hydroxide lying at the bottom of the cylinder. The most satisfactory mobile fluid found was the organic phase of a mixture of 1 part chloroform, 9 parts benzol and 1 part $N$ ammonium hydroxide. This mobile phase is introduced into the cylinder without desaturation of the atmosphere. A movement of 30 cm. on the paper takes 2–3 hr. at room temperature. The positions of the spots are observed after drying the paper by spraying it with a solution of antimony chloride in chloroform and heating at 90–100°. The $R_F$ values so obtained are, respectively, 0·89, 0·78 and 0·02 for œstrone, œstradiol and œstriol.

A similar separation is also obtainable with the same mobile phase, and methanol – water (1 : 2) being utilized for saturation of both the solvent and the atmosphere. The spots are, in this case, sharper, but the $R_F$ values for œstradiol and œstrone are closer.

If, after separation on paper, the œstrogens are to be estimated, it is advisable to cut the paper into transverse strips corresponding to their theoretical $R_F$ values. The elution of hormones is quantitative when utilizing the movement of a mixture of chloroform – acetone (1 : 1). The estimation may then be effected on the solutions by one of the known methods, especially fluorometry or polarography after nitration[7].

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## Colour Reactions on Paper Chromatograms by a Dipping Technique

IN a recent communication by Hulme and Arthington[1], writing of the isatin test for proline, they state that "it is surprising that this useful test has not been more widely used". This prompts a report of further advantages of this reagent and a description of a general technique which has been in use in this laboratory for some months.

In all experiments, 5 μl. of solution containing 0·01 $M$ pure amino-acid or a synthetic mixture of twenty amino-acids all in the same concentration was used. Normal and pathological urine was also tested. One- and two-dimensional chromatograms were prepared in phenol/ammonia or butanol/acetic acid on papers 10 in. square, mounted in Datta frames[2]. After thorough removal of the solvent in a cold-air draught, the papers were drawn through a 0·2 per cent solution of recrystallized isatin in acetone contained in a shallow 'Pyrex' dish. As soon as the acetone had evaporated from the paper, it was heated for 2 min. at 105° C. or for 15 min. at 65° C., when proline and hydroxyproline produced the usual blue colour. In addition, cystine and often tyrosine appear blue; aspartic and glutamic acids, initially pink, assume a blue tinge; tryptophane appears rose-red (as stated by Hulme and Arthington); and many other amino-acids, especially glycine, appear deep pink, although these pinks tend to fade. The comparison of this method with those of Hulme and Arthington and of Acher, Fromageot and Jutisz[3] is very favourable both with respect to depth and stability of colour and the number of amino-acids located.

Many substituted isatins, kindly supplied by Dr. S. J. Holt, have been tested. The N-methyl-, 6-Cl-, 7-Cl-, 5-methyl- and 5 : 7-dimethyl-isatins all give colours similar to isatin (but none of these justifies the replacement of isatin). The 6 : 7-dimethoxy, 4-Cl-, 7-COOH- and N-acetyl-isatins, 4 : 5-benzisatin and 5 : 5′-di-isatyl are negative.

The advantages of this dipping technique are that the amino-acids are insoluble in acetone and therefore do not spread, the paper dries in 1–2 min., there is no offensive smell (compare butanol or solvents containing 1 per cent collidine or pyridine) and the colours are generally deeper. The method is economical and the use of an expensive spray gun or tiresome and fragile handspray is eliminated.

Ninhydrin, as 0·2 per cent solution in acetone, is at least as satisfactory when applied by dipping as by the conventional spray technique. The colours develop after 1–2 min. at 105° C. or in 2–4 hr. in the cold. After this method had been in use for some time, it was noted that Toennies[4] had recommended the same method.

Dipping in Ehrlich's reagent, *p*-dimethylaminobenzaldehyde, prepared fresh as a 1 per cent solution in a mixture of nine volumes of acetone to one volume of concentrated hydrochloric acid, gives the usual purple tryptophane colour within two minutes in the cold, deepening on standing. This compares favourably with the method of Dalgliesh[5], which takes two hours for tryptophane to appear. In general, the method is quicker for many of the amino-acids and amines listed by Dalgliesh.

Although this technique was developed for my own work on amino-acids, it is particularly valuable for student use, especially where speed in development (as for tryptophane) is a great advantage.

The technique has only been applied to amino-acids; but I believe that it would be equally valuable for many other classes of compound which are insoluble in acetone, ether or other volatile solvents. In addition, the method should be of value for spot-test reactions on paper, as these are often more sensitive than those carried out in the test-tube.

I wish to thank Dr. J. B. Jepson for his help and encouragement.

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## Elastin and Elastase

In previous publications[1,2], we reported that extracts of animal pancreas made with fluids of different *p*H exhibit varying elastolytic activity (e.u./gm.) on account of the presence of elastase inhibitor, which in the pancreas is bound to elastase[3]. In crude neutral solution, the activation of elastase may be carried out by acidification, dialysis or precipitation with ammonium sulphate[1,3]. In all these procedures the elastase is being liberated from elastase-inhibitor. It has been pointed out by us that two types of elastase-inhibitor exist, namely, one in the pancreas and another in the blood serum[4]. Whereas that from the pancreas dialyses in 24–32 hr. and can be demonstrated in the dialysate, that from the serum cannot be dialysed.

We determined the elastase content of the pancreas of healthy young men who had died suddenly in consequence of accidents and compared the value obtained with the elastolytic activity found in the pancreas of men who had died of various diseases or had had arteriosclerosis[4]. Extracts were prepared from each human pancreas using the following methods: (1) fresh pancreas extracted with a double volume of *N*/10 acetate buffer of *p*H 4·7; (2) same as (1), with subsequent dialysation for 24 hr.; (3) extract of degreased pancreas powder prepared as (1) but with a five-fold volume of buffer; (4) same as (3), with subsequent dialysation for 24 hr.

We found that the pancreas of young healthy individuals (group 1, 10 cases) contained 208 ± 56 e.u./gm. The pancreas of those who had died of various diseases without arteriosclerosis (group 2, 14 cases) contained 155 ± 49 e.u./gm., whereas the pancreas of men who had had arteriosclerosis (group 3, 36 cases) yielded 9 ± 6·5 e.u./gm. Comparing the values of either group 1 or group 2 with group 3, the differences are significant. In 54 per cent of the cases of group 3, elastase could not be detected in the pancreas at all. Hall, Reed and Tunbridge[5] were not able to obtain elastase from human pancreas. This can be explained only by supposing that they disregarded the elastase inhibitor of the pancreas, the presence of which makes it impossible to demonstrate elastase without activation in sodium chloride or water extracts. Another possibility would be that they examined only human pancreas which contained no elastase. In the pancreas of men above the age of forty elastase is often lacking. Contrary to the finding of Hall, Reed and Tunbridge, however, we find that the pancreas of healthy men contains elastase, as has already been reported in our first publication[6].

Banga and Schuler[7] found that, following the action of elastase upon elastin, carbohydrate is liberated. This is in accordance with the finding of Hall, Reed and Tunbridge. The only difference is in the quantity of carbohydrate found. According to our results, as a consequence of elastolysis 10–12 per cent of carbohydrate is liberated from the elastin of Stein and Miller as well as from the elastins of both Gross and Banga. Hall, Reed and Tunbridge obtained from the aorta 2 per cent polysaccharide only. By the orcin method of Rimington[8] only a small part of the carbohydrate can be estimated, whereas the whole quantity can be determined by titration with hypoiodide or by the method of Hagedorn–Jensen. The elastin dissolved with elastase reduces ferric to ferrous iron in the cold and decolorizes dichlorophenolindophenol when heated. Molisch and Seliwanoff tests are negative. The carbohydrate liberated during dissolution of elastin resembles, in its reducing properties, glucosamine, since it cannot be estimated by the orcin method of Rimington and it does not give either the Molisch or Seliwanoff tests.

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## Effect of Acetoacetate on Glycogen Synthesis and Glucose Utilization in the Isolated Rat Diaphragm

The effect of ketone bodies on carbohydrate metabolism is still obscure, and several theories have been proposed to explain their action[1-3]. Nagler[4] incubated surviving rat diaphragm in phosphate buffer medium containing glucose (200 mgm. per cent), glucose and insulin (0·05 unit per 1·0 ml.), glucose, insulin and acetoacetate (50 mgm. per cent). No effect of acetoacetate on glycogen synthesis was observed. Parnes and Wertheimer[5] reported that acetoacetate depressed glycogen synthesis in the rat diaphragm, thus differing from other metabolites.

In the present experiments, we have extended the studies of Nagler and of Parnes and Wertheimer. Diaphragms of rats fasted for one day were incubated in phosphate buffer solution containing 50–100 mgm. per cent glucose. The addition of 100 mgm. per cent acetoacetate to the medium decreased glycogen synthesis and increased glucose utilization. These effects were highly significant when the medium contained 50 mgm. per cent glucose, and also significant in the presence of 100 mgm. per cent. Other products such as acetate, pyruvate and acetone were without effect.

The specific action of acetoacetate was influenced by the proportions of glucose to acetoacetate as shown in Table 1. An increase of the glucose concentration prevented the acetoacetate effect.

Table 1. EFFECT OF VARYING GLUCOSE CONCENTRATIONS IN THE PRESENCE OF ACETOACETATE ON GLYCOGEN SYNTHESIS AND GLUCOSE UTILIZATION

Diaphragms were incubated at 37° C. for 2½ hr. Glycogen synthesis and glucose utilization expressed as mgm. glucose per 100 mgm. wet tissue

| No. of experiments | Medium containing | | Glycogen synthesis (mgm./100 mgm.) | Glucose utilization (mgm./100 mgm.) |
|---|---|---|---|---|
| | glucose (mgm. per cent) | aceto-acetate (mgm. per cent) | | |
| 7 | 50 | — | 0·098±0·020 | 0·30±0·03 |
| 7 | 50 | 100 | −0·007±0·008 | 0·44±0·04 |
| 12 | 100 | — | 0·143±0·014 | 0·48±0·05 |
| 12 | 100 | 100 | 0·042±0·007 | 0·63±0·07 |
| 5 | 200 | — | 0·184±0·030 | 0·75±0·03 |
| 5 | 200 | 100 | 0·172±0·014 | 0·78±0·04 |

The results shown in Table 1 explain the results obtained by Nagler[4].

Addition of insulin to a medium containing glucose increased the glycogen synthesis and glucose utilization by the rat diaphragm, as was first described by Gemmill[6]. Addition of insulin to a medium containing glucose and acetoacetate caused a smaller increase, as illustrated in Table 2.

Table 2. EFFECT OF ACETOACETATE IN GLUCOSE AND GLUCOSE + INSULIN MEDIA

Diaphragms incubated at 37° C. for 2½ hr. Glucose concentration, 100 mgm. per cent; acetoacetate concentration, 100 mgm. per cent; insulin, 0·1 unit per 1·0 ml. Glycogen synthesis and glucose utilization expressed as mgm. glucose per 100 mgm. wet tissue

| No. of experiments | Samples incubated | Difference in | |
|---|---|---|---|
| | | Glycogen synthesis (mgm./100 mgm.) | Glucose utilization (mgm./100 mgm.) |
| 7 | Glucose with and without insulin | +0·123±0·018 | +0·51±0·010 |
| 9 | Glucose and aceto-acetate with and without insulin | +0·078±0·018 | +0·41±0·006 |

Results similar to those shown in Table 1 were observed in diaphragms of mildly diabetic rats (blood-sugar level, 100–300 mgm. per cent); but acetoacetate had no effect on the diaphragms of severely diabetic rats (blood-glucose level, 400 mgm. per cent or higher, acetonuria), of rats in diabetic coma, and of rats fasted for five to seven days. The latter group of fasted rats lost 35–40 per cent of their initial weight and were in poor condition.

A single intraperitoneal injection of 100 mgm. acetoacetate per 100 gm. body-weight was given to normal rats. Acetate or saline was administered to controls. 1–3 hr. after injection of these compounds, the animals were bled and their diaphragms incubated in a phosphate buffer medium containing 100 mgm. per cent glucose.

The injected acetoacetate depressed glycogen synthesis in the incubated diaphragms. Acetate and saline were without effect. Acetoacetate[3] as well as acetate caused hypoglycæmia and increased alkalosis. Acetoacetate increased acetone bodies in the blood to 10 mgm. per cent (controls, 4·5 mgm. per cent) 2 hr. after injection. These *in vivo* results were thus similar to those obtained *in vitro* by addition of acetoacetate to the incubating medium. They were due solely to the injection of acetoacetate, and did not appear after acetate or saline administration.

It is concluded that acetoacetate has both an *in vitro* and an *in vivo* influence on carbohydrate metabolism in muscle. The depression of glycogen synthesis by acetoacetate is demonstrable also in the presence of insulin.

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## Effect of L-Glutamic Acid Analogues on the Enzymatic Formation of Hydroxamic Acid

AQUEOUS extracts of acetone-dried sheep brain form hydroxamic acid from L-glutamic acid and hydroxylamine in the presence of adenosine triphosphate[1]. It was found that this reaction is inhibited by DL-N-(γ-glutamyl)-ethanolamine. Molar ratios of DL-N-(γ-glutamyl)-ethanolamine to L-glutamic acid varying from 2 : 1 to 10 : 1 gave inhibitions of 10–50 per cent. On the other hand, DL-α-methylglutamic acid not only did not inhibit the reaction between L-glutamic acid and hydroxylamine, but could be substituted for glutamic acid in this reaction, apparently with the formation of α-methylglutamohydroxamic acid.

The sheep brain transferase system[2] which forms glutamohydroxamic acid from hydroxylamine and L-glutamine is not affected by DL-N-(γ-glutamyl)-ethanolamine but is inhibited by DL-α-methylglutamic acid as well as by D-glutamic acid. Molar ratios of DL-α-methylglutamic acid to L-glutamine varying from 2 : 1 to 20 : 1 gave inhibitions of 25–70 per cent; whereas molar ratios of D-glutamic acid to L-glutamine varying from 1·25 : 1 to 5 : 1 gave inhibitions of 25–45 per cent.

Both the synthesizing and the transferring reaction were measured by estimation of the hydroxamic acid formed. The synthesizing reaction was also measured by estimating the inorganic phosphate liberated from adenosine triphosphate.

When in the synthesizing reaction between DL-α-methylglutamic acid and hydroxylamine the latter was replaced by ammonia, free phosphate was also liberated from adenosine triphosphate. Evidence indicating the formation of α-methylglutamine was obtained by use of paper chromatography.

An inhibition of the synthesis of glutamohydroxamic acid from glutamic acid and hydroxylamine by DL-N-(γ-glutamyl)-ethanolamine was also obtained with dialysed extracts of acetone-dried pigeon livers prepared according to Speck[3]. These extracts also formed a hydroxamic acid from hydroxylamine and DL-α-methylglutamic acid.

An inhibition of both the synthesizing system and the transferase system by methionine sulphoximine has recently been described by Pace and McDermott[4].

This investigation was supported in part by a grant from the Rockefeller Foundation.

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## Non-Effect of Hyaluronidase on the Spread of Œstrone

Since it is known that hyaluronidase increases the spread of certain substances in the skin of mammals by increasing the permeability of the dermis[1], it appeared possible that this enzyme might affect the spread of œstrone where this can be shown to be localized in the dermis.

The administration of œstrone to Brown Leghorn capons changes the colour of developing feathers from black to rust. If a small amount of œstrone in 60 per cent alcohol is injected intradermally, such an effect may continue for some days and is mainly produced in the vicinity of the injection[2], although feathers developing in other parts of the body may also react. It may be supposed, therefore, that while some of the hormone is carried away, some remains available near the site of the injection and is responsible for a localized reaction.

It is possible that such results are explained by the fact that the œstrone was injected in alcohol, since it is now known that, although alcohol penetrates the dermal barrier freely at first, the area of spread is afterwards limited by skin coagulation which follows[3]. Nevertheless, it was thought worth while to see if this partial localization of the effect of injected œstrone was affected by hyaluronidase.

Intradermal injections of œstrone with and without hyaluronidase were made in plucked patches where feathers were regenerating on the breasts of Brown Leghorn capons. These injections also contained hæmoglobin prepared from fresh sheep's blood, since the degree of spread of hæmoglobin is an accepted method of assay of hyaluronidase. Since œstrone is only very sparingly soluble in water and hæmoglobin coagulates in strong alcohol, it was found convenient to use a mixture of hæmoglobin and œstrone in 40 per cent alcohol. Doses of 0·1 ml. were given, and the concentrations were so arranged that each dose contained 0·05 mgm. of œstrone, or, in a few cases, half this. Similar mixtures, in similar doses, were used in the experimental series, but with the addition of hyaluronidase equal to the œstrone in weight. In each experiment each capon received two injections at intervals of a week. After three months, the feathers were plucked and filed.

When hyaluronidase was included in the injection, its presence was shown by an immediately increased rate of spread of hæmoglobin. The area of subsequent spread of hæmoglobin was recorded on plots of the feather patches approximately six hours after the injection. Fifty-four injections were made, half of which contained hyaluronidase: of these, seventeen gave an increased spread in six hours; in seven cases this spread was not markedly increased, and in three it was reduced as compared with the controls.

On the other hand, the inclusion of the enzyme was not associated with any significant change in the following measurements made on the plucked feathers: (1) the area of the largest rust-coloured mark on any feather in the patch; (2) the length of the longest rachis mark; (3) the average area of mark per affected feather; (4) the average length of rachis mark per affected feather; (5) the total affected area of feather; (6) the percentage of surviving feathers affected. These results were obtained from experiments on six birds, in which it was possible to make fifteen strict comparisons between marks caused by œstrone with and without hyaluronidase.

These results seem to indicate that, although the rate of spread of the hæmoglobin is affected, the spread of œstrone is not affected by hyaluronidase. It is, however, possible that the interstitial pressure did not remain sufficiently high for the hyaluronidase to affect the ultimate spread of the injection. It has been shown that, in an intradermal injection, hyaluronidase only acts if there is local increase of interstitial pressure produced by the injection. As the injected fluid spreads, the bleb pressure diminishes until it is equal to the normal interstitial pressure of the skin. At this point excess hyaluronidase no longer affects spreading[4]. In our experiments we found that the rate of spread of hæmoglobin was initially increased, but we do not know whether the ultimate area of spread was affected, as the indicator became too indistinct to be measured.

In further work to test whether hyaluronidase affected a non-local reaction, spayed female mice were implanted with a crystal of œstrone in the neck and half of them received in addition dry hyaluronidase. The hyaluronidase is probably rapidly dissolved in the body fluids. By this means any complications which might have arisen from the use of any solvent or vehicle were eliminated[5], although the possible different states of the crystals used may be a ground for criticism of this method. The results seemed to indicate that the enzyme did not affect the rate of uptake of œstrone by the animal as measured by the time of onset or by the rate of thickening of the vaginal epithelium. In another series, hyaluronidase dissolved in water was repeatedly injected subcutaneously following implantation of œstrone crystals as above. Once more, no significant effect of the enzyme could be found.

Although this work is not regarded as complete or conclusive, it appears that in the mouse the uptake of œstrone is controlled by some mechanism less easily disturbed by hyaluronidase than is, for example, the mechanism which controls the uptake of such substances as are used medically in hypodermoclysis[6].

This work was done during the tenure by one of us (M. E. B.) of a research award of University College, Hull.

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## Seasonal Fluctuations in the Degree of Hatching from Cysts of the Potato Root Eelworm

THE rate of hatching of larvæ from cysts of the potato root eelworm *H. rostochiensis* Woll. during *in vitro* hatching tests has been found by many workers to show seasonal fluctuations, a high level of larval emergence during the summer months declining to a negligible hatch during the winter.

After a series of experiments to measure this fluctuation quantitatively, Lownsbery concludes[1] that the phenomenon is inherent in the physiology of the worm and is not correlated with any seasonal difference in the leachings used. He agrees with Reinmuth[2] that exposure to winter conditions is not necessary for the induction of the dormant period. His attempts to break the dormancy by temperature and humidity control were unsuccessful. The phenomenon of winter dormancy was also demonstrated by Triffitt[3].

We have been conducting *in vitro* hatching tests for a number of years, and now wish to record that for the past three years we have not found any apparent diminution in the 'hatchability' of the cysts during the winter months. Cysts floated from soil collected during the spring and summer months are rolled from the debris and stored in small bottles or large tubes in a dark cupboard at room temperature. The corks are notched at one side to allow free air circulation. No attempt is made to maintain a uniform temperature; the normal fluctuations in room temperature appear to have no harmful effect provided the temperature does not fall below about 15° C. The root diffusate used in all the hatching tests is collected during the summer, pooled, mixed and then stored at about 3°–4° C. When setting up a hatching test, the cysts are weighed into batches on a micro-balance[4] and soaked in tap water for about fourteen days. Afterwards, the water is removed and root diffusate added, when normal hatching occurs.

Our experience indicates that *Heterodera* cysts are not essentially subject to a winter dormancy. The low hatches during the winter months encountered by other workers probably result from the influence of external environment, possibly soil conditions at the time of cyst extraction. This view is supported by the fact that cysts washed from soil taken from fields in late autumn or winter show an apparent dormancy, whereas cysts recovered from the above soil during the summer and stored under the same conditions do not. The apparent dormancy encountered cannot be of so fundamental a nature as suggested by Lownsbery[1], since cysts recovered from soil and stored under the conditions described above are capable of hatching at the normal rate throughout the winter months.

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## Experimental Induction of Male Cones in *Pinus sylvestris*

IT is well known that seedling trees of *Pinus sylvestris*, in common with those of many other woody species, pass through a juvenile period, during which no reproductive organs are formed. The first female cones appear at the age of about seven years, while male cones are not usually formed until several years later. These male cones generally appear first on the lower, older branches.

In 1950, I observed that certain trees of about twelve years of age growing in plantation at Oxshott Common, Surrey, bore numerous female cones; but none of the trees showed branches which had passed to the male condition. Closer inspection revealed a few isolated male shoots, however, and in every case these were borne on vegetative shoots of which the terminal bud had failed to develop in the previous season, due to attack by an insect (the identity of which has not yet been determined). As a result of this destruction of the terminal bud, the uppermost 'dwarf shoots' (bearing paired needles) had been stimulated to produce a resting bud, and it was in such buds that male cones had developed. I have since observed similar examples on several occasions in various localities.

In order to test whether experimental removal of the terminal buds would have the same effect, a considerable number of shoots on the lower branches of ten of the trees in question were disbudded by hand in January 1951. One or two of the uppermost dwarf shoots on each treated shoot developed resting buds during the summer of 1951, and these unfolded in the spring of 1952. Inspection in May 1952 revealed that 242 out of a total 472 treated shoots (that is, 53 per cent) had developed male shoots, and these were the only ones present on the trees in question (apart from a few isolated male cones again found to be associated with insect-destruction of the normal terminal bud). In some branches, 100 per cent of the treated shoots had produced male shoots.

Thus, experimental disbudding may be used for hastening the production of male cones in young trees of *P. sylvestris* and might prove a valuable addition to the other techniques, such as bark ringing and strangulation, already used in forest tree breeding.

The results of the present experiments correspond in certain respects with the experimental induction of lateral flower buds in the Haden mango by removal of the terminal bud[1].

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# FORTHCOMING EVENTS

### Monday, January 5

British Institution of Radio Engineers, London Section (at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 6.30 p.m.—Dr. G. A. Veszi : "The Modern Single Layer Selenium Photocell".

### Tuesday, January 6

Institution of Electrical Engineers, joint meeting of the Measurements and Radio Sections (at Savoy Place, Victoria Embankment, London, W.C.2), at 5.30 p.m.—Mr. D. McMullan : "An Improved Scanning Electron Microscope for Opaque Specimens".

### Wednesday, January 7

Physical Society, Colour Group (at the Imperial College of Science and Technology, Imperial Institute Road, London, S.W.7), at 3.30 p.m.—Scientific Papers.

### Thursday, January 8

Institution of Electrical Engineers (at Savoy Place, Victoria Embankment, London, W.C.2), at 4 30 p.m.—Sir John Cockcroft, F.R.S. : "Nuclear Reactors and Applications", at 6 p.m —Symposium on "Nuclear Reactor Instrumentation".

Linnean Society of London (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Mr. A. H. Haarer : "The Behaviour of the Chief Jute-Substitute Plants".

### Friday, January 9

British Phycological Society (in the Hatton Lecture Theatre, Queen Mary College, Mile End Road, London, E.1), at 10.30 a.m.—Symposium on "Marine Algal Ecology" ; Accounts of Recent Shore Surveys of (i) Fair Isle (Speakers · Dr. E. Conway, Dr. E. M. Burrows, Dr. S. M. Lodge and Mr. H. T. Powell), (ii) Anglesey (Speaker . Dr. J. R. Lewis) ; at 4 p.m.—First Annual General Meeting.

Royal Astronomical Society (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Scientific Papers.

Institute of Economic Engineering (at Cowdray Hall, Henrietta Place, Cavendish Square, London, W.1), at 7 p.m.—Mr. R. M. Currie . "Work Study as a Means of Improving Industrial Efficiency".

Society of Chemical Industry, Fine Chemicals Group (at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 7 p.m.—Prof. E. R. H. Jones, F.R.S. : "New Routes to Cortisone".

### Saturday, January 10

British Psychological Society (in the Sharpe Theatre, Department of Psychology, University College, Gower Street, London, W.C.1), at 2.30 p m.—Dr. Leonard C. T. Jones . "Frustration and Unreasonable Behaviour" ; Miss S. K. Madan : "An Interviewing Technique involving Projection from the Tactile Kinaesthetic Modalities".

# APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned .

Assistant (Grade B) in Chemistry (with good honours degree) at the Brighton Technical College—The Education Officer, 54 Old Steine, Brighton 1 (January 10).

Nutrition Officer (with an honours degree in biochemistry or physiology) to take part in work that will include the determination of the biological value of proteins, the study of calcium and phosphorus metabolism using radioactive tracers, vitamin D assays, and general nutritional experiments with rats—The Secretary, National Institute for Research in Dairying, Shinfield, Reading, quoting Ref. 52/14 (January 10).

Demonstrator in Chemical Pathology—The Registrar, The University, Leeds 2 (January 12).

Engineering and Physics Graduates to join a group working on non-linear servomechanisms and controls—The Secretary, Engineering Laboratory, Trumpington Street, Cambridge (January 15).

Principal—The Secretary, West of Scotland Agricultural College, 6 Blythswood Square, Glasgow, C.2 (January 16).

Biochemist at the Institute of Medical and Veterinary Science, Adelaide, to be responsible for all the routine work of the biochemistry division of the Institute, and also to have charge of the clinical biochemistry department of the Royal Adelaide Hospital—The Agent-General for South Australia, South Australia House, Marble Arch, London, W.1 (January 17)

Principal Scientific Officers and Senior Scientific Officers for research and development work associated with the testing and performance of guided missiles, Senior Experimental Officers and Experimental Officers (Grade 3) to be responsible for the detailed inspection of the work of sections engaged in the experimental or engineering aspects of guided weapons research and development, at the Long Range Weapons Establishment, Salisbury, Australia—The Senior Representative, Department of Supply, Canberra House, 87 Jermyn Street, London, S.W.1 (January 17).

Lecturer or Assistant Lecturer in Economic Statistics—The Registrar, The University, Manchester 13 (January 20).

Scientist, Grade I (physical chemist or chemical engineer, with not less than a second-class honours degree) to supervise the design and operation of pilot plants—The National Coal Board, Central Research Establishment, Stoke Orchard, Cheltenham, endorsed TT/577 (January 26).

Readership in Human Physiology at St. Mary's Hospital Medical School—The Academic Registrar, University of London, Senate House, London, W.C.1 (February 9).

I.C.I Research Fellowships in Physics, Chemistry, Engineering, Metallurgy, Pharmacology, or any related subject—The Registrar, The University, Liverpool (March 1).

Beit Memorial Fellowships for Medical Research—The Secretary, Beit Memorial Fellowships for Medical Research, Lister Institute, Chelsea Bridge Road, London, S W.1 (April 14).

Agricultural Officer (with a degree in agriculture, and, preferably, training in pasture management and soil conservation), Bechuanaland Protectorate—The Director of Recruitment (Colonial Service), Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting CDE.63/76/01.

Demonstrator in Botany—The Registrar, The University, Nottingham.

Deputy Head of the Department of Aircraft Propulsion—The Registrar, College of Aeronautics, Cranfield, Bletchley, Bucks.

Electrical Engineer or Physicist at the Royal Aircraft Establishment, Farnborough, to undertake experimental work on design of fuses for bombs and guided weapons—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting D.474/52A.

Engineer in the Ministry of Supply, London, for locating, assessing and developing capacity for pilot manufacture of electronic assemblies and components—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting D.500/52A.

Research Physicist—The Director, M.R.C. Radiobiological Research Unit, Atomic Energy Research Establishment, Harwell, Didcot, Berks.

Scientific Officer, Grade I (a good degree in science, engineering or mathematics is essential) in the Engineering Laboratory at Derby—The Director of Research, Railway Executive, 222 Marylebone Road, London, N.W.1.

Senior Scientific Officer or Scientific Officer (with first- or second-class honours degree in inorganic or physical chemistry) at the Water Pollution Research Laboratory, Watford, for research on the rates, under different conditions, of reactions occurring in the polluted Thames estuary including reduction of sulphate and oxidation of sulphide—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London S.W.1, quoting F.697/52A.

# REPORTS and other PUBLICATIONS

(*not included in the monthly Books Supplement*)

### Great Britain and Ireland

Department of Scientific and Industrial Research. Report of the Forest Products Research Board with the Report of the Director of Forest Products Research for the Year 1951. Pp. vi+66+8 plates. (London H.M. Stationery Office, 1952.) 3s. net. [1111

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# SOCIAL ADJUSTMENT IN THE MODERN STATE

IN his presidential address to the British Association at Blackpool in 1936, Lord Stamp urged that society should seek consciously to regulate the rate of change resulting from technological development to an optimum point in the net balance between gain and damage to society as a whole. Lord Stamp firmly believed in the possibility of a science of social adjustment, once we had accepted Whitehead's dictum that we are living in the first period of human history for which we can no longer assume that each generation will live substantially amid the conditions governing the lives of its fathers, and transmit those conditions to the succeeding generation. Moreover, in this address, as in his later book, "The Science of Social Adjustment", Lord Stamp fixed his gaze particularly on the human aspects of the problem of adjustment and the need for ordered knowledge and principles in such varied fields as production, industrial health and ethics.

That plea has found strong support since in the writings of Elton Mayo and Chester I. Barnard and others, and it is recalled by a book which has recently come from the British Institute of Management*. The three studies, by J. F. Scott and R. P. Lynton, of the Institute's Field Research Group, in this book, of a colliery, a village factory and a large hosiery factory, and the research method which they outline and discuss in an appendix, seem to express exactly the approach for which Lord Stamp pleaded. The book is both a tribute to the value and potentialities of the British Management Institute and a valuable contribution to the technique and philosophy of social adjustment on which it is becoming clear the future of the social security State largely depends. The critical account of research method is possibly the section of most direct interest to the man of science, and this alone should contribute to a sound appreciation of both the limitations and the value of social science, not merely in management but also in social problems and human relations generally.

The wide appeal and relevance of these three studies is most apparent, however, in the second part of the book, in which a comparative interpretation of the three studies is attempted and tentative generalizations are made on the broad issues of organization, communication, control, and especially on the process and means of continued adaptation. The bearing of the observations recorded, not merely on industrial relations, but also over a far wider field, is unmistakable; and perhaps the outstanding feature is not so much the complexity of the relations studied as the evidence provided that people are not unnaturally resistant to co-operation, change or adaptation once full account is taken of their interrelationship and the full situation. In contrast to the depressing picture of ossification revealed by such studies as that of Dr. Goldstein and some by the Acton Society Trust, we are given a picture of adaptability and of willingness to work and to co-operate which holds real promise for the economic future of Britain.

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* Three Studies in Management. By Jerome F. Scott and R. P. Lynton. Pp. x+220. (London: Routledge and Kegan Paul, Ltd., 1952.) 18s. net.

As has been said many times already, by Elton Mayo and others, industry, and especially industrial change, must be considered in the context of the society in which it exists. The complex, but informal, relations between those working together in an industry and the surrounding community constitute a social structure which cannot be disregarded in technical development and change. Should this structure be ignored, the industrial community loses its stability and sense of security. Social sickness develops, finding expression in absenteeism, inefficiency, and resistance to further change; and such social sickness must be cured before the industry can become strong and efficient, or the community secure and confident.

Evidence has already been provided by the Acton Society Trust of the difficulties caused by the careless disturbance of the old social structure by nationalization. The study described here of the pattern at a Scottish colliery shows how profound has been the disturbance of the miners' own ways of living and working together, and the social disintegration that nationalization and technical advance can cause, however unwittingly. What was once a highly flexible organization is steadily becoming more rigid, and the problem of adaptation becomes still more acute.

Even here, some attempt has been made to reconcile new methods with the old ways, and the encouragement of team-working at Bolsover is cited as example. The difficulty goes far deeper than the question of effective communications, joint consultation or of training and promotion, although the observations recorded by Mr. Scott and Mr. Lynton largely support the findings of the Acton Society Trust on these points. No formal alternatives exist to the re-establishment of good informal relationships, and the first concern of those involved in questions of productivity and efficiency in the nationalized industries—with all that those factors mean in Britain's economic future—should be to secure the conditions in which such relations can be fostered and developed spontaneously and undisturbed by political controversy.

In regard to the mining industry in Britain, the study points rather to the negative effect of the disruption of informal relations. In the other two studies—of the introduction of a new factory for finishing hosiery in a northern mining town without previous experience of industrial employment for women, and of the adaptation to post-war changes of the firmly established social structure in a large hosiery factory—positive evidence is given of the value of careful attention to that social structure. On one hand, it proved possible both to integrate the factory with the mining community and to carry the existing social structure into the factory; and on the other, to make the necessary changes without disrupting the accepted structure.

Too much stress clearly should not be laid on these two examples. The interest of the studies lies rather in the demonstration of what is possible by the use of appropriate methods. Experience doubtless will lead to the development of improved methods in time, if only as Mr. Scott and Mr. Lynton here urge, like J. T. MacCurdy ten years earlier, we take informal organizations seriously. Even specialization, they point out, is not necessarily a source of difficulty, provided it is kept in balance, and spontaneous processes are helped to adapt themselves to changing requirements. What is required above all is not so much that there should be no disturbance of balance as that a new balance should be achieved wherever the old is destroyed or disturbed. The question of size or functional specialization has to be considered and decided not on purely theoretical grounds, but on the practical issue of the effect on the balance between a works and its environment.

The first consideration is that a community should be a well-balanced, coherent social unit in which people work as well as play and live; this consideration is too frequently ignored, even though few factories can be so closely bound up with the surrounding society as a mine. None the less, they are all social institutions as well as industrial units, and Mr. Scott and Mr. Lynton are fully aware of the bearing of this consideration on town planning and the location or dispersal of industry. The response described in these two studies to efforts made to understand and foster existing relations in the community, to explain the reasons for change and to avoid adverse effects on status, shows that co-operation can be secured and change accepted without opposition.

On such evidence it is worth while taking time and making the effort to release the forces that make for co-operation, keenness to work, and adaptability. Nor is it simply a matter of education and improved means of communication, so that those affected can both understand the reason for a decision and feel that they participate in it: it involves searching demands on management to ensure that the implications and ramifications are worked out and assessed as the change proceeds, and that attention is paid to the social costs as well as to the material or economic costs. Above all, there must be consideration for the balance of security in his relations with others which a man requires if he is to remain adaptable and to accept change.

The emphasis placed on this last factor is the more important because in these studies no countenance is given to the illusion that security itself is an objective. The argument here is for security in the process of change; a disposition favourable to change arises from confidence that the change is necessary, and that the change and the methods by which it is carried out are really beneficial. The real task of management is to help the organization as a whole to perceive the need for adaptation and to adapt itself accordingly. The value of those studies, it may be reiterated, lies especially in the demonstration, not merely to industry, but also to the politician and government administrator, that, however drastically circumstances may change, there are still ways by which an organization may adapt itself rapidly in a civilized and efficient manner. The task of government, as well as of management, is to discover these ways and foster their use.

The optimism which these three studies encourage is supported by the trend of the discussion on the manager and the worker which took place at the Present Question Conference on Freedom and Responsibility. Both the Earl of Verulam, speaking on the manager, and Mr. A. E. Carthy, of the International Department of the Trades Union Congress, speaking on the worker, recognized that industry must take its part in the life of the community, and that industry must be built up in close and happy and fruitful relation with the outside world. Lord Verulam stressed first the responsibility of the manager for making his organization human, and for fostering the right atmosphere as well as the opportunity for achievement and for service to the community. Mr. Carthy no less clearly insisted on the social responsibilities of industry, and on the need for trades unions themselves to accept those responsibilities and to seek to train their members in social responsibility. Those who address themselves to the immense task of the education required to remove misunderstandings and old prejudices, or to the discovery, in any particular social or industrial context, of the vital informal pattern of human relations and to base their policy and actions thereon, need not despair of response. Nor need the trades unions themselves fear to take up the heavy task of modifying and adapting the archaic fossilized structure so powerfully indicted in recent books by Dr. J. Goldstein and by Mr. Alan Flanders, to enable the unions to meet the needs of an industrial or technical age.

## SOME FUTURE PROBLEMS IN AVIATION MEDICINE

**Physics and Medicine of the Upper Atmosphere**
A Study of the Aeropause. Editors: Dr. Clayton S. White and Brig.-General Otis O. Benson, Jr. The Proceedings of a Symposium on the Physics and Medicine of the Upper Atmosphere held at San Antonio, Texas, November 6, 7, 8, 9, 1951, sponsored by the Air University School of Aviation Medicine, Randolph Field, Texas; arranged by the Lovelace Foundation for Medical Education and Research, Albuquerque. Pp. xxiv+611+46 plates. (Albuquerque: University of New Mexico Press, 1952.) 10 dollars.

THE recognition of aviation medicine as a subject for special study and research dates from the First World War, when much attention was given to methods of selection of men suitable for flying duties. But the literature contains much of earlier origin: for example, observations on the physiological effects of atmospheric pressure change during balloon flights, sea-diving and mountaineering; and even Robert Boyle's account, published in 1670, of his experiments on animals under reduced pressure.

Although a great deal of work must always be devoted to methods of personnel selection, the bias has been tending to shift for some time. Modern aircraft impose conditions well beyond the extremes which even the fittest occupants can withstand; considerable research is necessary to reduce the full impact of these conditions; and the scope of this research advances step by step with aircraft performance. The book under review is based upon a symposium gathered to survey a wider field of knowledge than is ordinarily regarded at present as forming the territory of aviation medicine. Its aim was "the collection of available open data to provide much of the information essential to planning future research necessary for manned flight towards the top of the atmosphere". The result has been to bring more clearly into focus some of the problems which will arise when attempting to ensure health and safety, not only in the aircraft of the future, but also in man-carrying rockets and artificial satellites, and even in attempts at interplanetary travel. When some of these developments will take place is still uncertain, but something of their inevitability is conveyed by one contributor, H. Strughold, who, in a passage which appeals to the imagination, states: "The conquest of the outskirts of the atmosphere, and eventually space, is a revolutionary event comparable only to the transition of the aquatic animals to the land in geological times. . . . We are in the amphibian stage now".

There are articles contributed by thirty-four scientific workers, specialists in the topics discussed. It is not possible to reproduce the list of titles in full, but the subject-matter includes: the physics and chemistry of the upper atmosphere; the radiations occurring therein, including X- and ultra-violet radiations of solar origin and cosmic rays; the biological effects of these radiations; dangers from meteorites; temperature extremes encountered in high-altitude and high-speed flight, and protection therefrom; the effects of acceleration, and of 'weightlessness'; preservation of health during prolonged occupation of a sealed cabin; and ability to survive high-altitude conditions in emergencies, such as after cabin puncture or 'bail-out'.

Some of the apparatus, including rockets and balloons, which forms the equipment for ultra-high altitude research is also described briefly. Many of the problems mentioned could be further investigated only with such equipment, but it is pointed out that the steadily increasing range of artificially produced radiations arising from developments in particle accelerators may enable some of the relevant experiments on biological material to be performed at ground-level.

With such an unusual book as this, no very definite stipulations can be made as to what it should or should not contain. It is sufficient to say that there are some very readable articles which will provide useful introductions to more detailed study. Readers whose interests lie particularly in aviation or aviation medicine will surely find much food for thought. Also, anyone with more general interests, browsing at random, will discover a variety of information. For example, the correct procedure to be followed on finding a freshly fallen meteorite is probably not widely known and is described by L. Lapaz. Not only should all evidence facilitating an estimate of the angle and velocity of impact be preserved, but also the meteorite should be made available within a few hours at most to the nearest laboratory for autoradiographic and other tests for radioactivity. The precise importance of such tests is apparently the subject of some controversy; however, being performed on a sample of matter from space, they might lead to further knowledge of cosmic radiation, particularly regarding its potency in inducing radioactivity in exposed material.

The overlapping which is so often a fault with publications of this type seems very largely to have been avoided. It should perhaps be mentioned that the word "aeropause" is defined by its originator (K. J. K. Buettner) "as that atmospheric range in which the functions of the atmosphere, in a physiologically effective degree, fade out, one after the other".

References are given at the end of each article. The book is well produced and has a good index.

K. E. Spells

# PROGRESS IN CYTOLOGY

## International Review of Cytology

Edited by G. H. Bourne and J. F. Danielli. Vol. 1. (Prepared under the auspices of the International Society for Cell Biology.) Pp. xii+368. (New York: Academic Press, Inc., 1952.) 7.80 dollars.

ANOTHER new biological journal, or more correctly a new biological annual, has appeared, and, when such an event occurs, perhaps the most natural question to ask in this age of overcrowded book-shelves is whether this new publication can justify its place. Does it provide information which is not available elsewhere or could not appear more appropriately in existing journals? If so, is the method of presentation as economical as it could be and as helpful?

The first volume certainly contains many interesting articles, and much new information is presented as well as some very useful syntheses. It has been the aim of the editors to make the review truly international, and while they have partially succeeded in this aim, with perhaps an inevitable Anglo-American slant, the policy is inclined to lead to difficulties in language and outlook (though the articles are all, in fact, written in English) unless the editors are prepared to edit more scrupulously than they have apparently done in presenting the subject-matter of the first volume. The purpose of the international review is presumably to allow cytologists in all branches of the subject to become familiar in a general way with events occurring in fields other than their own. Very few of us can be expert in all branches of the subject, and the jargon of each becomes more and more exclusive and unintelligible to the others. If, therefore, a review of cell biology is to be useful, it must be written in simple language which all can understand. It must be the primary object of each author of the review articles to explain his subject as simply as possible and not to be as cryptic and clever with his jargon as he can. Two examples will illustrate the dangers. The following paragraph presumably means something to the author and perhaps to workers in the same field, but one wonders how much it conveys to others: "The activators and inhibitors mentioned under the Tween techniques have no effect whatsoever on the hydrolysis of the naphthol esters, except that eserine ($10^{-4}$ M) appears to inhibit the activity of the muscle-spindles of the mouse considerably". Another pair of adjacent sentences in another article seems a little curious to the uninitiated: "This is the basis of the acid-Giemsa technique, which is now widely used for bacterial cytology. It is of course obviously derived from the Feulgen reaction, but produces much clearer preparations". Why is it of course so obvious? Perhaps in the second and subsequent volumes the editors will help the reader over such difficulties. They will have a hard task; but they will have to face it if the review is to succeed.

Some of the sixteen articles, which are on various topics ranging as a whole from bacterial nuclei through the localization and mode of action of enzymes to physicochemical studies of cell structure and even to a short historical note on early cytological research, are little more than original papers or summaries of original papers by the same author. While sometimes individually interesting, they are, in my opinion, out of place. On the other hand, such reviews as those on freezing and drying techniques, on the basis of staining processes and on enzyme action in the penetration of cell membranes, are on the whole well balanced and useful. Perhaps the most interesting theory which is developed—and it is the declared policy of the editors to provide space for the development of new theories—involves the folding and unfolding of protein molecules as a basis for osmotic work done by cells. This seems to be full of possibilities.

On a minor point, I would suggest that the lists of references should include the titles of the papers.

E. N. Willmer

# USEFUL PLANTS OF THE TROPICS

## The Useful and Ornamental Plants in Trinidad and Tobago

Revised fourth edition by R. O. Williams and R. O. Williams, Jr. Original edition by W. G. Freeman and R. O. Williams. Pp. 335. (Port of Spain: Department of Agriculture, 1951.) 2 dollars.

THE fourth edition of "The Useful and Ornamental Plants in Trinidad and Tobago", by R. O. Williams, sen. and jun., will doubtless prove, like the earlier editions of this extremely useful reference work, to be of value in many other tropical countries besides the West Indies, for a large proportion of the plants dealt with are, more or less, cosmopolitan throughout the tropics. The authors are father and son, and the work affords a good example of family enterprise and co-operation. Both are now engaged in agricultural work in East Africa, and the senior author has produced a somewhat similar work there ("Useful and Ornamental Plants of Zanzibar and Pemba").

At the present time there is increasing interest in economic plants of all kinds. This is particularly noticeable where food plants are concerned, and those plants that fall in the category of protective food plants or which are rich in vitamins. This is perhaps a natural consequence of a rapidly increasing world population and the demand for more and yet more food. Medicinal and drug plants are another group of economic plants that are attracting much attention. Many feel that the thousands of native medicinal plants throughout the world in use by primitive peoples are worthy of intensive investigation on modern scientific lines, and that more extensive use might be made of some of them. There is interest at the present time in those plants known to be used by various primitive races of the world, notably on the North American Continent, for inducing sterility, or temporary sterility, in mankind. At present practically nothing is known of the active principles of these plants or the manner in which they function. Some consider such plants might possibly be utilized, with proper control by the State, in curbing the too rapid increase in population that is now taking place in some countries, such as India. Paresta and fodder plants for the tropics and sub-tropics, particularly leguminous fodder plants, are another group to which special interest is attached. Books of reference on the economic plants of different parts of the world, outlining what is already known of the useful plants of the region concerned, are therefore very desirable at the present time.

In the new edition of the Williams's book the first part is devoted to lists of economic plants arranged in groups such as major and minor plantation crops, forest crops, the various food crops, cover and green-manure crops, fodder crops and grasses, medicinal plants, oil seeds, perfumes, etc. Other headings include fibres, hat- and basket-making materials, windbreaks and protective hedges, shade trees. The ornamental plants are dealt with similarly. In the main part of the book the species concerned are dealt with alphabetically according to genera. For each species the family and common name or names are indicated, and the space devoted to each is dependent upon its importance. Cross-indexing of common names has obviated the need for a separate index. The book is well arranged and easy to use. It is almost double the size of the original edition.

# AWKWARD PROPERTIES OF MATTER

**Deformation and Flow in Biological Systems**

Edited by Prof. A. Frey-Wyssling. Pp. xii+552. (Amsterdam: North-Holland Publishing Co., 1952.) 38 f.

A CRAFTSMAN knows by experience whether his materials are in the right condition for his work; and the technologist who sets out to replace this traditional skill by a mechanical process may well find himself at a loss for terms in which to describe, measure and specify the consistency of a clay, for example, or the stickiness of a glue. For the biologist the failure of his materials to conform to any classical pattern is often a source of serious difficulty when an attempt is made to interpret a biological function in physical terms.

The rheologist, in whose province these problems fall, may usefully attack them qualitatively by defining new criteria to replace others the meaning of which is obscured by everyday use: thus 'spinnbarkeit'—that property of a liquid which permits it to be drawn into coherent threads—has a specific meaning, while 'plasticity' is ambiguous. His quantitative problem consists in measuring the properties he has defined and relating them to more familiar physical concepts such as elasticity and viscosity; often modifying familiar equations by making their constants adjustable.

Both approaches are exemplified in this book—the first of a series on the rheology of natural and synthetic products. Containing as it does nine independent monographs, the book cannot set out a unified view of the rheological problems encountered in biology; but some topics such as the flow of a real liquid through a real tube do recur in a number of contexts.

A. Frey-Wyssling is concerned with the mechanism by which latex is extruded from elastic-walled storage tubes when these are opened by cutting into the bark of the rubber tree. He concludes that this is a passive process because its time-course is the same as that predicted theoretically for passive extrusion from an elastic tube. Other problems of flow in elastic tubes, including the physiologically important case of pulsatile flow, are dealt with by J. J. Hermans. Both contributions intentionally neglect departures from classical behaviour.

The importance of these departures is well brought out in the monograph by L. E. Bayliss on the rheology of blood. Thus the apparent viscosity of blood flowing through a tube is a function of the rate of shear, of the diameter of the tube (after allowing for the effect of tube diameter on rate of shear) and to a small extent on the duration of the shear. It is thus very difficult to compare viscosity measurements made by different techniques. Some of the anomalies are consequent upon the fact that blood is a suspension and that the spatial distribution of plasma and cells is modified during flow by the influence of velocity gradients.

R. D. Preston criticizes the theory that water may be drawn to the tops of tall trees in columns which retain their coherence even when the local pressure is far below the vapour pressure of water. The early measurements of the tensile strength of water gave high values which, he concludes, are not valid under conditions existing in the xylem elements. Moreover, if a cut is made into the cambium, dye solutions are sucked in with a time-course consistent with the theory that the xylem vessels are actually filled with air at reduced pressure.

That a qualitative or semi-quantitative approach to rheological problems may lead to valuable results is illustrated by G. W. Scott Blair's paper on the rheology of secretions. Characteristic changes in the consistency of cervical fluid occur during the œstrous and menstrual cycles, so that comparatively simple tests may be used to determine the time of ovulation. W. Seifriz's long monograph on the rheological properties of protoplasm also contains many qualitative observations of great interest, but his interpretation of them is often uncritical. For example, Kamiya's discovery that myxomycetes may exert flow pressure with a regular cyclic recurrence, and that this cycle can be analysed into Fourier components, should scarcely be attributed to "interplay of rhythm and harmony" in protoplasm.

The remaining papers deal with the plasticizer theory of muscular function; the relation between mechanical properties and structure in plant cell walls; the production and circulation of cerebrospinal and intra-ocular fluid; and with the diffusion of solutes, including gases, in tissues. The book ends with a short report of the first International Colloquium on Rheological Problems in Biology, held at Lund in 1950.

Most of the contributions are of a very high standard, but each will be of interest mainly to the specialist, who may not care to buy a whole book in order to obtain the monograph that interests him. However, the book undoubtedly deserves a place in every library that has a biophysical section.

D. R. WILKIE

## Gazetteer of Agricultural and Forestry Research Stations in the British Commonwealth 1952

Including a List of such Stations in the Republic of Ireland. Pp. xix+517. (Farnham Royal: Commonwealth Agricultural Bureaux, 1952.) 30s.

THE list of research workers in agriculture and forestry in the British Commonwealth, published in 1938 by the Imperial Agricultural Bureaux (as they were then), has long been a valuable reference book for all concerned. A post-war edition has been anxiously awaited and is to be greatly welcomed, particularly in the greatly extended gazetteer-form it has now taken. It will probably come as a surprise even to those engaged in work in these fields to find that particulars are included for more than a thousand research centres of various types situated within the Commonwealth.

Appraisal of the value of the changes in arrangement, and particularly in the indexes provided, will probably vary according to the special requirements and practice of the user. The gazetteer has dropped the alphabetical index of names of research workers with their countries in favour of an index to the actual research stations themselves. The former was useful in various ways and will probably be missed, while the names adopted by the research stations do not lend themselves to indexing without a lot of duplicate entries, difficult to select; the numerical device for ensuring quick recognition of the country in which the station is situated is helpful. The index for subjects of research is on a completely different basis from that of the 1938 list, and its compilation must have been a difficult and laborious task. It occupies about a hundred pages and gives references to the stations at which work is in progress on the subject in question, the serial number of the station again indicating its whereabouts; plant and animal indexes are incorporated. No attempt is made to indicate which are the major references; but this would obviously be almost impossible. Perfection is unattainable, but the outcome of a varied test on this index was quite good.

This gazetteer constitutes a much-needed and most important addition to existing facilities for intercourse and co-operation in research. H. G. C.

## Acoustical Designing in Architecture

By Prof. Vern O. Knudsen and Dr. Cyril M. Harris. Pp. x+457. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1950.) 60s. net.

JUDGING by the number of books on the acoustics of buildings that have appeared in recent years, it is evident that the science of acoustics is now assuming its rightful place among the physical sciences, and this advance is to be welcomed.

The authors of the book under review are well known in the world of acoustics, and they have produced a work which is comprehensive, satisfying and very readable. It is intended mainly for architects and students of architecture, and others who probably wish for a non-mathematical yet thorough treatment of the subject; but it is safe to say that many students of physics and engineering will also find the book worth reading and investigating.

The first part of the work is devoted to a discussion of the basic principles and general procedures of design that determine the acoustical properties of all types of buildings, while subsequent chapters show how these principles and procedures can be applied to obtain the best acoustical effects. Practical applications are emphasized, and examples of good design are worked out; in addition, comprehensive tables give pertinent data on sound-absorptive materials and sound-insulative structures.

The book is well written and produced, and it should certainly serve conveniently as a handbook in the solution of most architectural acoustical problems.

## Sound

By W. Hall and O. M. Matthews. Pp. viii+239. (London: Edward Arnold and Co., 1951.) 9s.

THE authors of this book have clearly recognized that a fuller treatment must now be accorded in schools to the subject of sound, a subject which is of ever-growing importance, and they have provided an excellent little book up to a point.

On the credit side, due emphasis is put on the importance of vibrations and waves, and the book certainly keeps abreast of modern developments, devoting one chapter to ultrasonics and another to technical applications of sound. But against these undoubted virtues, one feels that, although many facts are given and much ground covered, few topics are dealt with sufficiently fully for sixth-form pupils, and in my opinion a serious deficiency is the absence of detailed reference to the vibration of bars (of which the tuning fork is an outstanding example) and of membranes and plates.

Simple harmonic motion is dealt with in an appendix; but this might have been put in the text as a prelude to the discussion on wave motion.

If the book is intended for sixth-form use, it is suggested that some of the elementary work at the beginning might be omitted, and it is difficult to understand why, in such a small book on sound, two pages are devoted to the Doppler effect in light.

A good selection of questions of the appropriate standard is included at the end of each chapter.

T. M. Yarwood

## Proceedings of a Second Symposium on Large-Scale Digital Calculating Machinery

Jointly sponsored by the Navy Department, Bureau of Ordnance and Harvard University at the Computation Laboratory, 13–16 September 1949. (Annals of the Computation Laboratory of Harvard University, Vol. 26.) Pp. xxxviii+393. (Cambridge, Mass.: Harvard University Press; London: Oxford University Press, 1951.) 52s. net.

THIS conference included papers on complete machines, machine components in development, numerical analysis, programming, and surveys of the possible applications of high-speed computing machines in physics, aeronautics, applied mechanics, and economics. Although nearly three years have elapsed since the conference took place, there is still a good deal of interest to be found in the report; for example, in the descriptions of the Harvard Mark 3 machine and the Bell Telephone Laboratories Model 6 and—in the section on programming—in D. H. Lehmer's characteristically pungent remarks on pseudo-random numbers and the use of high-speed machines for calculations connected with number theory. The paper by Harry D. Huskey on semi-automatic instructions is well worth reading in view of present-day trends in the technique of programming. M. V. Wilkes

# MEASUREMENTS OF ICE THICKNESS IN DRONNING MAUD LAND, ANTARCTICA

By G. de Q. ROBIN
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THE Norwegian–British–Swedish Antarctic Expedition, 1949–52[1], which returned to Europe last February, carried out a comprehensive programme of glaciological, meteorological and geological research, making considerable use of geophysical methods. Particular attention had been directed to mountainous areas of Dronning Maud Land by the air photographs taken in 1939 by the German *Schwabenland* expedition. These indicated a particularly useful area for glaciological studies.

The expedition sailed from London in November 1949 in the Norwegian sealing vessel *Norsel*, and established its base, known as "Maudheim", in lat. 71° 03′ S., long. 10° 55′ W. on a floating ice shelf in February 1950. The weather experienced during the two-year stay was less windy than in some other Antarctic localities, which helped considerably in carrying out the programme.

In addition to standard meteorological observations, upper-air temperatures and winds were measured daily to heights averaging more than 10 km. Special studies were made of the radiation balance, and of wind and temperature gradients up to the 10-m. level. Glaciological work included measurements of net accumulation, surface movement and ice thickness both at the base and inland. A boring machine enabled temperatures to be recorded, and crystallographically undisturbed cores to be examined, from depths down to 100 m. at Maudheim, and corresponding work at shallow depths was carried out on journeys inland. Other work included a ground survey supported by air photographs, an extensive geological reconnaissance, and some physiological investigations.

The full scientific reports of the expedition will be published as a special series by the Norsk Polarinstitutt, Oslo. The following is a preliminary account and discussion of the measurements of ice thickness made by the expedition.

## Method

Thickness measurements were made by standard seismic reflexion shooting techniques, using equipment with six recording channels. The seismometers were normally spaced 10 metres apart in line with, and separated from, the shot point by distances of 10–200 metres according to the depth of the ice. The shots consisted of TNT charges of 90–720 gm. placed in hand-bored holes at depths of 2–12 metres.

Three distinct waves were produced by each explosion, the longitudinal (*P*) wave of around 3,800 m./sec., a second wave at about 1,650 m./sec. which may be a transverse (*S*) wave, and a Rayleigh wave at approximately 1,050 m./sec. Refraction shooting techniques were used to measure the velocity $V_P$ of the *P* wave at four different locations, with results listed in Table 1.

Table 1

| Date | Seismic station No. | Distance from Maudheim (km.) | Height above sea-level (m.) | Ice temperatures (°C.) | Velocity of *P* wave (m./sec.) |
|---|---|---|---|---|---|
| 18/10/51 | 38 (Maudheim) | 0 | 37 | −17 | 3,730 ± 20 |
| 30/12/51 | 165 | 185 | 480 | −19 | 3,775 ± 20 |
| 13/11/51 | 97 | 418 | 1,575 | −27 | 3,785 ± 20 |
| 25/11/51 | 119 | 615 | 2,710 | −40 | 3,810 ± 20 |

The change in velocity of the *P* wave with temperature is less than has been found by other observers[2,3]. As the normal refraction shooting technique results in measurement of the maximum value of $V_P$ rather than its mean value over a range of depths, the accuracy of soundings cannot be considered so reliable as the measurements of $V_P$ and echo-times would suggest. In view of the variation of $V_P$ with locality and of checks of seismic thickness measurements by independent methods[4,5], an accuracy of depth measurement of 5 per cent would seem a reasonable claim.

## Surface Profile

Distances were measured by meters on the tracked vehicles and by sledge meters. These distances were adjusted to fit astronomical observations made at important points.

Heights have been determined by aneroid barometers. Heights at control points were evaluated from surface pressure and pressure-height records from Maudheim. Between these points, heights are interpolated by barometer readings taken frequently when travelling between control points in rapidly moving vehicles. Errors should not exceed 30 m. for the first 300 km. from Maudheim, as they are means of three journeys. Beyond 300 km. the greatest difference of height measurements at the same spot on the outward and return journey was 60 m., and the error is not likely to exceed this amount.

The reported elevation of 4,200 m. for the surface of the ice sheet in Dronning Maud Land[6,7], the greatest claimed in Antarctica, was found to be incorrect. On a practically level ice sheet, within 2 km. of the charted position of one such report, our measurement showed an elevation of 2,670 m. This was in keeping with the results of the surveyor, N. Roer, which showed mountain heights to be substantially lower than previously reported.

## Seismic Shooting Results

Fig. 2 shows the route followed on the main seismic field-journey which took place during October 18, 1951–January 6, 1952. The lines of small additional profiles are also shown. Fig. 3 shows the picture of the ice and the underlying rock profile along the main route. For discussion, the profile may be split into the following five regions, all distances noted being taken from Fig. 3: (1) floating ice shelves from 0 to 35 km. and 55 km. to 142 km. which may also be termed ice barriers or shelf ice; (2) 'coastal ice hills'* from 35 km. to 55 km. and 142 km. to 176 km; (3) mountain ice sheet region from 176 km. to 470 km., less region 4; (4) mountain region from approximately 315 km. to 395 km.; (5) the inland plateau beyond 470 km.

## Floating Ice Shelves and 'Coastal Ice Hills'

Evidence that the ice shelf is floating will form the subject of a separate report. The most direct measure-

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* This is a tentative name and the matter will be discussed shortly by the Royal Geographical Society's Committee on Antarctic Glacier Nomenclature. Other possible names are 'ice cupolas', 'ice swells' (which is more applicable to smaller features), 'ice shelf hills', etc.

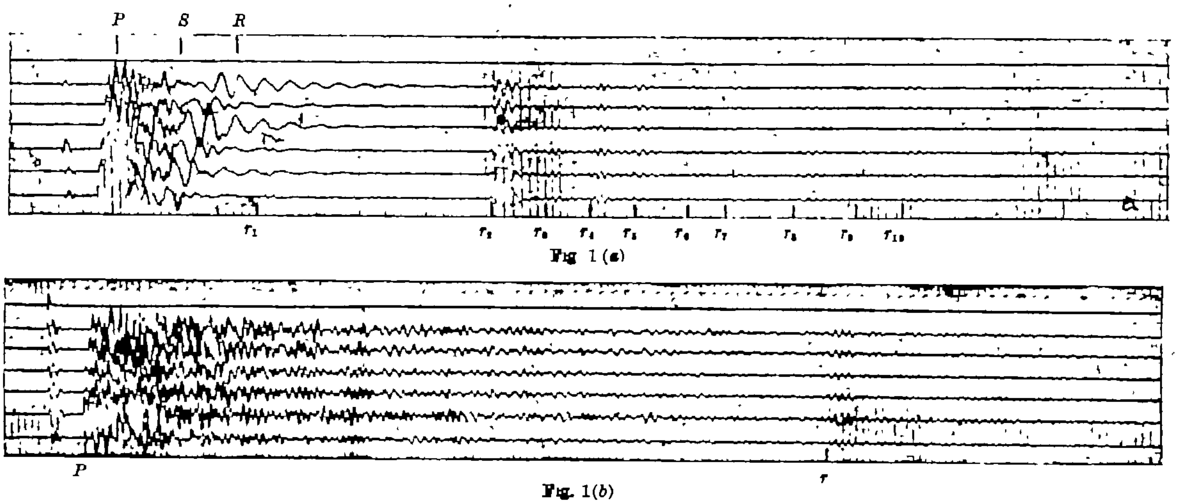

Fig 1(a)

Fig. 1(b)

Fig. 1. Seismic shooting records. The vertical lines represent time intervals of 1/100 sec. The top trace records the shot instant and the others the amplified output from six seismometers.

(a) Record taken on the ice shelf 2 km. south-west of Maudheim. *P*, longitudinal wave; *S*, transverse wave; *R*, Rayleigh wave; $r_1$, echo from bottom of ice shelf; $r_2$, echo from sea bottom, $r_3$, $r_4$, etc., echoes from lower surfaces and multiple echoes.

(b) Record taken on inland plateau 516 km. from Maudheim. Surface elevation, 2,505 m. Ice thickness ($r_1$), 2,290 m. On this record the output of adjacent seismometer channels are mixed to increase the apparent echo-strength, in order to overcome the excessive background noise caused by random snow collapse after the shot was fired

ment of the thickness of the floating ice at Maudheim has been made by the glaciologist, V. Schytt, by extrapolating his depth–density curve beyond its measured limit of 100 m., and using this together with the accurate surface elevation measured by N. Roer. This gives an ice thickness of 186 ± 5 m. Measurement of the *P*-wave echo-times from the bottom of the sea water for vertical and oblique rays through the ice shelf plus sea water gave a similar but less accurate result, 180 ± 30 m., for the ice thickness. This gives independent confirmation that the *P*-wave velocity is around 3,760 m./sec. for the whole thickness of the ice shelf, in contrast to the results found by Poulter[4] in the Bay of Whales area. He stated that the waves travelled with a velocity close to that in sea water when below sea-level in the ice shelf, thereby indicating that the sea water percolated through the ice shelf to that level. The glaciologists' core examinations and seismic shots fired at 100 m. depth (63 m. below sea-level) show that such an effect is not present at Maudheim. Wade's[5] figure of − 22° C. for the ice temperature at 41 m. depth (10 m. below sea-level) contradicts evidence of such percolation at the Bay of Whales.

At five stations, an echo has been observed which could not reasonably come from anywhere but the bottom of the floating ice. Schytt's thickness measurement at Maudheim has been used for calibrating this echo for other stations, as it is not clear whether this is a *P*-wave double echo (gives 205 ± 10 m.) or an *S*-wave echo (gives 215 ± 30 m.). In order to use the echo from the sea-bottom at stations where the ice thickness is unknown, the average of the five known values has been assumed as the ice thickness at that point. In view of the extremely flat nature of the ice shelf, this is unlikely to introduce errors of more than 50 m. in bottom depths.

Echoes obtained on the inland ice were verified to be *P*-wave echoes for a few stations, as is normally the case, and all inland ice echoes have been therefore taken as being such.

The profile across the hill 45 km. from Maudheim clearly shows the great increase in thickness where the ice is grounded. The profile does not cross the highest point of this 'ice hill'; but one seismic station was taken on the top of a smaller hill, and showed that the ice extends to 100 m. below sea-level there. The hill from 145 to 175 km. is similar in character,

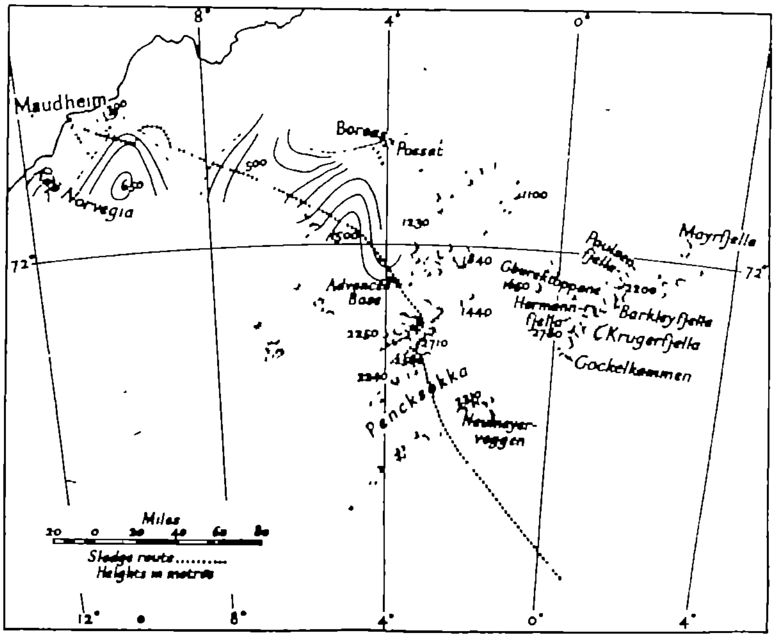

Fig. 2. Routes followed on main and subsidiary seismic journeys

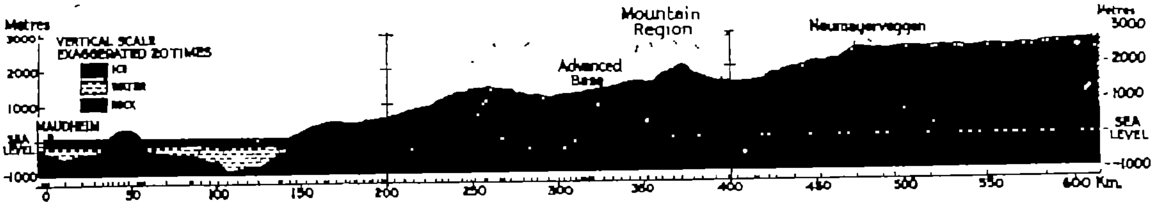

Fig. 3. Main seismic profile. The vertical marks above the distance scale show points at which seismic echoes were obtained

although it joins the mountain ice sheet on its inland side. The term 'coastal ice hill' is proposed for these features, where the visible hill is due to the accumulation of ice on a relatively flat base, and the form of which is determined principally by the mechanism of ice flow, rather than the underlying topography.

The detailed diagram (Fig. 4) of the ice shelf to inland ice junction is based on echoes at two seismic stations, plus theodolite levellings. A 1-m. change in surface level has been assumed to represent an 8-m. change in the thickness of floating ice.

As the mechanism of flow of ice shelves[10] has been neglected, compared with that of ice sheets and glaciers, the following points appear worthy of mention. (1) Although the upper layers of ice shelves may vary considerably in temperature at different localities, the bottom of an ice shelf is normally in contact with sea water, which is unlikely to differ much from − 1·8° C., its freezing point. (2) Except for layers nearer the surface, large density variations with locality appear to be unlikely. (3) As ice shelves are floating, they rest on a virtually frictionless base, and under some theories a theoretically negligible surface slope should be sufficient to cause flow. In these circumstances forces due to the rotation of the earth, and frictional forces with the air and sea should be considered, even though all these are small. (4) Fig. 4 shows clearly that, in a relatively short horizontal distance, the thick inland ice tends to thin out to a floating ice shelf of a thickness close to that at Maudheim and at other measured stations. (5) Accurate surface levelling at Maudheim by N. Roer showed that, in spite of the accumulation of more than one metre of firn, the general surface height above sea-level of the ice shelf changed by less than 5 cm. in twenty months.

In view of the above, and particularly of point (4), the idea that ice shelves tend to attain an 'equilibrium thickness' would appear reasonable, although probably an over-simplification. An ice shelf could then be formed by accumulation on frozen sea ice or coalescing glaciers without any appreciable flow taking place until such an equilibrium thickness was approached. When this had been attained, the additional accumulation would produce ice flow, by increasing the area of the ice shelf. In the absence of differential movement between different levels of the ice shelf, the following equation should hold:

$$\frac{\text{Annual net accumulation}}{\text{Equilibrium thickness of ice shelf}} = \frac{\text{increase in area per year}}{\text{total area}}$$

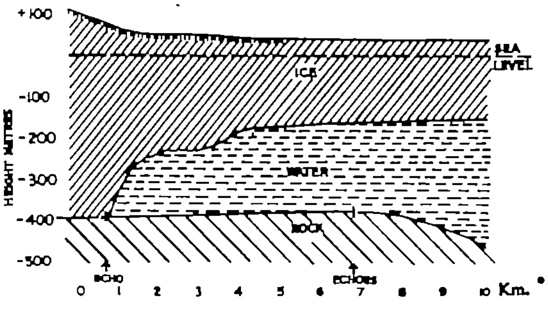

Fig. 4. Junction of ice shelf and inland ice 143 km. from Maudheim. Based on echo from ice–rock surface at 0·7 km. and from ice–water, and water–rock surfaces at 6·8 km., and from surface levelling by theodolite

Annual net accumulation in the above would also include any loss or gain on the bottom surface of the ice shelf due to melting or freezing of the sea water.

If we apply a possible figure of 40 cm. ice as the annual net accumulation over the Ross Ice Barrier, and take its equilibrium thickness as 200 m., as it is only free to expand to the north, we should get an advance of around 3 m. a day, compared with observed mean figures of up to 4 m. a day[9]. Accurate figures for this spreading which were obtained at Maudheim are at present being worked out by the glaciologists, Schytt and Swithinbank.

Now if an ice shelf is forming over an area of sea with insufficient depth to float this 'equilibrium' thickness, it will presently touch the bottom. If the area of contact remains small, any forward motion of the whole ice mass may slide the ice over the obstruction, as apparently happens in the Ross Ice Barrier. If the grounded area becomes too large, it will have to supply its own mechanism of flow by forming 'ice hills'.

Both the 'ice hills' shown in Fig. 2 follow the equations of flow $h = h_0/\alpha$ proposed by Nye[10], except near their edges, using the value of $h_0$ of $12\frac{1}{2}$ m., similar to that found in Greenland.

Such 'ice hills' are small-scale models of vast ice sheets, and as such may be worthy of thorough investigation. In Table 2, heights and minimum radii are listed for 'coastal ice hills'[11] with contours which suggest they are resting on a relatively level base. In each case the hills are wholly or partly surrounded by ice shelves. The calculated heights in the table are obtained by the formula proposed by Orowan[12] and later by Nye[10]:

$$h = \sqrt{2h_0 S},$$

where $h$ is the maximum thickness of ice; $h_0$ is a constant taken as 10 m., as Nye found in Greenland; and $S$ is the minimum radius of the hill.

The hill was assumed to rest on a level base 160 m. below sea-level, and a correction was applied assuming that shelf ice 200 m. thick surrounded the hills.

The increase of height with radius is clearly shown, and the agreement with calculated height is surprisingly good in four cases, considering the assumptions made about the underlying surface. The dependence of height on the area of the base was originally proposed so long ago as 1879 by Croll[13].

It is significant that values close to 10 m. for $h_0$ approximately fit hills listed in Table 2 and the depth

Table 2

| Position | Minimum radius $S$ (km.) | Observed height (metres above sea-level) | Calculated height (metres above sea-level) |
|---|---|---|---|
| 72° 15′ S. 60° 15′ W. | 5·3 | 190 | 220 |
| 71° 00′ S. 10° 07′ W. | 6·9 | 300 | 260 |
| 69° 55′ S. 61° 15′ W. | 7·2 | 300 | 270 |
| 70° 37′ S. 60° 48′ W. | 8·0 | 400 | 285 |
| 71° 00′ S. 60° 48′ W. | 8·8 | 490 | 305 |
| 71° 30′ S. 9° 50′ W. | 30 | 650 | 640 |

measurements on 'coastal ice hills' in Fig. 3. Nye found that the value of $h_0$ = 10 m. fitted the Greenland Ice Sheet, and values of 6–17 m. fitted European glaciers. Now $h_0$ is directly proportional to the shearing stress in the lowest levels of moving ice. Glen's laboratory studies on polycrystalline blocks of ice have shown that the shearing stress varies as approximately the fourth root of the rate of strain[14], so if other conditions are the same, the small spread in values of $h_0$ is not surprising. However, Glen has also found that the shearing stress required to produce a given rate of strain increases rapidly with decreasing temperatures, being approximately doubled when the ice temperature changes[15] from 0° C. to − 5° C. The inference is therefore that in the Antarctic the temperatures of the lowest levels of ice are not greatly below 0° C.

## Continental Shelf

From the evidence presented, it is apparent that the continental shelf of Antarctica may, if sufficiently shallow, be covered by gradually rising 'coastal ice hills', or, if deeper, its presence may still be hidden from ships by floating shelf ice. The reported absence of any antarctic continental shelf, as was reported[16] in longitude 3° E., cannot, therefore, be wholly based on ship-board information.

## Mountain Ice Sheet and Mountain Regions

Inland from 175 km. from Maudheim, the bottom relief changes remarkably to an alpine type, and so comes under Flint's[17] description of a mountain ice sheet, as a very occasional nunatak just breaks through the ice surface. On this section, several closely spaced stations were worked to examine the cause of step-like rises in the ice surface. At 187 km. such a step was apparently caused by a rock ridge submerged under 1,100 m. of ice at the point of measurement. At 210 km. and 248 km. the steps were caused by ice flowing over ridges some 500–600 m. below the ice surface, with the rock reaching its greatest elevation some 500 m. down slope from the crest of the step. Similar depths at 259 km. and 269 km. give the impression that, in this region, 500–600 m. of ice represents some kind of a critical depth for ice-flow across submerged ridges.

From 315 to 395 km. the route wound through a group of mountains rising to 2,700 m. above sea-level. This line of mountains runs towards the north-east with gradually decreasing height, and on either side of this line large glaciers drain the ice seawards. The valleys at 300 km. and 410 km. represent cross-sections of these glaciers. Ice-depths up to 2,000 m. in these valleys show that the underlying relief must be comparable to the most striking fjord type of country at present known, such as exists on the eastern coast of Greenland.

From 355 km. to 395 km. the ice depths were measured on mountain glaciers not more than 10 km. wide within the main mountain massifs.

From 415 km. to 475 km. the surface rises to the level of the exposed rock ridges of Neumayerveggen. The many crevassed patches on this escarpment make it probable that in many places peaks and ridges are not covered by any great thickness of ice. A typical profile would probably indicate a more jagged underlying relief than the gradual rise to Neumayerveggen which our measurements suggest. Our results here were influenced by the necessity of keeping our vehicles well clear of crevassed areas for reasons of safety, and also it was not possible to work anything like a desirable number of stations in the time available.

## The Inland Plateau

Inland from Neumayerveggen no rock is visible and the surface essentially becomes that of a high ice plateau formed by the damming of the ice on the inland side of mountain ridges. As there was considerable difficulty in obtaining soundings in this region, they are again too widely spaced to show much of the underlying relief; but the surface undulations seem to indicate that the rock floor is far from being a smooth basin. The soundings made at 615 km. show a bottom slope of 1 : 6 in direction 100° M. compared with a surface slope in the vicinity of the station of 1 : 440 in direction 200° M.

Unlike the central portion of the Greenland Ice Sheet, the rugged relief of the rock floor inland from 180 km. is such that the simple formula of Nye cannot generally be applied. While the underlying relief is in many ways reflected by the surface slopes in a more or less inverse proportion to the ice thickness, the direct interpretation of surface slopes is complicated by the damming action of ridges across the lines of flow. Further study here may, however, permit better interpolation of the underlying relief between seismic stations.

The findings described in this article have been the result of the work of the many people involved in the organization of the expedition, including the leader and other members of the wintering party at Maudheim, to whom I express my thanks. My particular thanks are due to my two companions throughout the seismic journey, P. Melleby (Norway), who looked after transport and camping equipment, and C. W. M. Swithinbank (Great Britain), who was responsible for navigation and general glaciology on this journey.

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# COMPOUND HELICAL CONFIGURATIONS OF POLYPEPTIDE CHAINS: STRUCTURE OF PROTEINS OF THE α-KERATIN TYPE

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LAST year we described several configurations for polypeptide chains, and suggested that one of them, the α-helix, which has about 3·6 amino-acid residues per turn of the helix, is present not only in synthetic polypeptides but also in proteins of the α-keratin type, and in hæmoglobin and other globular proteins[1]. We pointed out that the dimensions of the unit of structure, as indicated by the X-ray photographs, and the distribution of intensities in the equatorial direction are roughly accounted for by the α-helix. In addition, we mentioned that the structure is supported also by the meridional reflexions observed for muscle fibres and porcupine quill, in particular the reflexions with spacings 1·5 A. (the length per residue along the axis of the α-helix) and multiples of this value; the value of this evidence was emphasized by Perutz[2], who observed the 1·5-A. reflexion for hair, horn, and other α-keratin proteins.

We also pointed out that the X-ray pattern of α-keratin, as described by Astbury and Street[3], has a strong equatorial reflexion at 27 A., which is not accounted for by a structure involving α-helixes in regular parallel orientation, and we suggested that this reflexion is due to a long-range order to be elucidated through further study. Other difficulties for the proposed simple structure of the α-keratin proteins have been emphasized to us by several workers in the field. The most important of these difficulties are a discrepancy between the observed and calculated density, and the failure of the α-helix to explain the 5·2-A. arc on the X-ray photographs as a true meridional reflexion.

We have recently noticed that an α-helix for a polypeptide chain involving repeating sequences of amino-acid residues of different kinds would be expected not to have a straight axis; instead, the axis of the helix would itself be predicted to pursue a helical course. A protein might consist of a single polypeptide chain with the configuration of a compound helix; three such helixes might well be expected to twist about one another, to form a three-strand rope, and six might be expected to twist about a seventh, to form a seven-strand cable; still more complex structures may also be formed. There is good reason for believing that hair, horn, quill, and other proteins of the α-keratin type consist of seven-strand protein cables in parallel orientation, with single compound α-helixes occupying interstices between them.

The study of simple substances related to proteins has not only provided reliable values of interatomic distances and bond-angles, but has also indicated that the N—H···O hydrogen-bond distance may be expected to vary by about ± 0·12 A. about its average value[4] in compounds of this sort, 2·80 A. Variation in the hydrogen-bond distance might be caused directly by the interaction of side-chains of amino-acid residues with the carbonyl and imino groups of the adjacent amide groups, or indirectly by steric hindrance (especially adjacent to a proline or hydroxyproline residue) or by attraction between side chains. Let us consider an α-helix composed of a polypeptide in which a unit of four amino-acid residues of different sorts is continually repeated. Two of the hydrogen bonds might be longer than the other two, by about 0·2 A. This difference in length would cause a curvature of the axis of the α-helix. If the α-helix has 3·6 residues per turn, the normal to the curved helical axis would be rotated by 0·09 revolution by progressing from one unit to the next unit of four residues along the chain, which corresponds to a complete revolution in about eleven units. The axis of the α-helix would itself accordingly describe a larger helix, with pitch approximately 66 A., the axial length of 44 residues. The radius of the larger helix would be about 1·5 A., and the sense of the larger helix would be the same as that of the α-helix. A compound helix of this sort is represented in Figs. 1 and 2.

Another simple case is that of the compound helix with a repeating unit of seven amino-acid residues. An α-helix with 3·60 residues per turn executes 97·2 per cent of two turns in seven residues, and would accordingly be expected to complete a turn of the larger helix in about thirty-five turns of the α-helix, or 126 residues, corresponding to about 190 A. for the pitch of the helix. However, the prediction of the pitch of this compound helix is rather uncertain; decrease by 1·5 per cent of the number of residues per turn would cause the predicted pitch to be doubled, to the value about 400 A. The radius

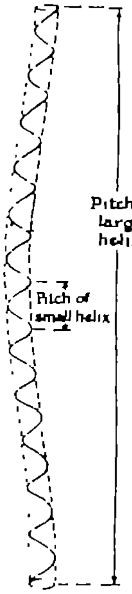

Fig 1

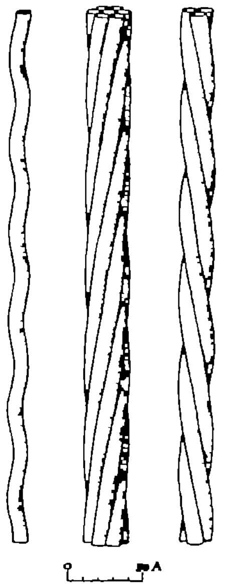

Fig. 2

Fig. 1. A compound helix with pitch of the large superimposed helix equal to 12·5 times the pitch of the small helix. For the compound α-helix the values might be 68 A. and 5·44 A., respectively

Fig. 2. At the left, a compound α-helix with pitch about 67 A. The diameter, shown as about 10 A., includes the volume occupied by side chains as well as the main chains of the protein. Centre, a seven-strand α-cable, with lead of about 400 A. In the proposed structures of proteins of the α-keratin type these cables are packed together, with compound helixes as shown at the left in the interstices. At the right, a three-strand rope, with lead of about 200 A., and with sense opposite to that of the seven-strand cable. In the suggested structure for feather rachis keratin, these ropes are packed together with seven-strand α-cables, in the ratio of two ropes to one α-cable

of the large helix might easily be as great as 10 A., with the variation in hydrogen-bond length mentioned above. The sense of the large helix of the seven-residue compound α-helix is opposite to that of the α-helix itself.

A radius of 6 A. for the large helix would permit three compound helixes to twist about one another, to form a three-strand rope (Fig. 2). Such a rope with the sense of twist of the strands opposite to that of the rope would be formed by the seven-residue compound helix, or with the sense of the strands the same as that of the rope by, for example, the fifteen-residue compound helix (with a repeating unit of fifteen residues, comprising nearly four turns of the α-helix).

Six compound helixes with radius of the large helix equal to 10 A. could twist about a central straight α-helix, to form a seven-strand cable. The repeating unit of seven amino-acid residues, comprising nearly two turns of the α-helix, is the simplest one that would give rise to compound helixes suitable to a seven-strand cable; the next simplest is the repeating unit of fourteen (perhaps containing one proline residue). A drawing of the seven-strand α-cable is shown in Fig. 2. We suggest that the symbol $AB_6$ be used for this cable.

The seven-strand α-cable is about 30 A. in diameter. A fibre containing these cables in parallel orientation would have a hexagonal unit of structure or pseudo-unit with $a$ equal approximately to 30 A. The observed equatorial reflexion with spacing 27 A. could then be explained as the 10·0 reflexion corresponding to this unit. The X-ray patterns of hair, horn, porcupine quill, and other α-keratin proteins are reasonably well accounted for by such a unit, with $a = 32{\cdot}4$ A. (for porcupine quill a multiple of this unit, indicating further superstructure, is needed to explain weak reflexions with larger spacing).

A plan of the packing of the seven-strand α-cable is shown in Fig. 3. It is seen that there is room enough at the positions ⅓ ⅔ and ⅔ ⅓ for other polypeptide chains to be introduced. If the adjacent seven-strand cables are staggered in azimuthal orientation, at a given level, α-helixes may be introduced in the positions ⅓ ⅔ and ⅔ ⅓. Because of the rotation of the cables, for which the value of the lead (vertical distance between a point on one strand and an equivalent point on the same strand after one turn about the cable) is about 400 A., and that of the pitch (vertical distance from one strand to an adjacent strand) is about 66 A., the inserted α-helixes must be compound helixes, with radius of the large helix about 1·5 A., and with pitch equal to the pitch of the cable, about 66 A. The sense of these compound helixes must be opposite to that of the cables, in order that they may fit between the strands of an adjacent cable. The four-residue compound helix, which has the proper sense and approximately the correct pitch, is accordingly satisfactory. We suggest the symbol $C$ for this compound helix.

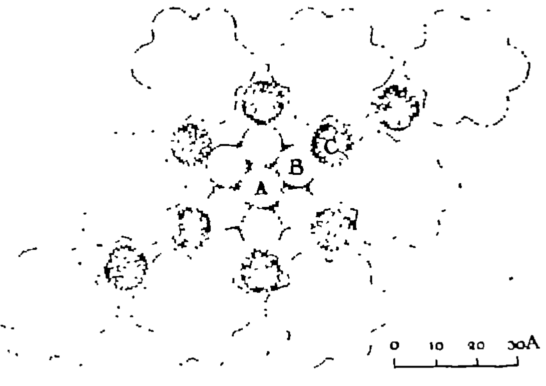

Fig. 3. A cross-section of the α-keratin structure, showing the α-cables $AB_6$ and the interstitial compound helixes $C$. The orientation of the cross-section of the cable changes with co-ordinate along the fibre axis. The central cable is shown in the most unfavourable orientation for the interstitial α-helixes. The protein chains are not so nearly circular in cross-section as indicated in the drawing, and space is filled more effectively than is indicated

The volume of a portion of the hexagonal unit with $a = 32{\cdot}4$ A., and with height 1·50 A., the axial length per residue, is 136·3 A.$^3$. The proposed structure involves nine amino-acid residues in this portion of the unit. With the reported range 107–118 for the average residue weight, the density of the protein is calculated to be 1·17–1·30 gm.cm.$^{-3}$. The indicated disagreement with the experimental value, about 1·32 gm.cm.$^{-3}$, may be due to the presence of a few per cent of water of hydration in the fibrous proteins. The much larger discrepancy between calculated and observed density that results from assuming the centre of the strong but broad equatorial reflexion, at 9·8 A., to correspond to the spacing of the reflexion 10·0 for the small hexagonal unit containing one α-helix is eliminated by the new indexing, which assigns the strong reflexion with centre at 9·8 A. to the overlapping of 21·0 at 10·6 A., and 33·0 at 9·3 A.

The strong 5·2-A. meridional arc, characteristic of the α-keratin proteins and previously given only rather unsatisfactory explanation in terms of the α-helix, is now explained in a straightforward manner as resulting from the co-operation of the seven residues, in a repeat involving approximately two turns of the α-helix, in the $B$ compound helixes of the $AB_6$ cable. With 1·50 A. as residue length of the α-helix, the unit of seven residues has length 10·5 A. The component of this distance in the direction of the fibre axis, assuming the cable to have lead 400 A. and radius 10 A., is calculated from the angle of inclination, 9·0°, to be 10·36 A. A weak meridional reflexion would be expected to occur with this spacing; the second order of this reflexion, with spacing 5·18 A., should be strong, because it involves reinforcement rather than extinction by the two turns of the α-helix in the repeating unit of seven residues. The 5·2-A. meridional arc, for which Astbury and MacArthur have recently reported spacings of about 5·15 A. or 5·18 A., is accordingly well explained by the proposed structure.

Strong support of the proposed structure is also given by many other features of the X-ray patterns of various proteins of the α-keratin type. One comparison of observed and calculated features is given in Fig. 4. At the top of this figure there is a sketch of the equatorial X-ray pattern of α-keratin. Astbury and Street[illegible] described the α-keratin pattern as having a strong reflexion at 27 A., a very strong and broad reflexion at about 9·8 A., and a vague region of darkening around 3·5 A. Examination of heavily exposed photographs shows that the last of these features is, in fact, a broad maximum, extending from about 5 A. to about 3·2 A. (This band may be due in part to the very strong 4·7-A. reflexion of β-keratin; it is known that specimens of α-keratin usually contain some β-keratin, and some of our photographs show a rather strong 4·7-A. ring.) There is then a minimum at about 2·8 A., a maximum at about 2·4 A., a minimum at about 1·8 A., a maximum

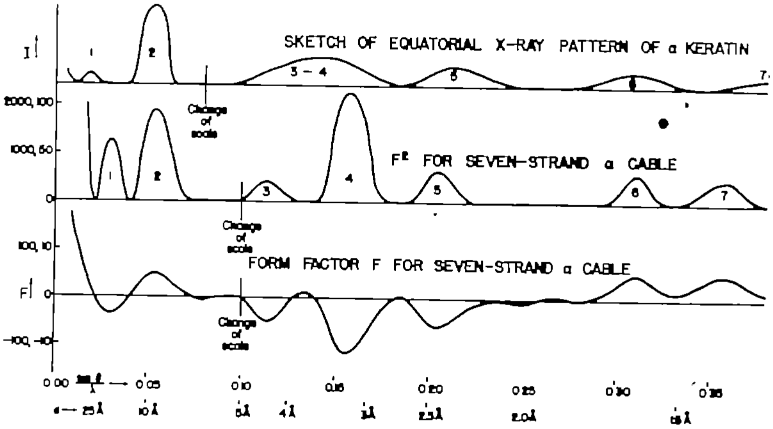

Fig. 4. Comparison of observed and calculated equatorial intensities on X-ray photographs of α-keratin. At the top there is a sketch of the observed intensity of reflexion by hair and horn. The decrease in intensity with increase in angle is more rapid than indicated. At the bottom, there is given the calculated form factor for the $AB_6$ cable, and in the centre the square of this form factor, which may be compared with the observed intensity curve

at about 1·6 A., a minimum at 1·4 A., and a further maximum. The form factor $F$ for the α-cable shown at the bottom of the figure is calculated by multiplying the form factor for the α-helix, including the β-carbon atom, as reported previously[1], by the factor $1 + 6J_0(4\pi\rho \sin\theta/\lambda)$, in which $J_0$ is the Bessel function of order 0, and ρ, the radius of the $B$ helixes of the cable, is placed equal to 10 A. Above the curve for $F$ there is shown the curve for $F^2$. It is seen that there is striking, although not complete, agreement between this curve and the sketch of the equatorial X-ray pattern. Inasmuch as the contribution of the two interstitial compound α-helixes and of the side chains, which together constitute just 50 per cent of the scattering matter in the fibres, have not been taken into consideration, the agreement must be considered to be excellent. It may be pointed out that, in the calculation of the form factor, no arbitrary parameters have been involved except the radius of the large helix; and that the value 10 A. for this quantity is required, to within a few per cent, by the dimensions of the unit of structure, if it is assumed that the three different kinds of polypeptide chains in the α-keratin proteins (the core of the cable, the six surrounding strands, and the interstitial compound helixes) have approximately the same average amino-acid residue weight.

The X-ray diffraction photographs of feather rachis keratin, which have previously been interpreted as involving β-keratin pleated sheets and α-keratin helixes in molecular distribution, may show a superimposed β-keratin pattern and α-keratin pattern. If this is correct, the α-keratin is different in nature from hair and horn α-keratin, probably consisting of $AB_6$ cables with $D_3$ ropes (three α-helixes coiled about one another) in the interstices. This structure accounts in a striking way for the characteristic features of the X-ray photographs.

The proposed structure of α-keratin involves three kinds of α-helixes, which presumably differ in amino-acid composition. We propose to examine these materials by fractionation. It is interesting that Goddard and Michaelis have reported that wool put into solution by reduction with thioglycollic acid or other reducing agent and treated with iodoacetic acid to form a carboxymethyl derivative can be converted into fractions with different chemical composition by ammonium sulphate precipitation[5]. We suggest that a solution of wool might be fractionated into the $AB_6$ cables and the protein keratin-C, and that the $AB_6$ cables might be further separated into keratin-A and keratin-B.

We think it not unlikely that actomyosin has the structure shown in Fig. 3, and that its fractionation into myosin and actin is a separation of the seven-strand cables $AB_6$ (myosin) from the single α-helixes $C$ (actin). The amounts of myosin and actin obtained by the fractionation are approximately in the predicted ratio 7 : 2, and, as predicted, the 5·2-A. meridional X-ray reflexion is observed for actomyosin and myosin but not for actin.

We are indebted to Prof. W. T. Astbury, Dr. I. MacArthur, Mr. F. H. C. Crick, and other workers in the field of the structure of proteins for having discussed with us the question of the structure of α-keratin, and especially for having emphasized the necessity for refinement of our suggestions. The detailed description of compound α-helixes and aggregates of them, and discussion of fibrous proteins which they compose, will be presented in later papers, to be published in the *Proceedings of the National Academy of Sciences* of the United States of America. This investigation was supported in part by a research grant from the National Institutes of Health, Public Health Service, and by a contract (Nonr-220(05)) with the Office of Naval Research. [Oct. 14.

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# THE RICCI CALCULUS

By Prof. H. S. RUSE
University of Leeds

GREGORIO RICCI-CURBASTRO, inventor of the tensor calculus, was born at Lugo, in Italy, on January 12, 1853.

The absolute differential calculus, as he himself called it, gained little attention until Einstein used it for the formulation of general relativity, even though it had reached a mature form by 1895, after some ten years of growth. It was so little thought of, indeed, that in 1901 Ricci was denied the Italian Royal Prize in mathematics on the ground that the calculus was "useful but not essential for the treatment of some mathematical questions". Nevertheless he himself retained a belief in its value, and in that had the sympathy and support of a young colleague at the University of Padua, Tullio Levi-Civita. The work captured the interest, too, of a young American, Luther Pfahler Eisenhart, who heard of it from Levi-Civitá during a visit to Padua in 1905, and from 1909 onwards used it in post-graduate courses on differential geometry at Princeton University. In 1912 Einstein's attention was directed to it by his colleague, Marcel Grossmann, and the outcome was the relativistic theory of gravitation published in 1916. Ricci was thereupon elected to a full fellowship of the National Academy of the Lincei, the last honour he received being his election to the Pontifical Academy in the year of his death, 1925.

For some fifteen years following 1916, the tensor calculus occupied a central place in mathematical research. Levi-Civitá's definition of infinitesimal parallelism in 1917 led to wide developments in differential geometry, these being coupled initially with the search for a satisfactory unified theory of gravitation and electromagnetism. At the same time the calculus was seen to apply to a number of classical physical theories, and notably to electromagnetism (as noted by Einstein and Grossmann in 1913), dynamics and elasticity. In recent years it has also been applied to network problems in electrical engineering; but this development has not gained universal acceptance among those interested.

To-day, in 1953, some knowledge of tensor analysis forms part of the ordinary intellectual equipment of most mathematicians and physicists. An account of it is usually included in university undergraduate courses, and numerous introductory books are available for those who want a working knowledge of it*. Most of these books contain chapters upon its physical applications, so the question may well be asked whether, for the physical sciences, the tensor calculus merely provides a convenient notation, or whether it is essential to them.

There is no need to dally over the word 'merely', since a good notation is a thing of value in itself. General tensor analysis (as apart from the theory of Cartesian tensors, which is little more than an alternative to ordinary vector and dyadic analysis) certainly provides the best means at present available for dealing with covariance and contravariance and with absolute differentiation, concepts implicit in traditional physical theories and explicit in relativity.

In ordinary three-dimensional vector analysis, no distinction is made between the covariant and contravariant components of a vector. The distinction arises, however, the moment one abandons a rectangular frame of reference in favour of an oblique frame, since a second oblique system, the axes of which are respectively perpendicular to the co-ordinate planes of the first, immediately claims attention. If units of length are suitably chosen, the two systems are said to be dual or reciprocal to one another, and the components of a given vector with respect to the two frames are respectively called contravariant and covariant. This generalizes to spaces of any number of dimensions and assumes a special importance in relation to curvilinear co-ordinate systems in flat or curved spaces, the mesh-system at each point providing a local frame of reference which is, in general, non-rectangular.

The concept of absolute differentiation likewise arises naturally and unavoidably. Like a mathematical M. Jourdain, one may in fact find oneself differentiating absolutely without knowing it. For example, the absolute time-derivative of the radial-and-angular-velocity vector $(\dot{r}, \dot{\theta})$ in plane kinematics is not $(\ddot{r}, \ddot{\theta})$, but is $(\ddot{r} - r\dot{\theta}^2, \ddot{\theta} + 2\dot{r}\dot{\theta}/r)$, the extra terms arising because the radial and transverse directions, which at each point provide a local frame of reference, change as one goes from the point $(r, \theta)$ to the point $(r + \delta r, \theta + \delta\theta)$. This example is a special one not only because it is concerned with a particular co-ordinate system in a particular space (a Euclidean plane), but also because the local frames are rectangular, the radial and transverse directions at any point being orthogonal. The intrinsic nature of absolute differentiation shows itself even more forcibly in connexion with general curvilinear co-ordinate systems, whether in Euclidean or in some more general space. The value of a calculus that deals simply and simultaneously with covariance, contravariance and absolute differentiation, in spaces of any number of dimensions, flat or curved, scarcely needs further demonstration. It is to be observed, too, that the relativistic principle of covariance, namely, that the general laws of physics can be expressed in a form which is independent of the co-ordinate system, has a meaning only in so far as there exists a way of expressing them in such a form. The Ricci calculus provides a means of doing so. Local frames are frequently used in relativity under the guise of local Galilean spaces of individual observers.

For a short time in 1928, the tensor calculus seemed, after all, inadequate for the expression of all general physical laws, since Dirac's relativistic equations for the electron did not obey the ordinary tensor laws of transformation. This led to the definition of a new kind of tensor, a spin-tensor or 'spinor', and to a significant development of the Ricci calculus, Dirac's equations thereby being brought into the covariant fold. Some time later it was shown that certain combinations of Dirac's equations, mathematically fully equivalent to the original set and expressible without the use of spinors, did, in fact, transform according to the ordinary tensor law. This result was of no physical significance; but it did show, once again, the adequacy of the ordinary tensor calculus for the framing of physical laws.

A distinctive feature of the tensor notation is the conciseness lent to it by its use of indices. A rather more elaborate system than Ricci's own has been developed by J. A. Schouten, its chief merit being a systematization both of notation and of terminology. A third style, originated by Élie Cartan, cuts the use of indices to a minimum, and, through his calculus of forms, often dispenses with them altogether. Cartan's notation has proved of greatest value in such purely mathematical theories as his own generalized geometries, the theory of groups and generalized potential theory (harmonic forms and harmonic integrals). The present tendency is in favour of the greatest possible simplicity of notation, and index-manipulation is certainly no longer regarded as a suitable full-time occupation for mathematicians. But the tensor calculus is fully established as one of the main instruments of modern mathematics, and gives to its inventor a permanent place in the history of the subject. The verdict of 1901 no longer stands.

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* Books published since the end of the Second World War include Taylor, J. H., "Vector Analysis with Introduction to Tensor Analysis" (Prentice Hall, New York, 1947), Michal, A. D., "Matrix and Tensor Calculus with Applications to Mechanics, Elasticity and Aeronautics" (Chapman and Hall, 1947), Synge, J. L., and Schild, A., "Tensor Calculus" (University of Toronto Press, 1949); Lass, H., "Vector and Tensor Analysis" (McGraw-Hill, 1950), Sokolnikoff, I. S., "Tensor Analysis: Theory and Applications" (Wiley, New York, 1951), and Schouten, J. A., "Tensor Analysis for Physicists" (Oxford, 1951).

# OBITUARIES

## Sir Frederick Keeble, C.B.E., F.R.S.

FREDERICK WILLIAM KEEBLE, who died on October 19, was a biologist of great versatility who in his time was academic botanist, Civil servant, horticulturist with a flair for garden design, agricultural adviser to industry and, last but not least, a man who was a witty talker and one with marked literary gifts.

Keeble was born on March 2, 1870, and educated at Alleyn's School, Dulwich, and Caius College, Cambridge. After taking a degree in botany, he was appointed Frank Smart Student of the University of Cambridge, and spent a year in Ceylon on plant-physiological research. On his return to England, he became for two years assistant lecturer in botany at Owens College, Manchester. He was then appointed professor of botany at University College, Reading. where he stayed until, in 1914, he was made director of the Wisley Gardens of the Royal Horticultural Society. On the outbreak of war in the year of this appointment, Keeble was drawn away to war-work at the Board of Agriculture, where he became controller of horticulture in the Food Production Department. He did not, however, sever his connexion with Wisley until he became, in 1919, an assistant-secretary to the Board. While in this position, he did a great service to horticultural research, for it was with his support and encouragement that the constitution was drafted which, in 1919, gave East Malling Research Station its position as a separate independent institute.

He was soon, however, to resume academic work, for in 1920 he was appointed Sherardian professor of botany at Oxford. He held the chair for seven years; but after this there came a new phase in his career, for he was invited by Lord Melchett to become adviser in agriculture to Imperial Chemical Industries, Ltd. There his main concern was with the use of fertilizers, and under his direction the Company's experimental and research station at Jealott's Hill, near Bracknell, was developed. He resigned from his position with Imperial Chemical Industries in 1932.

The literary charm with which Keeble could invest a scientific subject was first brought home to his biological colleagues in a little book, published early in his career, entitled "Plant Animals", in which he described the behaviour of the curious animal, *Convoluta roscoffensis*, a heliotropic, chloroplast-bearing flat-worm inhabiting sandy tide-pools on the coast of Brittany. The same literary grace was also shown in the autobiographical "Polly and Freddie", which he published in 1936, and also in his articles in the *Gardeners' Chronicle*—a journal he edited during 1908–19. In addition to scientific memoirs, published mostly in the *Proceedings of the Royal Society*, he was the author of a number of other books—"Practical Plant Physiology", "Life of Plants" and "Fertilisers and Food Production".

Keeble was elected a Fellow of the Royal Society in 1913 and was knighted in 1922. He married in 1898 Matilde Maréchal, who died suddenly in 1915, leaving a daughter. In 1920 he married Lillah McCarthy, and while at Oxford they lived at Hamels, on Boars Hill. This was a place of great attraction, for the house was an old oak tithe-barn from Herefordshire adapted as a residence, and the garden, laid out by Keeble, one of great beauty.

Keeble had a quick mind and was a fluent speaker who could adorn his subject with wit and felicitous phrasing. Though on occasions he barbed his wit with sarcasm, he was essentially warm-hearted, as his friends knew well. For some modern scientific trends, such as mechanism, he had little sympathy. At a dinner held in his honour not long ago, he chose as the subject of his after-dinner speech the thesis, "The future of biology lies with the naturalist".

V. H. BLACKMAN

## Mr. J. A. Howe, O.B.E.

JOHN ALLEN HOWE was born on October 27, 1869, and died in his eighty-fourth year on December 11, leaving a widow and one son. He will be remembered by some of the older generation as the genial custodian of the old Museum of Practical Geology, 28 Jermyn Street, Piccadilly, London. This somewhat gloomy edifice, opened by the Prince Consort in 1851, was built not only to house the Geological Survey and its collections but also as a teaching and research establishment, particularly for natural history, chemistry, mining and metallurgy. Those classes ultimately grew into the Royal School of Mines and the Royal College of Science, which were later transferred to South Kensington, where they are now parts of Imperial College. They were followed there by their parent when the new Museum of Practical Geology in Exhibition Road was opened in 1935 to mark the centenary of the Geological Survey.

Howe, previously an assistant in the geological department of the Royal College of Science, joined the Geological Survey in April 1901. He served at first on the field-staff in Cheshire and in the London area, but in September 1902 was chosen to succeed Rudler as curator of the Museum. His early work was concerned with clays, roadstones and building stones, he maintained his interest in these materials almost to the last and was often consulted about them.

He was made assistant director of the Geological Survey, in charge of England and Wales, in October 1920, and continued in that post until his retirement in July 1931. The esteem in which he was held was marked by the award of the O.B.E. for his services to the Ministry of Munitions during the First World War, by the Bolitho Medal of the Royal Geological Society of Cornwall and by the presidency of the Institute of Mining and Metallurgy; he also served on the Council of the Geological Society of London.

Howe was a good companion, who will be missed, alas, by an ever-narrowing circle of friends and acquaintances.

T. EASTWOOD

## Mr. L. O. Newton

MR. L. O. NEWTON, who was honorary secretary of the Institution of Chemical Engineers for seven years, died on October 2 at the age of seventy. He was educated at Tiffins Boys School, Kingston-on-Thames, King's College (University of London) and the Sir John Cass Technical Institute. He served an apprenticeship with the Locomotive Co. of America and in 1902 became assistant works manager to the Locomotive Co. of Great Britain, Ltd. In 1907 he joined Lassen and Hjort, water purification engineers, and in 1912 became manager of Sofnol, Ltd., Greenwich, and from 1921 until his death was managing director. He was also retained as consulting chemical engineer to United Water Softeners, Ltd., London.

Mr. Newton had extensive experience in the manufacture of calcium hydrate, soda lime, etc. He practised as a consultant on industrial and domestic water supply and purification, trade wastes, air and flue gas purification and analysis.

Apart from his numerous scientific interests, Mr. Newton was also a member of Gray's Inn and brought to his position as honorary secretary of the Institution of Chemical Engineers invaluable help in all legal matters. He will be remembered by members of the Institution as a kindly and generous gentleman who did not stint himself in their service and who is sadly missed by all.

He is survived by his son, Mr. K. O. Newton; his widow, Mrs. V. Newton, only survived him by a few days.

WE regret to announce the following deaths:

Prof. Johan Bohm, director of the Research Institute for Organic Synthesis in Pardubice and associate member of the Czechoslovakian Academy of Sciences, on November 27, aged fifty-seven.

Mr. W. T. Gibson, O.B.E., chief valve engineer of Standard Telephones and Cables, Ltd., and manager of their Ilminster laboratories and factory, on December 27, aged fifty-three.

# NEWS and VIEWS

## New Year Honours List

THE list of New Year Honours conferred by H.M. the Queen contains the following names of scientific men and others associated with scientific work:

*Baron:* Lord Eustace Percy, rector of the Newcastle Division of the University of Durham during 1937–52;

*O.M.:* Prof. W. G. Penfield, professor of neurology and neuro-surgery, McGill University;

*G.B.E.:* Lord Brabazon of Tara, for services to civil aviation;

*K.B.E.:* Sir Patrick Laird, secretary, Department of Agriculture for Scotland;

***Knights:*** Dr. Harold Roxbee Cox, chief scientist, Ministry of Fuel and Power; Dr. Arthur W. M. Ellis, consulting physician, London Hospital, and emeritus professor of medicine, University of Oxford; Prof. William G. Holford, professor of town planning, University College, London; Prof. Harold Jeffreys, Plumian professor of astronomy and natural philosophy, University of Cambridge; Dr. Peter MacCallum, a member of the Medical Board, State of Victoria, and formerly dean of the Faculty of Medicine, University of Melbourne; Dr. James F. Mountford, vice-chancellor, University of Liverpool; Dr. Arthur Landsborough Thomson, second secretary, Medical Research Council;

*C.B.:* J. Buckingham, director of research programmes and planning, Royal Naval Scientific Service, Admiralty; Dr. W. H. Glanville, director of the Road Research Laboratory (Department of Scientific and Industrial Research); Dr. R. Spence, chief chemist, Atomic Energy Research Establishment, Harwell (Ministry of Supply);

*C.M.G.:* T. Hytten, vice-chancellor, University of Tasmania; R. C. Wakefield, director of surveys, Sudan Government;

*C.B.E.:* W. Cawood, deputy director, Royal Aircraft Establishment (Ministry of Supply); Prof. M. V. C. Jeffreys, professor of education, University of Birmingham; Dr. D. N. McArthur, director, Macaulay Institute for Soil Research, Aberdeen; Prof. A. Macbeath, professor of logic and metaphysics, Queen's University, Belfast; Prof. R. A. McCance, director of the Department of Experimental Medicine, Medical Research Council and University of Cambridge; J. Macdonald, director of research and education, Forestry Commission; G. S. Peren, principal of the Massey Agricultural College, New Zealand; H. J. Poole, chief superintendent, Armaments Research Establishment (Ministry of Supply); J. A. Smale, engineer-in-chief, Cable and Wireless, Ltd.; A. Turnbull, vice-chairman of the governors, Royal Technical College, Glasgow; C. J. Turner, chief engineer, Division of Atomic Energy (Production), Risley (Ministry of Supply); L. C. Tyte, deputy chief scientific officer, Fort Halstead (Ministry of Supply).

## Sir Hans Sloane, Bart. (1660–1753)

SIR HANS SLOANE, who died two hundred years ago, on January 11, 1753, is a striking example of a man upon whom the highest scientific honours were bestowed but who made no solid contributions to scientific knowledge. He was born at Killyleagh, County Down, Ireland, on April 16, 1660, and at the age of sixteen developed symptoms of pulmonary tuberculosis, so that for more than seventy-five years he had to lead a temperate life. He studied botany and medicine in London, Paris and Montpellier, obtained the M.D. of the University of Orange in 1683, and on his return to London lived with Thomas Sydenham, the 'English Hippocrates', who taught him practical medicine. At twenty-five he was elected to the Royal Society, and in 1687 a Fellow of the Royal College of Physicians. That same year he went to the West Indies as physician to the Duke of Albemarle, governor of Jamaica, but returned within eighteen months, after the duke's death, bringing back eight hundred different species of plants, of which he published a catalogue in Latin. He soon became a fashionable doctor in Bloomsbury Square, served as physician to three successive sovereigns—Queen Anne, George I and George II—and was the first medical practitioner to receive a hereditary title in 1716. He was president of the Royal College of Physicians during 1719–35. He introduced Peruvian bark into British medicine and popularized inoculation against smallpox. His association with the Royal Society was long and distinguished. In 1693 he was appointed secretary and revived the publication of the *Philosophical Transactions*, and in 1727 he succeeded Sir Isaac Newton as president, holding office for fourteen years. His best-known work, "A Voyage to the Islands of Madera, etc." (1707) was responsible for his election to the Paris Academy of Sciences. Sir Hans Sloane is remembered in history as a great collector, whose books, manuscripts and curiosities went to form the collection which was opened to the public in 1759 as the British Museum. In 1712 he purchased the manor of Chelsea, and to this day his memory is kept green by Sloane Square, Sloane Street and Hans Place. In 1721 he founded for the Society of Apothecaries the botanic garden at Chelsea. He retired from practice in 1741, and died twelve years later at the advanced age of ninety-three.

### American Association for the Advancement of Science: Prize Awards

THE Newcomb Cleveland Prize of the American Association has been awarded to Dr. Andrew M. Gleason, assistant professor, Department of Mathematics, Harvard University, for his paper on "Natural Co-ordinate Systems". This is the twenty-fifth award of this Prize, which is worth 1,000 dollars, and is made at the annual meeting of the Association for a paper presented as part of the meeting which represents an outstanding contribution to science.

A prize of 1,000 dollars for an essay on theoretical sociology, provided by a donor who wishes to remain anonymous, was offered by the American Association for the first time in 1951; none of the entries was considered adequate, and no award was made. The prize was offered again for 1952, for essays reporting upon inquiry into the theory of social processes and group behaviour, and has been awarded to Dr. Arnold M. Rose, Department of Sociology, University of Minnesota, for his paper on "The Theory of Social Organization and Disorganization". There were some sixty entries. Dr. Rose, who is thirty-two, was associate professor of sociology in Washington University, St. Louis, during 1947–49, and is now associate professor of sociology in the University of Minnesota; he held a Fulbright Fellowship in France during 1951. A series of papers submitted by Stuart C. Dodd, director of the Washington Public Opinion Laboratory, University of Washington, was given honourable mention.

### Oceanographical Exhibition in London

AN exhibition entitled "Exploring the Sea", which has been organized by the Royal Geographical Society and the National Institute of Oceanography, with the co-operation of the Hydrographic Department of the Admiralty, the Institute of Navigation and the British Museum (Natural History), was opened on January 3 at the Royal Geographical Society, Kensington Gore, London, S.W.7; the exhibition will remain open to the general public, admission free, until January 31 (10 a.m.–6 p.m., Sundays excepted). The object of the exhibition is to show how recent scientific developments have very much increased our knowledge of the underwater world, and the display has been arranged in three sections corresponding to work in the three principal fields of oceanographical exploration: "Exploring the Sea Bed", "Life in the Sea" and "The Moving Ocean". In the first section are included an instrument for recording sea temperatures photographically, a deep core, and the equipment for refraction shooting; a deep-sea echo sounder on show is arranged to measure variations of depth in a tank of water. In the section on life in the sea there are many specimens of plankton, a new plankton recorder, and different types of water bottles for taking samples and the temperature of water at depth. In the third section the effect of wind on waves is shown in a model; other exhibits include a working wave-recorder and instruments which record erosion and the graduation and profile of beaches, and current meters and tide recorders, which show how direct measurements of water movements are taken.

### Polymer Science: Seminar in University College, London

EIGHT lectures were given at a seminar on "Polymer Science", held in the Chemistry Department of University College, London, during October 24–December 5, 1952, and they can be classified under three headings: mechanism of formation of polymer, methods of establishing homogeneity, size and shape of polymer; and properties and reactions of macromolecules. In the first section, Dr. C. H. Bamford dealt with the general background of polymerization kinetics and with a study of some co-polymerizations from which it follows that the reactivity of a growing polymer is not solely determined by the terminal grouping. Factors were also discussed which influence the course of polymerizations under conditions such that polymer precipitation occurs. In the second section, Dr. R. A. Kekwick and Dr. P. Johnson reviewed theories and experimental details of the ultracentrifuge, electrophoresis and light-scattering measurements. Methods of determining the shape of macromolecules, particularly proteins, were indicated by Dr. A. Elliott and Dr. C. Robinson, who discussed results obtained with the help of polarized infra-red radiation and a new type of space-filling molecular models. The models are useful for demonstrating stiffness or flexibility of macromolecules. In the third section, on the properties and reactions of macromolecules, Dr. L. R. G. Treloar lectured on statistical thermodynamics of polymer – liquid interaction. Difficulties were pointed out which prevent the straightforward extension of the Flory–Huggins treatment to such systems as water and polar fibrous materials. Furthermore, the influence of external stress on equilibrium swelling was discussed. G. Stainsby, M. L. R. Harkness and Dr. A. Wassermann described the properties and reactions of ash-free gelatin and actomyosin. Prof. M. Stacey dealt with chemical and immunological properties of degraded dextran. Methods for breaking down these macromolecules and for fractionating the resultant products were also outlined. Each of the eight lectures was followed by a discussion, which was facilitated by making available, in advance, short abstracts indicating not only the main topic, but also the general background and important literature references.

### Application of Science in the Textile Industries

THE inaugural lecture "Science in Industry" which Sir Ben Lockspeiser delivered in the new premises of the Textile Institute, Manchester, on October 24, emphasized that the application of science to industry is the primary means of providing the power of adaptation to new conditions on which the economic survival of Great Britain depends. After illustrating this by reference to the part science has played in the introduction and application of the new man-made fibres and their effect on the older fibres, Sir Ben turned to the importance of the small firm in the effective application of science to industry. A recent survey in a small town engaged mainly in the light industries showed that only one-third of the firms had anyone with a special responsibility for advising on scientific and technical problems, and only half of these advisers had any technical qualifications. Sir Ben believed that a survey being conducted in the Manchester area would show that it is rare for textile firms employing five hundred people or less to employ a science or engineering graduate: only in the few firms with a thousand or more employees are scientific workers to be found in reasonable strength.

Sir Ben pointed out that the research associations in Britain are largely intended to help these smaller firms, and he went on to emphasize the wealth of opportunity in the exercise of craftsmanship to be found in this machine age if only it is recognized that the secret of craftsmanship lies in finer and finer control of the machine and in the apt choice of materials that goes with the knowledge of their properties. The extent to which exploitation is made of the vast field offered to the scientific worker and craftsman in fabrics manufactured from natural and mixed fabrics largely depends on the size and status of the textile industry. Success will depend on the knowledge of the materials being used, the appropriateness of machinery that is possessed for their utilization, and the instrumental aid which can be provided to enable the man at the machine to satisfy his creative instinct for craftsmanship. Such considerations, Sir Ben thought, are particularly important in industries that have grown from handcraft. He also suggested that the time spent on discovering the principles on which manufacture in the textile industry rests provides the surest basis for the solution of future problems, and creates the intellectual climate which promotes discovery and the growth of new ideas. It is in the utilization of results coming from the research associations that the Textile Institute is specially important, and on its members rests a large share of the responsibility for seeing that methods now available for the more economical use of materials and for quality control in mills and factories are used.

## Seed Health in Flax

Prof. A. E. Muskett, of the Faculty of Agriculture, Queen's University, Belfast, read a paper before Section K (Botany) of the British Association at its meeting in Belfast, in which he reviewed developments in the treatment of flax against seed-borne disease. A considerable number of such troubles include those caused by the fungi *Polyspora lini*, *Colletotrichum linicola*, *Botrytis cinerea*, *Fusarium lini* and *Phoma* sp. Seed-borne diseases of flax brought very considerable losses of yield during the First World War. The later discovery of organo-mercurial dusts did not solve the problem on flax as it did for cereals. 'Short-wet' methods were used, but eventually tetramethylthiuram disulphide ('Nomersan') was found to be the most effective seed-dressing. Prof. Muskett, however, went a stage further, and, using his 'Ulster' plating method, made a wide survey of the natural health of seed produced in various regions. This intensive work has now been continued for ten years, and shows that seed from the southern and eastern parts of Britain has little seed-borne disease. Larger yields of seed are, moreover, usually obtained in these drier and warmer areas. This simple but effective finding has been fully justified in practice, and the seed used in Northern Ireland is now all obtained from the south and east of England. The only disease fungus which is seed-borne to any extent from these areas is *Botrytis cinerea*, and that is dealt with by routine seed treatment. It is obviously much better to start with naturally clean seed than to treat diseased samples, and the results of this object lesson might well be applied to other crops and in other areas.

## Microbial Genetics at the University of Glasgow

The Nuffield Foundation has made a grant of £6,000 over three years for the expansion of research in the Department of Genetics, University of Glasgow. The grant will be used mainly for fellowships. It will make it possible to increase the research team working under Dr. G. Pontecorvo in microbial genetics. The approach followed in the past few years in the Department has been mainly that of making use of the resolving power of genetic analysis in order to get some insight into the details of biochemical organization of the cell. It is hoped that a strengthening of the team especially on the biophysical side may lead to useful advances.

## Canadian National Research Council Scholarships

The National Research Council of Canada intends to award about two hundred postgraduate scholarships which will be available without restriction of nationality for study in the fields of science and engineering during the year 1953–54. The majority of the awards will be tenable at Canadian universities and are divided into bursaries, studentships and fellowships worth, respectively, 600, 900 and 1,200 dollars each; they may be increased by an extra 500 dollars for the summer months. Bursaries are for graduates who have no previous research experience, studentships for those with at least one year of research, and fellowships for those in their last year of work for a Ph.D. About twenty of the awards will be tenable outside Canada and are divided into special scholarships for those who either have completed or are completing their work for a master's degree, and postdoctorate overseas fellowships for specialized training; the former are worth 1,500 dollars and the latter 2,500 dollars for twelve months. Applications should be made before February 1 to the Awards Officer, National Research Council, Ottawa 2.

## Announcements

The Institution of Mechanical Engineers has awarded its James Watt International Medal for 1953 to Sir Harry Ricardo, for his contributions to knowledge of the fundamental principles of internal combustion engines and the application of these principles to design and development. This Medal, which is in gold and is the highest honour that the Institution can bestow, is awarded every two years, and for it the Institution has the co-operation of the principal engineering institutions and societies in all parts of the world as nominating authorities.

The Council of the Royal Society has awarded two Mackinnon research studentships to the following: R. C. Jennison, of the University of Manchester, for work on radio astronomy at the Jodrell Bank Experimental Station; and Dr. F. K. Duxbury, of King's College, Newcastle upon Tyne (University of Durham), for work on organic chemistry at the University of Liverpool.

The American Association of Spectrographers is planning a symposium on "Emission Spectroscopic Determination of Metals in Non-Metallic Samples", to be held in Chicago on May 1. Papers in the fields of petroleum, geology, agriculture, pharmacy, biology, ceramics, etc., are invited. All inquiries should be directed to the chairman of the symposium committee, J. P. Pagliassotti, c/o Standard Oil Company (Indiana), Box 431, Whiting, Ind.

# SOIL FERTILITY AND CROP PRODUCTION

## MEETING IN DUBLIN

A JOINT meeting of Commissions 2 (Soil Chemistry) and 4 (Soil Fertility and Plant Nutrition) of the International Society of Soil Science was held in Dublin during July 21–31, 1952, under the auspices of the Irish Department of Agriculture, with Prof. F. Steenbjerg (Royal Veterinary and Agricultural College, Copenhagen) as chairman. The meeting was the outcome of a resolution passed at the Fourth International Congress of Soil Science, held in Amsterdam in 1950, when it was agreed that a need existed for a meeting to discuss as fully and critically as possible present techniques for the evaluation of soil fertility in relation to improved crop production. This was taken as the basis for the Joint Commission meeting, and some 148 soil scientists attended, representing universities, agricultural colleges, research institutes and government departments in many countries. The Vatican, the United Nations Food and Agriculture Organization, the Organization for European Economic Co-operation and the Mutual Security Agency sent observers.

Indoor sessions were held in University College, Dublin, during July 21–26, and were followed by a tour to places of agricultural and scientific interest in the south and west of Ireland during July 27–31. More than a hundred delegates joined in this tour. At the end of the meeting tributes were paid by various speakers to the Irish Department of Agriculture, for the success which attended the various sessions was in no small measure due to the fine work which the Department had done on the organization side of the meeting.

An introductory paper on the evaluation of soil fertility was read by Dr. E. M. Crowther (deputy director, Rothamsted Experimental Station). In his paper, which summarized many important aspects of the investigations on soil fertility, Dr. Crowther pointed out that the approach to soil fertility problems requires integration of several lines of investigation generally undertaken by separate groups of specialists. He listed these as the study of chemical, physical and microbiological characteristics of soil and of the physiology and biochemistry of plants; the characterization of soil and climatic conditions; the examination and improvement of farming systems; and the production and application of increasing quantities of better and cheaper fertilizers and liming materials. Dr. Crowther also stressed, as a priority need, the proper grading of laboratory tests for nutrients by proper field experiments.

The detailed work of the meeting was then divided between three sections. Section *A* dealt with laboratory techniques for assessing the nutrient status and nutrient-supplying potential of soils. This Section was divided into six different sessions. Section *B* dealt with plant and field techniques used in, and applicable to, the evaluation of soil fertility and was divided into two sessions. Section *C*, which dealt with correlation and general inquiry, was divided into three sessions. In all, eleven sessions were held. Each session was opened by a major review paper and two supporting papers dealing with important aspects of the subject-matter of the session. These papers were available in printed form in Vol. 1 of the Transactions of the meeting, and, consequently, it was possible to dispense to a very considerable extent with formal reading of papers and to devote the maximum amount of time to discussion. While in some instances discussion was along the lines of prepared papers, in the great majority of cases it was of a spontaneous nature. This procedure proved most successful, and the meeting was characterized by very lively and valuable debates. More than fifty additional papers and a summary of the discussions will be published shortly in Vol. 2 of the Transactions.

In Session 1, on organic matter and nitrogen, which was under the chairmanship of Prof. H. J. Page (lately principal of the Imperial College of Tropical Agriculture, Trinidad), the major review paper was given by Dr. H. H. Lees (University of Aberdeen), who paid particular attention to the importance of assessing the activity of carbon and nitrogen in soils in relation to fertility studies. In the supporting paper, Dr. G. Drouineau (Antibes Research Station) summarized researches on nitrogen in the south-east of France, and in another supporting paper Dr. J. Tinsley (University of Reading) reviewed the methods for estimating the organic matter status of soils. Many valuable contributions were made to the discussion, and it is obvious that there has been a considerable reawakening of interest in this sphere of study.

A considerable amount of work has been proceeding on methods aimed at assessing the phosphorus status of soils, but the fact that much still remains to be done in this field was made especially obvious during Session 2, which dealt with phosphates, and was presided over by Prof. J. A. Prescott (director of the Waite Agricultural Research Institute, Australia). The major review paper, on evaluating the phosphorus status of soils, was given by Dr. E. G. Williams (Macaulay Institute, Aberdeen), particular attention being paid during this paper to modern concepts of fixation processes. Dr. Williams stressed the need for an adequate programme of field experiments in evaluating the phosphorus status of soils. In a supporting paper Dr. L. A. Dean (Bureau of Plant Industry, Soils and Agricultural Engineering, United States Department of Agriculture, Beltsville) dealt with the use of radioactive phosphorus in evaluating soil fertility, and described in particular the usefulness of the 'A' value method as an index of the phosphorus fertility of soils. Other aspects of the use of phosphorus-32 in the study of soil phosphorus behaviour were dealt with by Dr. G. Barbier (Station Centrale d'Agronomie, Versailles), and a considerable amount of the discussion which followed centred around the use of this technique.

Session 3, with Prof. T. Wallace (director of the Long Ashton Research Station, Bristol) as chairman, was devoted to a consideration of various aspects of the potash status of soils. A review paper on the availability of native and fixed non-exchangeable soil potassium was read by Dr. R. F. Reitemeier (Bureau of Plant Industry, Soils and Agricultural Engineering, Beltsville), in which various extracting techniques were appraised and the role of non-exchangeable potassium discussed. The role of clay minerals in potash fixation was dealt with by Dr. S. Henin (director of research, Laboratoire des Sols, Versailles), and Dr. F. Alten (Hanover) discussed some fundamental aspects of the potassium nutrition of plants.

The recurring problems associated with the determination of lime requirements in the soil were fully discussed in Session 4, under the chairmanship of Dr. P. Bruin (acting director-in-chief, Agricultural Experimental Station and Institute for Soil Research, Groningen). This subject was introduced by Prof. S. Tovborg Jensen (Royal Veterinary and Agricultural College, Copenhagen), who examined important aspects, both practical and theoretical, of the determination of the lime requirement of soils, illustrating his remarks with the results of classical Danish experiments in this sphere. In a paper on a biological approach to soil acidity, Dr. E. J. Hewitt (Long Ashton) indicated the various factors associated with the soil acidity complex, and Dr. G. E. Smith (University of Missouri), in presenting a paper by Drs. Albrecht and Smith on soil acidity as calcium (fertility) deficiency, gave the basis of an approach which is gradually gaining considerable strength where the proper liming of soils is concerned. Though the work of this session indicated that a number of questions of outstanding practical importance still remain to be resolved in this sphere, it was clear that many of the seemingly conflicting ideas on lime requirement problems can easily be reconciled in terms of soil-type characteristics and plant requirements.

Session 5 (chairman, Dr. Henin) was a lengthy one and was devoted to consideration of methods for determining the magnesium and minor-element status of soils. The major review paper was read by Mr. W. Morley Davies (Ministry of Agriculture and Fisheries, Great Britain), and Dr. F. C. Gerretsen (Groningen) and Dr. E. B. Davies (Soil Research Station, Rukuhia, New Zealand) contributed supporting papers. These papers showed that much still remains to be done in the field of analysis of trace elements in soils, but considerable progress was reported by many of the delegates present. In this connexion the New Zealand approach, as outlined by Dr. Davies, where work on trace elements has been closely related to soil type, provides a very fine example of what the proper integration of research in this field can accomplish.

With Dr. R. K. Schofield (Rothamsted Experimental Station) presiding, Session 6, which was on the subjects of base exchange, nutrient balance and interactions, was notable for the attention which it focused on the importance of ion activity in evaluating soil fertility. This matter was fully discussed in the review paper by Dr. A. C. Schuffelen (Wageningen), and a paper on various aspects of the release and absorption of nutrients was presented by Prof. Wiklander (Royal Agricultural College, Uppsala). Prof. M. M. Elgabaly (Alexandria), in a supporting paper, discussed various aspects of nutrient element balance, pointing out the distinction which must be made between nutrient balance effects as determined in culture solution and soils. From discussions which followed, it was apparent that, with the development of new analytical techniques and a more thorough understanding of physico-chemical reactions, considerable advances in this field may be expected.

Session 7, presided over by Dr. Crowther, dealt with field experiments and pot culture techniques. Dr. F. Van der Paauw (Groningen), in a major review paper, outlined the methods in use for evaluating the nutrient status of soils by field experiments. This theme was further elaborated by Dr. H. L. Richardson (Central Agricultural Control, Imperial Chemical Industries, Ltd.), who illustrated his discussion by results from an elaborate series of field experiments directed by him in China. The resulting discussions were particularly valuable. Dr. J. W. S. Reith (Macaulay Institute) directed attention to the necessity for basing the evaluation of soil testing methods on further field experiments carried out on soils belonging to well-defined series. Pot culture techniques in evaluating soil fertility were dealt with by Prof. E. von Boguslawski (Germany), and a discussion on this subject attracted considerable attention.

In present-day work the diagnosis of soil fertility through plant diagnostic methods has come to play a very important part. This approach was fully discussed in Session 8 under the chairmanship of Prof. Steenbjerg. Prof. Wallace, who has been responsible for much of the work in this sphere, outlined in a major review paper the various methods used, and pointed out the necessity for a thorough understanding of soil characteristics for proper application of these methods. Dr. W. A. Roach (East Malling Research Station) discussed the various factors coming into play in the diagnosis of mineral deficiency by plant analysis and plant injection. The discussion which followed showed clearly the extent to which reliance is now being placed on this line of approach in many countries. In concluding this session, Prof. Steenbjerg directed attention to the importance of discriminating between extreme physiological disorders as determined in sand and water cultures and those mainly of a threshold nature which are observed under field conditions.

The extent to which soil test data can be used to evaluate soil fertility needs on a broad basis was discussed in Session 9, Prof. H. Kuron (Germany) being in the chair. The major review paper in this session was presented by Dr. W. L. Nelson (North Carolina State College), who dealt with soil test summaries and their usefulness to various workers engaged in the agricultural research and extension services. The supporting paper in this session was contributed by Dr. H. Riehm (Augustenberg, Germany), who discussed the value of the results of several million soil tests which had been carried out in Germany. Another aspect of survey work was discussed by Dr. L. de Leenheer (Ghent), who dealt with the determination of productivity ratings for different soil types. This is an aspect of the investigation of soil fertility which is attracting considerable attention and which must play an increasingly important part if soil survey is to be of increased value to agricultural technology.

Session 10 was devoted mainly to the consideration of methods used in soils advisory services in various European countries and presented the first systematic attempt to bring together an account of the techniques used. Dr. Nelson presided over this session, which was opened by a paper from Dr. K. A. Bondorff (Lyngby, Denmark) on the evaluation of soil analysis. Papers were presented describing the methods used in almost all European countries, and these, when finally published, should prove a valuable reference for workers in this field.

Session 11 was devoted to a discussion on general correlation, with Dr. P. H. Gallagher (University College, Dublin) as chairman. Dr. Bruin, in this session, outlined the development of soil fertility research in the Netherlands, being supported by a paper from Prof. Steenbjerg on general questions affecting the verification of chemical soil and plant analyses. These papers paid particular attention to yield curves and to various factors influencing the shape of such curves. The final supporting paper in this session was given by Prof. Prescott, who stressed the necessity for basing the solution of soil fertility problems on a full understanding of climatic and geochemical factors. In this connexion it would seem that the total analysis of soils may be considerably more important, especially where trace elements are concerned, than they are generally acknowledged to be.

The meeting was brought to a close in a session presided over by Prof. Steenbjerg, when certain proposals concerning international collaboration in the sphere of soil fertility were considered.

During the meeting a short tour took place in the adjoining counties of Kildare and Meath, where delegates inspected field experimental work, typical County Meath pasture land and peat bogs used for electricity generation. The tour, following on the indoor sessions, was designed to include experimental work relevant to the subject-matter of the discussions during the meeting, together with experimental work on liming problems, soil type characteristics in relation to phosphate and potash utilization, and trace element relationships, especially in connexion with livestock nutritional problems. During the tour an opportunity was provided of seeing some of the major soil series on which the agriculture of the country is based. A visit to an area in County Limerick where selenium toxicity is an important factor in livestock nutrition was of special interest. Visits to the Albert Agricultural College, Glasnevin, and Johnstown Castle Agricultural College were included; at the latter a day was spent examining the field experiments and the laboratories where routine soil testing is carried out on a considerable scale. An opportunity was also provided of seeing land reclamation and drainage units of the Department of Agriculture in operation.

T. Walsh

# THE BRITISH COUNCIL

## REPORT FOR THE YEAR 1951–52

The eighteenth report* of the British Council, covering the year ended March 31, 1952, again records a reduction in grants from United Kingdom funds, which for 1951–52 stood at £2,750,000, one-third being for work in the British Commonwealth, as compared with one-fifth four years ago. Of the Commonwealth expenditure, £365,000 came from the Commonwealth Relations Office and £523,000 related to the Colonies; of that sum, £80,000 from the Colonial Development and Welfare Fund was towards the welfare of overseas students in the United Kingdom. One section of the report gives a clear account of this important work among overseas students, of whom there are now more than five thousand from Colonial territories, as many more from India, Pakistan and Ceylon, and almost an equal number from other countries. For all such students the Council provides a programme designed to help them in their leisure time to meet people in Britain, to study the country's ways of life and modes of thought, and to help them to understand what has made and makes the British the people that they are. The London centre at 3, Hanover Street has a membership of more than eighteen hundred students representing a hundred and four countries, with an average daily attendance of two hundred and three hundred and fifty at the week-ends. The London hostels managed by the Council now accommodate two hundred and twenty men and thirty-five women out of more than two thousand five hundred Colonial students in London. Temporary residents at the Hans Crescent residence totalled nearly nine hundred in 1951, and permanent accommodation was found during the year for 1,071 overseas students, including 900 from the Colonies; for students outside London, the figures were 1,604 and 771, respectively. Accommodation in private lodgings was found for 538 overseas students in London and for 1,084 outside London. Some 2,600 students were met on arrival, and 5,504 attended Council centres.

The grants for work relating to foreign countries were reduced by 16·4 per cent to £1,862,000, and a further 9·0 per cent reduction in the estimates for 1952–53 brings the total reduction in five years to 42 per cent, the devaluation of sterling and rising prices abroad making the effective reduction in terms of work considerably higher. The Colonial Office Vote represents a reduction of 16·4 per cent since 1947–48, and the Commonwealth Relations Office Vote a reduction of 12·6 per cent on the peak year 1950–51. Together the reductions for 1951–53 have involved a diminution of 26 per cent in established posts, making 43 per cent since 1946–47. Expenditure in Latin America has been reduced by 41 per cent by closing the Council's own offices and reducing supply services. Except in Yugoslavia and in Germany, work in Europe has been substantially reduced, with the closure of all French provincial services and of the institutes at Turin, Venice, Valencia and Bilbao. The work in Egypt has been substantially reduced, and offices closed in Melbourne and Canberra as well as the institute at Aden, and three offices and centres in the United Kingdom have been similarly cut down. All supply services have been drastically reduced, notably expenditure on publications, lectures, books, periodicals and scholarships; about one-third of this expenditure is concerned with the sciences, including medicine and agriculture.

Work in the Middle East during the year has on the whole been encouraging. Although most of the twenty thousand volumes in the library in Cairo were lost by fire during the January riots, new premises for the British Institute and the Council's offices have been found, and reference is made to the part which the Council is playing in technical assistance throughout the Middle East, notably by bringing young men from the Middle East to the United Kingdom under its bursaries scheme or by giving assistance to the governments of those countries in placing their own nominees for training. Technical visits to Britain are also arranged for senior officers and specialists for short periods of study; and the Council's advice and help have been sought in recruiting British technicians to supervise training.

The present report includes a section dealing with the libraries of the Council, which now contain nearly nine hundred thousand volumes and are claimed to be the most far-flung network in the world. The Council's libraries in foreign countries are essentially special libraries, in which a high place is given to works on the English language and its teaching and to English literature of all periods, but which are also strong on subjects that fall into the framework of British civilization and institutions. In science, medicine and technology the tendency is to concentrate wholly on those aspects in which the British contribution has special significance for the country concerned. Expenditure on the purchase of books has fallen from £81,000 in 1947–48 to less than £20,000 in 1951–52, and of the latter sum only £1,500 was for books presented to other libraries (virtually all in the Colonial territories) compared with £19,000 in 1947–48, of which more than a half was for foreign countries. The scope of the Council's library activities in the Colonies has been restricted since 1948, but the report comments on the difficulty of keeping libraries supplied with new books on a budget a quarter of its size five years ago and with prices rising steeply: gaps left by years of scarcity are for the most part unfilled. Statistics for the stock, issues and membership of the Council's libraries are appended to the report. There are some remarkable variations in the ratio of book stock to monthly issues. Rio de Janeiro and Cairo, each with approximately 21,000 volumes, have monthly issues of 165 and 1,600, respectively. Ibadan and Zagreb issue 1,275 and 1,118 volumes monthly out of a stock of 3,000, while Barcelona issues 4,207 volumes monthly out of 10,000, Bandung (Indonesia) 2,124 out of a stock of 6,000, and Madras 1,709 out of 3,800. Only 44 out of Nairobi's 1,500 volumes, and 60 out of Blantyre's 1,200 volumes are issued monthly; there would seem to be room for some inquiry as to whether all the libraries are worth maintaining and whether the resources of others should be extended.

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* Report on the Work of the British Council for the Year ended 31st March, 1952. Pp. 104. (London: British Council, 1952.)

# NEW ZEALAND DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH

## REPORT FOR THE YEAR 1951–52

THE twenty-sixth annual report* of the Department of Scientific and Industrial Research, New Zealand, covers the year ended March 31, 1952, during which no expansion of activities was possible and those of many branches were curtailed in consequence of a restriction in the financial vote. Net expenditure for the year was £1,036,581, and, while the recruitment of scientific staff was exceptionally low, losses of experienced staff were high, although partly offset by the return from overseas of men who had completed advanced studies in various fields. The total staff on March 31, 1952, was 1,012, including 402 professional and 354 technical workers. Achievements of the year stressed in the secretary's report include the completion of geological surveys of the four main coalfields; very extensive coal-measures found in the Kaitangata field are of special interest. Surveys in North Auckland have indicated the rock formations associated with good and bad prospects for securing water supplies for farm purposes, while geological and geophysical investigations have located a hot area at Wairakei sufficiently promising for the inauguration of a development programme to prove the existence of a steam potential capable of generating 20,000 kW. Chemical investigations indicate that the steam has a low content of gas and is free from corrosive properties. An efficient geothermograph has been designed and constructed to measure temperatures at depth in bores.

Research on spontaneous combustion in wool cargoes indicates that the fires are confined to wools removed from skins by a bacterial process. These often contain a high percentage of body fat, and this potential source of danger can at present only be overcome by a very thorough scouring of the wool. The solution of this problem would save thousands of pounds annually. Following the discovery of the causal agents of the yellow-leaf disease of *Phormium*, it has now been found that the insect vector may be killed in all its stages by flooding areas growing New Zealand flax to a depth of two to three feet for fourteen days. Yellow-leaf disease has halved the production of flax fibre since 1938, and this advance promises to save almost the whole industry.

The nutritional value of the branched-chain acids discovered earlier in butter-fat is now being investigated, and accurate information on the changes in butter-fat composition that occur during the season has been obtained for the first time. A system for the certification of plant hormone sprays, based on the experimental work of the past few years, has now been established and is regarded as of considerable economic importance both in protecting growers from losses incurred in misapplication and in assisting manufacturers in production. Broad correlations revealed between soil types and tree-growth characteristics in soil surveys of the Kaingaroa Plains are expected to assist the State Forest Service in its development of the timber resources of this area as well as timber production, management and utilization elsewhere. The efficiency of boric acid in controlling *Ambeodontus*, the New Zealand wood-boring insect second in importance to *Anobium*, was proved during the year, and New Zealand timbers used for building and furniture can now be proofed against the three prevalent boring insects by treatment with boric acid.

In the tobacco industry use of methyl bromide as a soil sterilizer in seedling beds appears likely to supplant to a large extent the present costly and cumbersome steam sterilization operation. Striking results have been obtained in reducing the growth of laterals when tobacco plants have been topped by spraying the upper leaves with certain chemicals such as maleic hydrazide and mineral oil. Both discoveries promise considerable savings to the tobacco industry, while a new sample survey method of collecting agricultural and pastoral statistics designed by the Applied Mathematics Laboratory is expected to reduce markedly the costs incurred by the Census and Statistics Department in collecting this information. Investigations in the Dominion Physical Laboratory of a number of enclosed domestic stoves burning solid New Zealand fuels have shown that efficiencies of 45 to more than 70 per cent can be obtained, with proper design and control, compared with 10–15 per cent with the ordinary open-hearth fire. Since the cost installed does not exceed that of the ordinary chimney and grate, considerable savings should be possible in the use of coal for domestic heating. Radioactive cobalt and iridium have been used in the X-ray examination of welded metals and castings and in testing steel conduits for hydro-electrical installations. Further work by the Leather and Shoe Research Association on the modification of New Zealand fish liver oils for the production of chamois leather has yielded a process for utilizing vegetable oils in oil-tanning which, besides producing stronger leather, enables white washable gloving leather to be obtained without bleaching. Bark from *Pinus radiata* has been proved to be a possible source of tannin, and the detrimental effect of high temperatures upon pickled pelts in storage and transport has been demonstrated. The investigations by the Pottery and Ceramics Research Association indicate that for ceramic manufacture deposits of ball clays from Canterbury, Otago and Southland are equal in quality to any such deposits found elsewhere in the world.

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* New Zealand. Twenty-sixth Annual Report of the Department of Scientific and Industrial Research. Pp. 84. (Wellington: Govt. Printer, 1952.) 1s. 9d.

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# OCEANOGRAPHY IN THE UNITED STATES

IN 1927 the United States National Academy of Sciences appointed a Committee to consider the share of the United States in a world-wide programme of oceanographical research. Much of the Committee's report was published in book form under the title "Oceanography: Its Scope, Problems and Economic Importance", by Henry B. Bigelow (1931). One of the major outcomes of the decisions of that Committee was the building and endowment of the Oceanographic Institution at Woods Hole, and there was a general all-round increase in marine research.

In 1949 a second Committee on Oceanography was established by the National Academy. The reason for the setting up of this second body was not lack of interest in oceanography. Owing to the recognition of the practical applications of oceanography during the Second World War, marine research had, in fact, flourished; but it was chiefly government sponsored. As a result of inflation and the heavy cost of maintenance of modern research ships and equipment, private endowments were entirely inadequate, and research could only continue at its present scale with heavy government support. The Committee considered that "the healthy growth of oceanography has been hampered by the uncertainty as to how long this support may be available, and by other restrictions". It was to report on this situation that the Committee was appointed. Its report, entitled "Oceanography 1951", is now published*.

As in the previous report, the relations of the science to biology, geology and meteorology, and certain recent notable advances, are surveyed. The advance in physical oceanography has been very striking. That this is so is largely due to the War, which has resulted in the provision of "a nucleus of 80 to 100 physical oceanographers in this country, compared with perhaps half a dozen prior to 1930. . . . More than half of the funds being expended for oceanographic investigations at the present time come from the Department of Defence".

The sea is a source of food, and it is necessary to ensure that research is also directed towards increasing the yield from the sea fisheries, as well as gaining knowledge useful in war. The annual yield of the world's fisheries is quoted as twenty million tons, giving only one-fiftieth of the total protein consumption, yet half the world's population has a diet seriously deficient in protein. The Committee considers that "Heretofore most fishery research programmes were attempted on too small a scale. This was due to lack of appreciation of the complexity and magnitude of fishery problems, so that insufficient funds were assigned to many projects". Recently, however, there have been large-scale attacks on certain problems, such as the causes of the disappearance of the Californian sardine; the potentialities of the pelagic fisheries of the central North Pacific; and the movements of the Gulf Stream.

But the Committee considers that oceanography is not developing in a well-balanced manner and that there is almost no financial support for general marine biology. It thinks that inadequate attention is being paid to many challenging problems which do not have military significance and do not bear on specific fisheries; and it feels that, in order to ensure more freedom of research into such basic problems, greater private financial support is needed. At the same time, government support on a liberal and far-sighted basis should be continued, to provide the large-scale co-ordinated effort which the size and complexity of oceanic phenomena demand. Through the United Nations and President Truman's Point Four Programme, the United States should also encourage the development of oceanography in other countries, and especially in the southern hemisphere and western Pacific. The Committee recommends the securing of private funds for the provision of research fellowships at existing oceanographic institutions; for facilities for visiting investigators; for the provision of more permanent posts; and to supply increased funds for operating ships and for basic research in biology and chemistry.

The present total income of institutions in the United States carrying out oceanographical research is about 2,300,000 dollars, four-fifths of which is supplied by the government. It is recommended that the additional funds from private sources should be between 500,000 and 750,000 dollars. This would bring the total annual expenditure on oceanographical research into the region of one million pounds sterling by those laboratories other than the Federal and State organizations.

F. S. RUSSELL

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* National Academy of Sciences—National Research Council. Publication 208: Oceanography 1951; a Report on the Present Status of the Science of the Sea by the Committee on Oceanography of the National Academy of Sciences. Pp. vii+36. (Washington, D.C.: National Academy of Sciences—National Research Council, 1952.)

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# PRESERVATION OF THE LAKE DISTRICT

THE Report and News Letter for August of the Friends of the Lake District* records a discouraging year, and refers particularly to the absence of a Joint Planning Board except in name for the Lake District National Park and to the hobbling of that authority by the failure to appoint a planning officer for the Park. The practical consequences of this position are concisely and clearly indicated, as well as the requirements for the effective functioning of any joint board. Local matters on which the Report and News Letter comment are the assurance received from the superintendent of the Eskmeals military range that the proposed night firing is, in fact, abnormal, and the decision given by the Minister of Fuel and Power in favour of the Electricity Board's proposal to serve farms in Martindale by overhead lines.

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* Friends of the Lake District. Report and News Letter, August. Pp. 20. (14 Princes Street, Ulverston, 1952.)

In Langdale no change is reported in the Electricity Board's policy of withdrawing the scheme on grounds of economy; but reference is again made to the improvement of the Hardknott from a mountain trackway with a loose rough surface into a motoring road in spite of the clear and unequivocal assurance to the contrary given in November 1946 by the chairman of the Highways Committee of the Cumberland County Council. Attention is also again directed to the general difficulty that arises because the virtual control of road-widths and traffic policy is in the hands not of the new Planning Board or even the local highway authorities, but of the Licensing Authority, a body which is detached from any interest in the preservation of the countryside. The intricate work of completing the footpath survey and official statutory map is likely to continue for another two years at least, but the review of open country in the area has been completed in the counties of Cumberland and Westmorland and in the National Park as a whole.

The Friends of the Lake District have been concerned in a preliminary review of the needs and possibilities of new footpaths on the shore of Lake Windermere, and representations have been made regarding the minimum flow in the Dash Beck water scheme for the rural district of Wigton as well as the construction of any necessary buildings. Together with the Council for the Preservation of Rural England, the Friends of the Lake District have made representations regarding the Forestry Commission's proposal to plant Low Holme Park exclusively with conifers and its effect on the footpath between Eskdale and Nether Wasdale.

# NEUROSECRETORY PATHWAYS IN THE HEAD OF CRUSTACEANS, INSECTS AND VERTEBRATES

By PROF. BERTIL HANSTRÖM
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STUTINSKY[1,2] and B. Scharrer[3,4] have recently proved that the chrome-hæmatoxylin-phloxin of Gomori selectively stains the neurosecretory pathways in several of the Pterygota in identically the same way as it stains the neurosecretory tractus supraoptico-hypophyseus in vertebrates (Bargmann[5], Hanström[6]). Thus, to the formerly known detailed similarities between the corpus cardiacum – allatum system in insects and the hypophysis in vertebrates—similarities which were originally pointed out by me in 1941 [7]—the fact has been added that the neurosecretory tracts, which in insects connect the pars intercerebralis of the brain with the corpus cardiacum and in vertebrates the nucleus supraopticus (and the nucleus paraventricularis) of the diencephalon with the neurohypophysis, both react positively and selectively with the Gomori stain. I think it worth while also to consider whether the neurosecretory substance in insects—as seems to be the case in vertebrates (Bargmann and E. Scharrer[8])—is connected with the production of a hormone regulating water-balance.

In 1940 [9] I described in some of the Apterygota two groups of cells on the surface of the protocerebrum which lie within a separate connective tissue sheath, only connected with the brain through a small aperture in their capsule. On account of their position, these groups of cells ought to be the homologue of the lateral frontal organs in crustaceans and the X-organs of these arthropods, which in 1934 were described by me as neurosecretory structures and which are transformed frontal organs. In the Apterygota these groups of cells give rise to a pair of nerves which take a characteristic course through the brain and can be traced outside it into the corpora cardiaca. In addition, I found that the cells in *Petrobius maritimus* contained secretory droplets which could be traced for a considerable distance along the axons. In higher insects these groups of cells ("the medial neurosecretory cells"), which give rise to the same nerve, are situated within the ordinary brain capsule, but otherwise show the same relations. Thus the lateral frontal organs, which in several lower crustaceans are located in the hypodermis and completely independent of the brain (though connected to it by a nerve), in other crustaceans are transformed into the X-organs, which adhere to the brain, and in the Apterygota into the groups of neurosecretory cells on the surface of the protocerebrum. In the Pterygota, finally, they have been thoroughly retraced into the brain as the medial neurosecretory cells of the pars intercerebralis, which cells, according to E. Thomsen[10] (cf. M. Thomsen[11]), must be regarded as the over-all controlling centre of the endocrine system in insects.

For comparative neurological reasons, I first assumed that a synapse may be present in the nervous pathway between the groups of neurosecretory cells and the corpora cardiaca in the Apterygota, though I did not try to verify this assumption by using special nerve-staining methods. Owing to the considerable physiological importance of the medial neurosecretory cells, which has been proved by a number of recent investigators for the Pterygota, I have now applied the chrome–hæmatoxylin–phloxin method of Gomori to several series of sections through the head of *Lepisma saccharina* and one series of *Petrobius maritimus* with the following result, which mainly deals with the former species.

Within the whole brain, nothing but the medial neurosecretory cell groups, their axons, and their endings within the corpora cardiaca have stained deep blue or blue-black with the hæmatoxylin. The plasm of the cells themselves contains conspicuous small droplets or irregularly formed larger colloid masses of the secretory product, and small droplets are also found along the greater part of the axons. The axons are very delicate, and since the number of neurosecretory cells is very small, the axons cannot be clearly observed without an oil-immersion lens. With the aid of an oil-immersion objective, however, the thin bundle of axons could be seen standing out very sharply, stained blue-black against the phloxin-red of ordinary nervous tissue from the entry of the nerves at the surface of the brain all the way into the corpora cardiaca. Thus, there were no signs of any synapse in the neurosecretory pathway, either in *Lepisma* or in *Petrobius*; further, no such structure has been mentioned in the Pterygota by Stutinsky[2] or by B. Scharrer[3]. At the entrance of the secretory fibres into the corpora cardiaca of *Lepisma*, they become thicker and are equipped with smaller or larger—often relatively considerable—enlargements, which stain as blue-black as the axons and droplets within the cell bodies. The special cells of the corpora cardiaca, on the contrary, do not show any hæmatoxylin reaction at all. This seems to be another parallel to the relations in the hypophysis, in which only the neurosecretory nerve endings from the hypothalamus in the neural lobe and no other colloid in this or the glandular lobe is truly Gomori-positive (Hanström[9]).

In this connexion it is interesting to note that Passano[12] and Bliss[13] seem to have detected at last a function for the X-organ in crustaceans. According to these authors, it is actually the cells of the X-organ which secrete the moult-inhibiting hormone and transport it through their axons into the sinus gland, described by me in 1931, in which structure it is accumulated, and then released into circulation in the adjoining blood sinus. As regards the nature of the secretory mechanism, the X-organ plus the sinus gland can thus be compared with the hypothalamo–hypophyseal system in vertebrates, and the pars intercerebralis–corpus cardiacum system in insects. This latter interpretation further supports the parallels between the X-organ and the medial neurosecretory cells. In addition to the common origin from the lateral frontal organs, there is a similar neurosecretory function: the secretory product is not directly released into the circulation but is transported to a place of storage, the sinus gland in crustaceans and the corpus cardiacum in insects.

It should, however, be pointed out that the parallel between the X-organ – sinus gland system in crustaceans, the pars intercerebralis – corpus cardiacum – allatum system in insects and the complete hypothalamo – hypophyseal system in vertebrates is less perfect than the mutual comparison between the latter two systems, as shown by me and by the Scharrers in earlier papers. Thus, in crustaceans, only the first two links of the chain are present, the X-organ and the sinus gland (comparable, respectively, to the medial neurosecretory cells and the corpus cardiacum in insects, and the neurosecretory nuclei of the hypothalamus and the neural lobe of the hypophysis in vertebrates), while the third link is missing, being represented by the corpus allatum and the glandular lobe (adenohypophysis), respectively, in the other two animal groups. Exceedingly interesting and suggesting a similar structure is the light blue colour which distinguishes not only the neurosecretory cells of the pars intercerebralis of the insect brain, the cells of the X-organ (and the sinus gland) in crustaceans, and, at least in some instances, the neurosecretory cells of the hypothalamus in vertebrates.

Though the medial neurosecretory cells in the Apterygota are placed on the surface of, not within, the brain, they show the same specific staining reaction and the same relations to the corpora cardiaca as in the Pterygota. In accordance with B. Scharrer[3], I conclude that the neurosecretory substance is produced by these groups of cells and transported along their axons into the corpora cardiaca, from which it can easily be released into the circulation because these glands adhere to the aorta.

It may finally be added that an investigation of the function of the endocrine system of the head of apterygotous insects, such as *Lepisma* and *Petrobius*, might yield interesting results. The position of the medial neurosecretory cells outside the brain should facilitate extirpation and transplantation experiments, and the particularly simple structure of the incretory system (in which the corpora allata are missing; Hanström[9], Cazal[14]) and the simpler development of these primitive insects, examined in relation to hormonal factors, may be able to throw new light on the regulation of the more complicated development of their higher relatives.

[Aug. 22.

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# THE LIGAMENT IN THE LAMELLIBRANCHIA

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THE ligament in the Lamellibranchia should be considered in relation to the different layers of the shell, of which it is an integral part, and so in terms of the areas responsible for the secretion of these layers. As is well known, the shell consists of a superficial periostracum and underlying outer and inner calcareous layers. These three layers have different origins. The periostracum is secreted as a thin sheet within a groove between the outer and middle lobes of the mantle edge, while the outer calcareous layers are produced by the outer lobe of the mantle margin and the inner calcareous layers by the general surface of the mantle. Thus growth of the periostracum and of the outer calcareous layers is by increment from the periphery of the mantle, while the inner calcareous layers normally continue to increase in thickness throughout life.

The Lamellibranchia were probably derived from ancestors having a simple dome-like shell with a single centre of calcification[1]. In the course of evolution the mantle became greatly extended and laterally compressed. This must have been accompanied by the partial division of the mantle into lateral lobes each possessing a centre of calcification. These two pallial lobes remained connected mid-dorsally by a neck of tissue, the shell in this area being left largely uncalcified[2] and constituting the ligament. Thus the shell in the Lamellibranchia consists of two valves with a dorsal connecting ligament.

It is proposed to describe the connecting neck of tissue between the two lobes of the mantle mid-dorsally as the 'mantle isthmus'. This represents the original mid-dorsal surface of the mantle. This region has frequently been described as the pallial

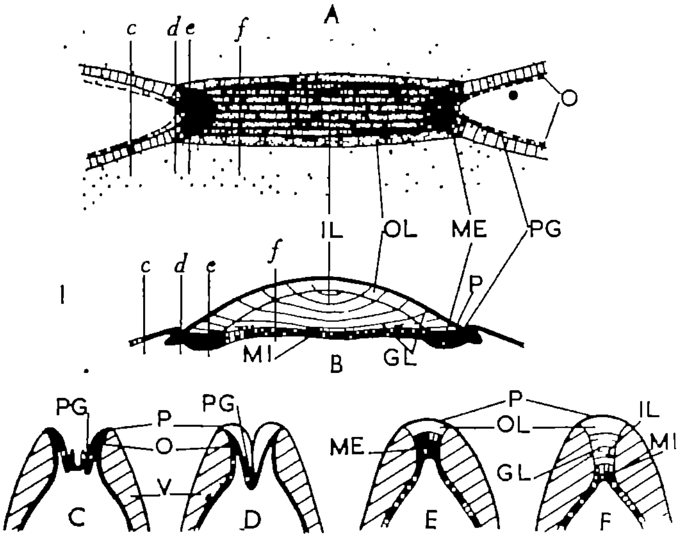


Fig. 1. Diagrams of primary ligament (*A*), viewed dorsally; (*B*), in sagittal section, (*C–F*), in transverse section, the positions being indicated by lines *c–f* in (*A*) and (*B*)
*GL*, growth lines, *IL*, inner layer of ligament, *ME*, outer lobe of mantle edge secreting 'outer' layer of the ligament; *MI*, mantle isthmus, *O*, outer lobe of mantle edge; *OL*, 'outer' layer of ligament; *P*, periostracum; *PG*, periostracal groove; *V*, valve
In *A* the extent of the periostracum is indicated by light stippling, the 'outer' layer by more dense stippling, and the inner layer by parallel lines

suture, conveying the erroneous suggestion that it represents the fusion of two originally separate pallial lobes. It is also proposed that the term 'ligament' should be used to include all structures linking the two valves dorsally. The structure and formation of the ligament can now be considered.

Like the rest of the mantle, the two ends of the isthmus are bounded by the mantle edge. This possesses here, as elsewhere, the capacity to secrete both periostracum and outer shell layers. Similarly, the epithelium of the isthmus retains the capacity to secrete inner shell layers. Thus the ligament primarily consists of a superficial periostracum and an 'outer' and an inner layer. These two layers, unlike those composing the rest of the shell, are largely uncalcified[3]. The results of the activities of these various zones of secretion are shown in Fig. 1. Fig. 1*A* represents a dorsal view, Fig. 1*B* a sagittal section, and Figs. 1*C–F* transverse sections through appropriate regions of such a ligament. The periostracum (*P*) is formed marginally and therefore extends, unchanged, over the ligament from each end. Secretion of largely uncalcified organic matter by the mantle edge (*ME*) in the depth of the embayments at the anterior and posterior ends of the isthmus (*MI*) results in the production of the 'outer' layer (*OL*) extending beneath the periostracum. The epithelium of the isthmus secretes the bulky inner layer (*IL*) of the ligament. Growth results in the extension of all three layers. Thus, although the sections represented in Figs. 1*C–F* are shown as having been taken from different regions of the same specimen, they could be interpreted equally well as having been taken, *at a constant distance from the umbones*, from different specimens at various stages of growth. Fig. 1*C* would then represent the youngest growth stage and Fig. 1*F* the oldest growth stage.

Fig. 2 represents a section through the margin of a valve. A comparison of this diagram with Fig. 1*B* reveals the identity of fundamental structure between valves and ligament (together constituting the shell). The periostracum (*P*) covers all regions of the shell although it is often worn away, especially over the ligament, the inner and 'outer' layers (*IL*, *OL*) of which are derived from the same origins as the inner and outer calcareous layers (*IV*, *OV*) of the valves. This is revealed by a comparison of the growth lines (*GL*) of the inner and 'outer' layers of the ligament with the corresponding layers of the valves. The lines of growth of the inner calcareous layers of the latter run parallel to the outer epithelium of the mantle and are continued into the outer calcareous layers to intersect the outer surface of the valve. The lines of growth of the inner and 'outer' layers of the ligament follow a similar pattern (Fig. 1*B*). They also run nearly parallel to the surface of the isthmus (*MI*) before continuing into the 'outer' layer to intersect its outer surface. Referring to the ligament, Mitchell[3] writes, "both layers appear to be of essentially the same composition as the organic matrix of the shell (conchyolin)". This is so because inner and outer layers of valves and of ligament represent local modification of the same two layers of the shell.

It should be noted that in some genera additional calcareous layers occur between the outer and inner layers of the valves, as in *Tivela stultorum*[4] and *Tellina tenuis*[5]. These additional layers are produced by "the less active part of the mantle edge" between "the extreme edge, where the growth is the most active" and the inner calcareous layer of the valves[4]. Weymouth[4] regards these intermediate calcareous layers as essentially extensions of the outer calcareous layers of the valves.

The structure of the ligament outlined above represents with reasonable probability the primitive condition, restricted to the region of the mantle isthmus and consisting of the three layers: periostracum, 'outer' and inner layers. This may be termed the 'primary ligament'.

This ligament probably originally extended from the anterior to the posterior adductor muscle, these being formed in the depth of the embayments by cross-fusion of the pallial muscles in these regions. Subsequent specialization has led to its reduction, and in this connexion conditions in the Lyonsiidæ[6]

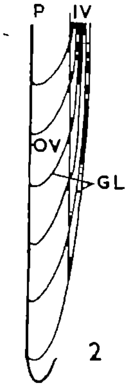


Fig. 2. Diagrammatic section through the edge of a valve
*IV*, *OV*, inner and outer calcareous layers. Other lettering as before

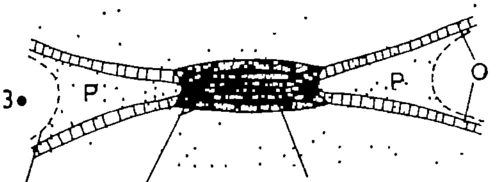
(*Lyonsia, Entodesma, Mytilimeria*) are of interest. Here the mantle isthmus is short and very characteristically formed; but the valves are united by a thick periostracum over the entire dorsal surface from the anterior to the posterior adductor. Such a condition, in which the inner and 'outer' layers of the ligament are reduced while the periostracum remains long, is indicated diagrammatically in Fig. 3. For reasons given below, the elongated periostracal layer in this ligament is more probably primitive than secondary.

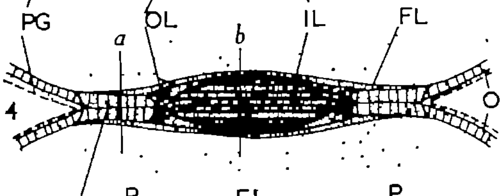
Following reduction in length, secondary extension can take place at either or both ends of the ligament. This is due to fusion of the mantle margins. Discussing the formation of siphons, it was shown by Yonge[7] that this may involve fusion (1) of the inner lobes only, for example, naked siphons of Tellinacea or Cardiacea; (2) of these with the middle lobes and periostracal grooves (now regarded by him as probably always associated), for example, siphons of Myidæ or Mactridæ, covered with periostracum; (3) of the outer lobes also, for example, siphons of *Cuspidaria*, encased in shell.

Fusion takes various forms, as will be discussed elsewhere by one of us (C. M. Y.). In the case of the periostracum, apparent fusion may result when the grooves are separated only by a low ridge representing the completely fused middle mantle lobes (that is, a condition somewhat intermediate between those shown in Figs. 1*C* and *D*). The secretions may then actually unite before spreading laterally over the surfaces of the valves. The periostracum can thus increase in extent and thickness with the growth of the animal; for example, in *Mya*, the fused surfaces remaining attached to the mantle tissues which secreted them. They do not represent additions to the ligament, the condition described in the Lyonsiidæ (Fig. 3) being for that reason probably primitive.

Fusion of the outer lobes of the mantle edge does, however, occur and causes secondary extension of the ligament. Such fusion (Figs. 4 and 5*A*, *FO*) has taken place, to greater or less extent, in many Lamellibranchia. It represents the coalescence of originally free mantle edges in very early post-larval life, after which all regions grow at relatively the same rate, with no further fusion of free surfaces. The result is the formation of a fourth layer in the ligament (described as layer "1*A*" and as "cover" by Trueman[2,8]). It represents material secreted by the united tissues (a true suture in this case) of the outer mantle lobes, as indicated in Figs. 4 and 5*A* and *B*. It is everywhere covered by periostracum (Fig. 5*A*), lying between this and the 'outer' layer in the region of the primary ligament (Fig. 5*B*). It is here proposed to call this the 'fusion layer' of the ligament (*FL*). It occurs without affecting the 'outer' or inner layers. It may be short or may extend for considerable distances beyond one or other end of the isthmus, usually posterior to this as in *Cuspidaria*[7] or in *Pinna* (as will be described elsewhere). In both these genera it extends to the extreme posterior end of the shell. This fusion layer contains a high proportion of organic matter and is similar to the 'outer' layer, although thinner. It generally shows growth-lines nearly parallel with its under-surface, indicating slow secretion over the full length of the fused epithelia.

In contrast to this secondary extension of the ligament is the reduction and possible final disappearance of the mantle isthmus, the two pallial lobes separating. This is what occurs in the Adesmacea, for example, in *Teredo* and *Zirphæa*, where there is no mantle isthmus and so no ligament, the valves being united solely by way of the adductor and, to a less extent, the pedal muscles.





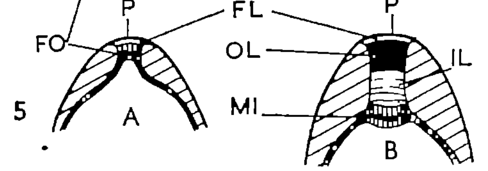


Fig. 3. Diagram of a ligament viewed dorsally, with a long (probably primitive) periostracal layer and relatively short 'outer' and inner layers. Lettering and shading as before

Fig. 4. Diagram of a ligament secondarily elongated as a result of fusion of the outer lobes of the mantle edge. *FL*, fusion layer, *FO*, fused outer lobes of mantle edge. Intermediate stippling indicates the extent of the fusion layer. Other lettering and shading as before

Fig. 5 (*A*, *B*). Transverse sections in areas indicated by lines *a*, *b* in Fig. 4. Lettering as before

Throughout the Lamellibranchia the ligament varies greatly in form. This is the result not only of the varying degrees of pallial fusion or separation but also of the growth pattern of the entire shell, the lines of growth of which radiate from nodes of zero or minimal growth represented by the umbones[9]. The position of the isthmus relative to the umbones therefore determines the growth pattern of the ligament. Primitively, the mantle isthmus probably lay between the umbones, and the amphidetic ligament extended during growth equally in both directions (Fig. 1). The isthmus may, however, be anterior or, more usually (for example, in *Tellina*), posterior to the umbones, with the formation, respectively, of prosodetic or opisthodetic ligaments.

In each group of Lamellibranchia the ligament is formed in a characteristic manner, being 'internal' or 'external', elongated or condensed, and with the primary and secondary constituents variously developed. No general description will cover all cases. In this article the mode of origin of the various layers composing the ligament has been described and suitable nomenclature suggested. It is hoped that this may lead to a clearer understanding of the nature of the ligament generally, and also aid in the comparative description of the many and very varied forms it may assume in different bivalves.

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# LETTERS TO THE EDITORS

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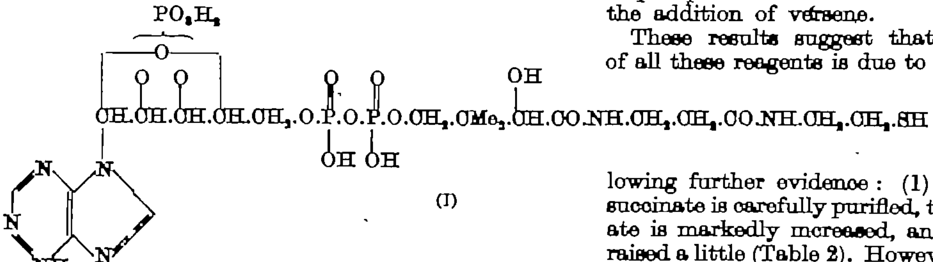
## Structure of Coenzyme A

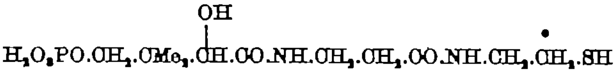
CHEMICAL[1] and enzymic[2] studies from these two laboratories suggested that coenzyme A is best represented by formula (I) (cf. ref. 3). While the synthesis of various fragments of the molecule[4] has lent considerable support to this structure, the enzymic and chemical evidence did not agree on one point. This concerned the nature of a substance obtained by the action of nucleotide pyrophosphatase on the coenzyme and which stimulated the growth of *Acetobacter suboxydans*[5]. Although not isolated in a chemically pure state, it was thought to be a simple phosphate of pantothenic acid[6]. None of the synthetic pantothenic acid phosphates showed activity towards this organism; consequently, it was suggested[1] that this '*Acetobacter*-stimulatory factor' might be pantetheine-4′phosphate (II). An unambiguous synthesis of (II) is described here.

D : L-Pantetheine-O$^{2'}$ : S dibenzyl ether was prepared from pantothenic acid-2′benzyl ether by reaction with ethyl chloroformate and then 2-benzylthioethylamine. Phosphorylation with dibenzyl chlorophosphonate and removal of the four benzyl groups with sodium in liquid ammonia gave D : L-pantetheine-4′phosphate.

A more reliable method of assay for the '*Acetobacter*-stimulatory factor' consists in its resynthesis to coenzyme A by a partially purified enzyme system isolated from pigeon liver[7]. This system does not respond to pantetheine or to pantothenic acid phosphates. Synthetic D : L-pantetheine-4′phosphate, when examined in this system, showed an activity equivalent to 265 units of coenzyme A per milligram, which represents a 47 per cent conversion into coenzyme A. This is in excellent agreement with the expected 50 per cent conversion for the optically inactive substance.

Pure D(+)-pantetheine-4′phosphate, $[\alpha]_D^{18}$ 10·8°, was synthesized by direct phosphorylation of pantetheine with dibenzyl chlorophosphonate followed by removal of benzyl groups with sodium in liquid ammonia. This method, although ambiguous, is very convenient in operation, and the product showed a coenzyme A activity in the above test of 450 units/mgm., which represents an 82 per cent conversion. This synthesis establishes beyond doubt the structure of the pantetheine phosphate part of the coenzyme molecule, and it is hoped to extend these studies to the synthesis of pyrophosphates more closely related to coenzyme A.


(I)



$$H_2O_3PO.CH_2.CMe_2.\overset{OH}{CH}.CO.NH.CH_2.CH_2.CO.NH.CH_2.CH_2.SH$$

(II)

Full details of this work will be published separately elsewhere.

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## Activation of Enzymes by Chelating Agents

LYSINE and glyoxaline-4-5-dicarboxylic acid[1] and histidine[2] have been shown to activate preparations of Keilin horse-heart succinoxidase in unfavourable environments. A property common to these compounds is their ability to chelate heavy metals. We have accordingly tested the effect of other well-known chelating agents upon this system in bicarbonate buffer, which has been shown by Bonner[3] to depress its activity. In Table 1 are shown typical results.

Table 1

| Enzyme in | µl. oxygen/ 20 min. |
|---|---|
| Phosphate buffer (0·13 *M*) | 300 |
| Bicarbonate buffer (0·025 *M*) | 65 |
| ,, ,, + histidine (1·0 mgm./ml.) | 270 |
| ,, ,, + pyrophosphate (1·0 mgm./ml.) | 240 |
| ,, ,, + 8-OH-quinoline (0·1 mgm./ml.) | 300 |
| ,, ,, + versene (0·1 mgm./ml.) | 330 |
| Phosphate buffer + versene | 330 |

Each Warburg flask contained: 0·2 ml. enzyme (see ref. 3), 0·2 ml. cytochrome c, 2·4 ml. buffer (pH 7·3), 0·3 ml. activator to give final concentrations listed above, 0·2 ml. sodium succinate (0·4 *M*). Temp. 37° C., gassed with oxygen with phosphate buffer, and oxygen containing 5 per cent carbon dioxide with bicarbonate buffer.

The most effective reagent, versene (ethylenediaminetetraacetic acid), raises the activity in bicarbonate to a level even higher than that in optimum concentrations of phosphate. The activity in phosphate can be increased to the same figure by the addition of versene.

These results suggest that the activating effect of all these reagents is due to their ability to remove heavy metals from the reacting system. This suggestion is supported by the following further evidence: (1) If commercial sodium succinate is carefully purified, the activity in bicarbonate is markedly increased, and that in phosphate is raised a little (Table 2). However, the effect of versene is still marked, which is not surprising since succinate is not the only source of heavy metals in the system. (2) Concentrations of $2 \times 10^{-5}$ *M* cupric and zinc ions in phosphate buffer inhibit the succinic oxidase completely, and the activity is restored

Table 2

| Enzyme in | μl oxygen/20 min. Commercial sodium succinate | μl oxygen/20 min. Purified sodium succinate |
|---|---|---|
| Phosphate buffer | 300 | 324 |
| „ „ + versene | 330 | 440 |
| Bicarbonate buffer | 60 | 182 |
| „ „ + versene | 330 | 376 |

Conditions and concentrations as in Table 1

above the original by the addition of versene (Table 3). (3) In mitochondrial preparations carefully made with glass-distilled water and pure reagents, histidine no longer increases the activity in phosphate buffer[4].

Table 3 also shows that the well-known activation of the oxidase by calcium ions[5] and by aluminium or chromium ions[6] in the presence of phosphate is of the same order as that due to versene, and that the simultaneous presence of versene causes no further increase, but also no decrease. Keilin and Hartree ascribed activation by these reagents to a physical effect. They suggested that the insoluble precipitates formed by these metals could provide surfaces on which the oxidase could be 're-orientated'. However, the concentration of versene used here causes the rapid solution of the calcium and chromium ion precipitates but causes no diminution in activity. Calcium phosphate and the hydroxides of aluminium and chromium are known to be good adsorbents. An alternative explanation of the action of these precipitates is, therefore, that they strongly adsorb heavy metals. This may also explain the action of denatured globin, another well-known activator.

Table 3

| Addition to enzyme in phosphate buffer | μl. oxygen/20 min. No versene | μl. oxygen/20 min. Versene added* |
|---|---|---|
| None | 194 | 220 |
| $Cu^{++}$ $2 \times 10^{-[illegible]}$ $M$ | 18 | 215 |
| $Zn^{++}$ „ | 6 | 219 |
| $Ca^{++}$ „ | 230 | 228 |
| $Al^{+++}$ „ | 213 | 210 |
| $Cr^{+++}$ „ | 227 | 217 |

* 1·0 mgm./ml. final concentration

If heavy metals are as important as these experiments suggest, metal-binding by phosphate may explain the necessity for using high concentrations of phosphate with a Keilin horse-heart preparation compared with the small phosphate concentrations necessary in mitochondrial preparations. Concentrations of phosphate above the minimum probably act by binding heavy metals, and high concentrations are necessary to exceed the solubility product of the heavy-metal phosphates and cause their precipitation by mass action. The appearance of an optimum rather than a plateau may be caused by a direct inhibition of enzyme by phosphate at these very high concentrations. This inhibition may well become important before the full potential-activating effect of phosphate has been reached, so that versene may still raise the activity even at optimum phosphate concentrations.

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## Paper Electrophoresis of Polyglutamyl Peptide

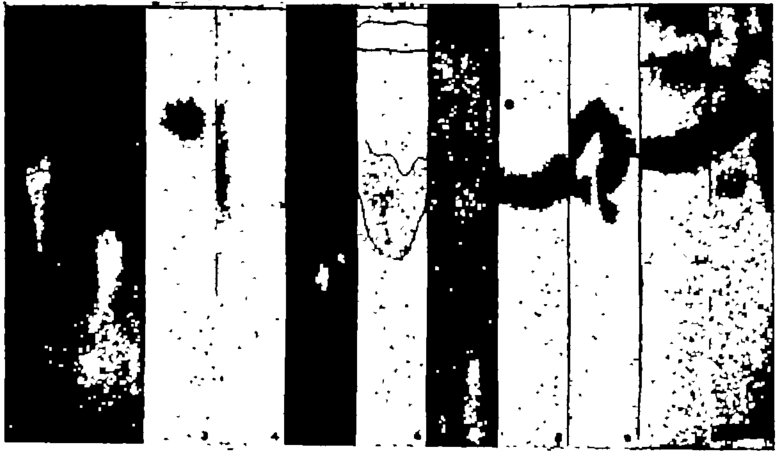
AFTER capsulated *B. anthracis* had grown in a modified synthetic medium of Brewer *et al.*[1], a mixture of growth products was isolated from the glass-filtered medium which gave a precipitate with copper sulphate. Crude polyglutamyl peptide was obtained from this precipitate[2]. An attempt was made to separate the components of the original mixture of growth products by paper electrophoresis using a tank as described by Flynn and Mayo[3], and it was found that the peptide could not be detected using naphthalene black, bromo-phenol blue, ninhydrin or ultra-violet light[4]. We found it could be detected by taking advantage of the acidic nature of the peptide, using the following technique: (1) paper strips with the peptide applied are run in a suitable buffer, for example, veronal/veronal sodium at pH 8·6 or acetic acid/sodium acetate at pH 4·5, and dried at 100°; (2) the buffer is washed out with two changes of 80 per cent ethanol; (3) the strips are treated with $N/50$ hydrochloric acid in 90 per cent ethanol; (4) the acid is thoroughly removed with ethanol; (5) after drying, the strips are dipped into $N/300$ alcoholic sodium hydroxide containing 0·04 per cent bromo-cresol purple, which is repeated if necessary until colour differentiation is obtained, and the strips are blotted.

The peptide appears as a bright yellow spot on a blue background. The method described by Reid and Lederer[5] for fatty acids was not suitable, since the background faded almost immediately and incorporation of formalin in the indicator solution caused proteins to give a faint acid reaction. Strips prepared as above were permanent for some days.

0·2 mgm. of two samples of the peptide, one obtained from the capsules of *B. anthracis*[6] and the other from the synthetic medium after growth and glass filtration, were applied to 3 cm. × 36 cm. strips of No. 4 Whatman paper and run in veronal buffer at pH 8·6 for 19 hr. using a 120-volt high-tension battery. The strips were treated as above and photographed (Figs. 1 and 2). The dye was eluted from one of the papers with ethanol and the peptide eluted with water and hydrolysed with 6 $N$ hydrochloric acid for 20 hr. The residue run on a paper chromatogram[7] showed only glutamic acid.

The mixture of growth products isolated from the synthetic medium was run in duplicate as before. One strip was stained by the naphthalene black method, differentiation being improved by including a wash in $N/100$ hydrochloric acid in 80 per cent methanol. The other strip was treated as above. Separation of the peptide from two components staining with naphthalene black had occurred; but in this case the peptide had travelled much faster (Figs. 6 and 7).

Artificial mixtures of the peptide and complete proteins gave rise to distorted pictures. With 70 μgm. of liver catalase and 150 μgm. of the peptide, a separation had occurred; but the catalase was repelled to the sides of the strip (Figs. 3, 4 and 5). Mixed with 200 μgm. of crystalline bovine albumin, 150 μgm. of the peptide moved at approximately the same rate but again appeared to repel the protein and be concentrated in the centre (Figs. 8 and 9). Similarly, when mixed with 10 μl. of normal human serum, all the protein components were distorted (Figs. 10 and 11).



In each paper strip the starting line is shown at the top (1) 0·2 mgm. of peptide from synthetic medium; 19 hr.; bromo-cresol purple. (2) 0·2 mgm. of peptide from organism; 19 hr.; bromo-cresol purple. (3) 0·07 mgm. of liver catalase; 19 hr.; naphthalene black. (4) 0·07 mgm. catalase + 0·15 mgm. peptide; 19 hr.; naphthalene black. (5) 0·07 mgm. catalase + 0·15 mgm. peptide; 19 hr.; bromo-cresol purple; (6) 1 mgm. growth products from synthetic medium; 19 hr.; naphthalene black. (7) 1 mgm. growth products from synthetic medium; 19 hr.; bromo-cresol purple. (8) 0·5 mgm. crystalline bovine albumin; 16 hr.; naphthalene black. (9) 0·5 mgm. albumin + 0·15 mgm. peptide; 16 hr.; naphthalene black. (10) 10 $\mu$l. normal human serum; 16 hr.; naphthalene black (11) 10 $\mu$l. serum + 0·15 mgm. peptide; 16 hr.; naphthalene black

These results suggest interaction between protein and polyglutamyl peptide, and we suggest this is a factor to be considered when electrophoresis is used as a method of separating unknown mixtures.

We should like to thank Dr. D. Herbert for helpful criticism. Acknowledgment is made to the Chief Scientist, Ministry of Supply, for permission to publish this letter.

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## Effect of Calcium Chloride on Choline Esterase

The effect of salts on choline esterase activity has been studied by a number of investigators[1-13]. The results may be summarized as follows: (1) True choline esterase: salts with univalent or divalent cations inhibit at low concentrations of acetylcholine, whereas these salts activate at high concentrations of acetylcholine; the optimum substrate concentration is shifted to higher values, though this was not found by Augustinsson[13]. (2) Pseudo-choline esterase: salts with univalent cations inhibit, whereas divalent cations activate. In most experiments, hitherto, acetylcholine only was used as substrate, and choline esterase activities were determined manometrically,[9] thus introducing a possible complicating effect of bicarbonate and other buffers present in the system. An effect of the salts (especially at high concentrations) on the bicarbonate – carbon dioxide equilibrium cannot be excluded.

In the present communication, only the results with calcium chloride will be given, although preliminary experiments with other salts show that the effects observed are by no means specific for calcium chloride. They may be considered as general cation effects.

All enzyme activities were determined by the continuous titration method at $p$H 7·4 using a direct-reading $p$H meter[14] at 24° C. Spontaneous hydrolysis of the substrates was practically unaffected by the presence of even very high concentrations of calcium chloride and was taken into account in all experiments. The chlorides of the choline esters were used, with the exception of acetyl-$\alpha$-methylcholine and the acetyl-$\alpha$-$\beta$-dimethylcholines which were used as the iodides. The following enzyme preparations were used. *True choline esterase*: (1) a suspension of ox nucleus caudatus, prepared as described previously for rat brain[14] (crude true choline esterase); (2) Winthrop–Stearns choline esterase from ox erythrocytes (purified true choline esterase). *Pseudo choline esterase*: (1) Horse serum partially purified by Strelitz's method[15], as described previously[16] (crude pseudo-choline esterase); (2) horse serum purified as far as Strelitz's sixth stage (purified pseudo choline esterase).

Fig. 1 shows the effect of calcium chloride concentration upon the activity of crude true choline esterase and crude pseudo-choline esterase hydrolysing acetylcholine at a concentration of 0·01 $M$. In addition, a curve is shown for liver esterase (rat liver homogenate) hydrolysing ethyl butyrate at a concentration of 0·015 $M$.

While true choline esterase is activated by more than 100 per cent, pseudo-choline esterase activation only amounts to 20 per cent, whereas liver esterase is not activated at all. At high calcium chloride concentrations all three enzymes are inhibited.

In Fig. 2 is shown the effect of 0·1 $N$ calcium chloride and 0·1 $N$ sodium chloride on the acetylcholine hydrolysis of purified true choline esterase at

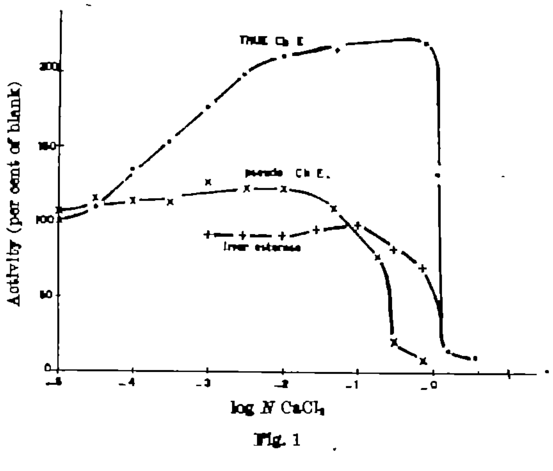

Fig. 1

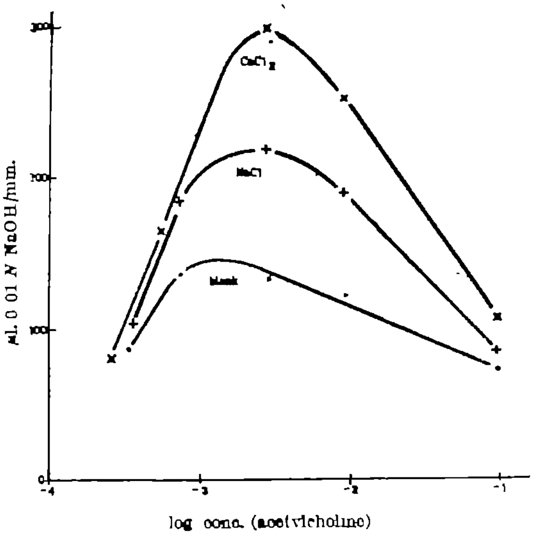

Fig. 2

varying concentrations of substrate. Activation is maximal at the optimum substrate concentration. No definite shift in this optimum is found, and this was confirmed in experiments with crude true choline esterase.

Table 1 shows the comparatively small effect of 0·1 *N*, 0·01 *N* and 0·001 *N* calcium chloride on the acetylcholine hydrolysis by crude pseudo-choline esterase. The activation increases slightly with increase of substrate concentration.

Table 1. EFFECT OF CALCIUM CHLORIDE ON THE HYDROLYSIS OF ACETYLCHOLINE BY CRUDE PSEUDO-CHOLINE ESTERASE

| Concentration of acetylcholine (*M*) | Concentration of calcium chloride (*N*) | % Activation |
|---|---|---|
| 1 | 0 1 | 20 |
| | 0·01 | 35 |
| | 0·001 | 29 |
| 0·1 | 0 1 | 19 |
| | 0·01 | 26 |
| | 0·001 | 10 |
| 0 01 | 0 1 | 13 |
| | 0·01 | 21 |
| | 0·001 | 25 |
| 0·001 | 0 1 | —19 |
| | 0·01 | — 6 |
| | 0·001 | 11 |

Table 2. EFFECT OF CALCIUM CHLORIDE ON THE HYDROLYSIS OF SUBSTRATES BY CRUDE TRUE CHOLINE ESTERASE AND CRUDE PSEUDO-CHOLINE ESTERASE*

| Substrate (0·01 *M* unless otherwise stated) | % Activation by calcium chloride (optimum concentrations in brackets) | |
|---|---|---|
| | True choline esterase | Pseudo-choline esterase |
| Acetyl choline | 129 (0 1 *N*) | 25 (0·01 *N*) |
| Propionyl choline | 105 (0·1 *N*) | 20 (0 01 *N*) |
| Butyryl choline | 90 (0 1 *N*) | 8 (0 01 *N*) |
| Benzoyl choline | not hydrolysed | 26 (0·01 *N*) |
| Acetyl-$\alpha$-methylcholine | 117 (0·1 *N*) | 16 (0·01 *N*) |
| Acetyl-$\beta$-methylcholine | 2 (0·01 *N*) | not hydrolysed |
| Acetyl-$\alpha,\beta$-dimethylcholine threo | 10 (0·01 *N*) | not hydrolysed |
| Acetyl-$\alpha,\beta$-dimethylcholine erythro | not hydrolysed | not hydrolysed |
| Butylacetate (0·028 *M*) | 113 (1 *N*) | 118 (0·1 *N*) |
| Isoamylacetate (0·0096 *M*) | 77 (1 *N*) | 101 (0·1 *N*) |
| 3,3 Dimethylbutylacetate (0 004 *M*) | 85 (1 *N*) | 76 (0·1 *N*) |
| Triacetine | 76 (1 *N*) | not hydrolysed |

* With the purified preparations the results were essentially the same, although the activations with the non-choline esters were somewhat lower.

The effects of calcium chloride on the hydrolysis of a number of substrates were compared. The results obtained for maximum activations taken from experiments with varying substrate and calcium chloride concentrations are shown in Table 2.

It is apparent that the optimum concentration of calcium chloride depends on the substrate and on the enzyme preparation used.

With pseudo-choline esterase the results can be summarized as follows. Uncharged substrates (non-choline esters) are hydrolysed and the hydrolysis is activated by calcium chloride. Charged substrates (choline esters) lacking a methyl group in the $\beta$-position are hydrolysed, but only slightly activated with calcium chloride. Charged substrates with a methyl group in the $\beta$-position are practically not hydrolysed.

With true choline esterase, uncharged substrates as well as charged substrates without a $\beta$-methyl group are hydrolysed, and this hydrolysis is activated by calcium chloride. Charged substrates with a $\beta$-methyl group are hydrolysed (with the exception of acetyl-$\alpha$-$\beta$-dimethylcholine (erythro)), but their hydrolysis is not activated by calcium chloride. Uncharged substrates with a methyl group next to the ester linkage (comparable with the $\beta$-position of choline) are under investigation. Preliminary experiments with pentanol-2-acetate suggest activation by calcium chloride of its hydrolysis by true choline esterase and practically no hydrolysis by pseudo-choline esterase.

A more extensive report and a discussion of the results will be published at a later date.

I am indebted to R. A. Oosterbaan and the Chemical Laboratory of the National Defence Research Council T.N.O. for preparing some of the substrates.

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## Occurrence of Choline Oxidase in Plant Tissues

Mann and Quastel[1] showed that choline is oxidized to betaine aldehyde by homogenates of rat liver, and evidence was obtained that the betaine aldehyde so formed was further oxidized to betaine. Bernheim and Bernheim[2] showed that synthetic betaine aldehyde was oxidized to betaine at *p*H 7·8 by extracts of rat liver, but at *p*H 6·7 betaine aldehyde remained unchanged. As the result of further experiments, Mann, Woodward and Quastel[3] concluded that the choline oxidase system consists of choline dehydrogenase, cytochrome *c* and cytochrome oxidase. Muntz[4] has shown that betaine, formed by oxidation of choline, is an active donor of a labile methyl group for transmethylation in animal tissues. Although betaine is of widespread occurrence in plants, particularly in the Chenopodiaceæ, little is known of the mode of synthesis and the part played by this compound in the metabolism of higher plants.

Preliminary experiments which we have carried out have revealed the presence of an enzyme system in dialysed homogenates of young roots of sugar beet (*Beta vulgaris* Linn.) which brings about the oxidation of choline to betaine. The addition of cytochrome *c* facilitated the oxidation. The enzyme was inhibited by cyanide and inactivated by heat. The conclusion was reached that a choline oxidase system is present which bears a close resemblance to that of animal tissues.

The homogenate was prepared by grinding root tissues with sand in a mortar previously chilled, and straining through muslin to remove cell debris. The homogenate was dialysed against distilled water at 2° for 24 hr. To 12·5 ml. of the dialysed homogenate was added 12·5 ml. of an $M/5$ solution of phosphate buffer $pH$ 7·4, 12 mgm. of choline and 1·5 ml. of a solution of cytochrome *c* containing $1 \times 10^{-7}$ $M$/ml. After a period of 24 hr. at 20°, the $pH$ of the homogenate was adjusted to 4·5, protein was precipitated at 85°, removed by filtration and the filtrate clarified by heating with charcoal. After filtration, unchanged choline was precipitated with ammonium reineckate at $pH$ 8. The filtrate was brought to $pH$ 1 with hydrochloric acid and kept at 4° for 30 min. The copious precipitate which appeared was filtered off on a chilled sintered-glass crucible, washed with water-saturated ether, dissolved in warm water and recrystallized. The reineckate melted at 155°–156° and contained 12·2 per cent chromium. Pure betaine reineckate has a melting point of 154°–156° and requires 11·95 per cent chromium.

Homogenates previously heated to 100° and homogenates with added cyanide did not oxidize choline to betaine. Analysis of controls using homogenates without added choline and cytochrome *c* showed the presence of 0·7 mgm. residual betaine not removed by dialysis, as against 3·7 mgm. found in homogenates to which 12 mgm. of choline and cytochrome *c* had been added. Homogenates of young leaves of sugar beet were inactive under all conditions.

The conclusion is reached that betaine is formed in the root tissues of sugar beet by oxidation of choline and moves upwards into the leaves. Full details of these experiments will be published elsewhere. One of us (S. D. R.) is in receipt of a grant from the Agricultural Research Council.

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## Inhibition of *E. coli* Strains by Amino-Acids

THAT amino-acids can inhibit growth of certain bacteria has been known for some time[1]. Thus Gladstone[2] showed that several strains of *Bacillus anthracis* which grew well on a synthetic amino-acid medium failed to grow when leucine or valine was added in concentrations as low as 1 μgm. per ml.; but a very small amount of leucine could abolish the inhibitory effect of valine and vice versa. A similar, though less marked, relationship was shown to exist between serine and threonine.

Washburn and Niven[3] have described analogous effects with a strain of *Streptococcus bovis* growing on a synthetic medium containing arginine as the only amino-acid. Addition of *iso*leucine or leucine in amounts of the order of 1 μgm. per ml. completely suppressed growth. Simultaneous presence of even smaller concentrations of valine would prevent this inhibition.

I wish to record a similar effect with strains of *Escherichia coli*. In the course of auxanograph tests, it was found that the *K*12 strain growing on the minimal medium of Davis and Mingioli[4] was specifically and strongly inhibited by DL- or L-valine. This inhibition was completely reversed in the presence of DL-leucine or DL-threonine. In liquid minimal medium, as little as 1 μgm./ml. of valine suppressed growth for 24 hr., and the inhibition caused by 90 μgm./ml. of valine could be prevented by the simultaneous addition of 15 μgm./ml. of leucine or 8 μgm./ml. of threonine.

In order to see whether this is a general phenomenon among *E. coli* strains, the same technique of testing was applied to a miscellaneous collection of one hundred *coli* strains selected from routine plates for their ability to grow on the minimal medium. Not one further strain was inhibited by valine; but a surprising number of other inhibitions came to light. Thus ninety strains were inhibited in varying degrees by *nor*leucine, seventy-five by *nor*valine, nine by serine, seven by α-amino butyric acid, five by aspartic acid, five by histidine, three by cystine, two by lysine, one by leucine and one by tyrosine. Some strains were obviously inhibited by several amino-acids, others only by one. In every case reversal of the effect was possible by simultaneous presence of one or more different acids, the commonest reversers being leucine and methionine.

This agrees with the finding of Porter and Meyers[5], who reported that inhibition of *Proteus morgani* strains by *nor*leucine or *nor*valine could only be consistently prevented by methionine. This contra-inhibitory effect in *E. coli* is, however, by no means confined to methionine and leucine; for example, inhibition of one strain (61) by aspartic acid could be reversed by valine, with another strain (89) by valine, proline and glutamic acid; inhibition of strain 28 by serine was prevented by aspartic acid or α-amino butyric acid but not by leucine or methionine. By following the growth of these strains in liquid medium, it was observed that the inhibition consisted of an increased lag of up to 24 hr. duration; eventually the populations on minimal media with or without an inhibiting amino-acid reached the same density.

These phenomena are quite distinct from the reported[6,7] inhibition of *Escherichia coli* by D-amino-acids such as D-leucine and D-valine at concentrations of about 1–5 mgm./ml. The toxic effect of these relatively high concentrations of D-amino-acids is exhibited in nutrient broth, whereas all the other inhibitions described above are completely reversed in the presence of nutrient broth.

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## Protoporphyrin in the Integument of *Asterias rubens*

MACMUNN in 1886[1] extracted the integument of *A. rubens* (then known as *Uraster rubens*) with ethyl alcohol containing sulphuric acid. The extracts were red-fluorescent to ultra-violet light, and MacMunn reported the presence of hæmatoporphyrin in them—the only porphyrin then known, having been discovered by Hoppe-Seyler in 1871[2]. So far as we know, there is no further mention of hæmatoporphyrin in *Asterias* in the literature.

As part of a survey of marine animals from the point of view of porphyrin content, *Asterias rubens* has been re-investigated by us, when it was found that the integument contained free protoporphyrin and not hæmatoporphyrin.

The details of this work will be published elsewhere, but the essentials are as follow. The integument was freed from adhering cæca, chopped fine, and extracted by shaking with a 5 : 1 mixture of peroxide-free ether and glacial acetic acid, with addition of 1/10 volume of petroleum ether to avoid emulsion formation. After washing out most of the acetic acid with water, the porphyrin was extracted with 5 per cent w/v hydrochloric acid, and driven back to peroxide-free ether with sodium acetate. The ether solution was washed, evaporated to dryness, and the residue rinsed with petroleum ether. The dry residue was dissolved in chloroform, from which the porphyrin was flocculated by adding petroleum ether.

The porphyrin was purified by esterification with methanol saturated with hydrochloric acid, and chromatographed on magnesia from chloroform solution[3]. Impurities remained at the top of the column as a dark brown band, and a strong violet-red band formed some 2 cm. below. This band was eluted only by 3 : 100 methanol–chloroform, indicating protoporphyrin ester. The porphyrin ester crystallized from chloroform/methanol in red prisms, melting at 225° C. (uncorr.).

Evidence of identification of the porphyrin is as follows.

(1) Methyl ester crystallizes in red prisms melting at 225° C. These gave a mixed melting point of 225° C. with a sample of protoporphyrin IX dimethyl ester (melting point 226° C.) made from blood.

(2) Absorption spectrum (Hartridge reversion spectroscope) in chloroform :

| | I | II | III | IV | |
|---|---|---|---|---|---|
| *Asterias* porphyrin | 630 | 575 | 540 | 507 | mμ |
| Protoporphyrin IX dimethyl ester (blood) | 631 | 575 | 541 | 507 | mμ |

(3) Paper partition chromatography using a lutidine–water system in an atmosphere of ammonia vapour. The free porphyrin gave one spot only, of $R_F$ value 0·8, indicating a dicarboxylic porphyrin[4].

(4) Elution of the methyl ester from magnesia by 3 : 100 methanol–chloroform indicated protoporphyrin.

(5) Reduction of the methyl ester by hydriodic acid and subsequent esterification gave mesoporphyrin IX dimethyl ester (melting point 215° C.). Therefore, the original porphyrin could only be protoporphyrin IX, a type-III porphyrin derived from ætioporphyrin III[5].

(6) Chu's test 1946—adding a few drops of concentrated hydrochloric acid to a chloroform solution of the porphyrin—gave a green colour, suggesting protoporphyrin.

Fluorimetric estimation of the protoporphyrin[6] in the integument of various colour groups of *Asterias* gave the following mean contents :

| Violet-brown group | Red group | Pale group |
|---|---|---|
| 69·1 μgm./gm. | 16·0 μgm./gm. | 5·0 μgm./gm. |

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## Dehydrogenation of Various Substrates by *Vibrio choleræ*

A DETAILED investigation of the enzyme make-up of *Vibrio choleræ* has been undertaken with the view of studying the metabolic activities of the pathogen. Deamination of amino-acids by a few strains of *Vibrio choleræ* has been reported elsewhere[1]. This communication covers preliminary observations on the dehydrogenase activity of an Ogawa strain (No. 49514—Kasauli), and the Inaba and the Rough variants derived from it[2].

Twenty-four hour growth of the organism on agar slopes ($p$H 8·0) was harvested with saline (0·85 per cent sodium chloride for Ogawa and Inaba and 0·3 per cent sodium chloride for Rough) and, after centrifugation, washed once with salt solution of appropriate concentration and recentrifuged. The residue was finally suspended in saline and adjusted to a fixed turbidity value using a Lumetron model *A* photo-electric colorimeter. The nitrogen content of the suspension was determined in an aliquot portion by the micro-Kjeldahl procedure. The reaction mixture, consisting of 1 ml. of $M/100$ substrate, 1 ml. of $M/15$ phosphate buffer of $p$H 8·0 and 1 ml.

DEHYDROGENATION OF VARIOUS SUBSTRATES BY *Vibrio choleræ*

| Group | Substrate | Turbidity of suspension (% $T$ in Lumetron) | Nitrogen content of suspension (γ/ml.) | Reduction time (min.) | | |
|---|---|---|---|---|---|---|
| | | | | Ogawa | Inaba | Rough |
| *A* | Formate | 40 | 65·0±1·0 | 26·0 | 20·0 | 13·0 |
| | Pyruvate | ,, | ,, | 30·0 | 21·0 | 12·0 |
| | Fumarate | ,, | ,, | 40·0 | 35·0 | 24·0 |
| | DL-Alanine | 20 | 110·0±4·0 | 16·0 | 13·0 | 9·0 |
| | L-Cystine | ,, | ,, | 61·0 | 42·0 | 32·0 |
| | Glycine | ,, | ,, | 37·0 | 23·0 | 18·0 |
| | DL-Isoleucine | ,, | ,, | 24·0 | 16·0 | 11·0 |
| | DL-Leucine | ,, | ,, | 38·0 | 24·0 | 13·0 |
| | L-Proline | ,, | ,, | 21·0 | 14·0 | 9·0 |
| *B* | Glucose | 40 | 65·0±1·0 | 9·0 | 8·0 | 5·0 |
| | Lactate | ,, | ,, | 18·0 | 17·0 | 10·0 |
| | Succinate | ,, | ,, | 22·0 | 20·0 | 15·0 |
| | L-Glutamate | ,, | ,, | 46·0 | 43·0 | 34·0 |
| | DL-Phenylalanine | 20 | 110·0±4·0 | 17·0 | 16·0 | 14·0 |
| *C* | L-Arginine HCl | 20 | 110·0±4·0 | 14·0 | 12·0 | 12·0 |
| | DL-Histidine | ,, | ,, | 32·0 | 19·0 | 16·0 |
| | L-Lysine | ,, | ,, | 35·0 | 19·0 | 16·0 |
| | DL-Threonine | ,, | ,, | 23·0 | 15·0 | 14·0 |
| | DL-Tryptophane | ,, | ,, | 60·0* | 35·0* | 30·0* |
| | DL-Valine | ,, | ,, | 14·0 | 10·0 | 8·0 |

* Decolorization was not complete.

of $M/10,000$ methylene blue, was kept in the main compartment of a Thunberg tube. 1 ml. of the bacterial suspension was taken in the hollow stopper. The tubes were evacuated with a high-vacuum pump, equilibrated at 38° C. for 5 min. and then mixed. The time taken for the complete discharge of the blue colour was taken as the end-point. Results of some typical experiments (two sets of triplicates) on a few substrates are given in the accompanying table.

It is evident that almost all the amino-acids and aliphatic acids employed in the present study act as hydrogen donors for the respiratory activity of this organism. Ethyl alcohol and malic acids were, however, found to be resistant to dehydrogenation. It may be inferred from the results that the dehydrogenases of *Vibrio choleræ* are linked up with cytochrome systems reported[2] to be present in these organisms. However, the possibility of other coenzyme systems taking part in this process cannot be excluded.

In control experiments with water in place of substrate there was no discharge of colour up to 18–20 hr.

The results obtained would indicate that dehydrogenation by *Vibrio choleræ*, based on activity, falls into three main groups, namely,

Group *A* : Rough > Inaba > Ogawa
Group *B* : Rough > Inaba ~ Ogawa
Group *C* : Rough ~ Inaba > Ogawa

This is in contrast to the pattern observed in deamination wherein the activity was of the order Ogawa–Inaba–Rough[4].

Barron[5] has shown that when the regulatory mechanism within a cell is progressively blocked by the controlled use of alkylating or thiol reagents, catabolic reactions proceed at a faster rate, resulting in an increase in cellular respiration. A faster rate of dehydrogenation in the converted variants (Inaba and Rough) now observed would therefore indicate a higher metabolic activity.

The conversion of the Ogawa into Inaba and the Rough has been considered to be a loss variation[3]. Against the background of the work of Barron[5], it would appear from the present investigation that some factor present in the parent cell is lost during the transformation.

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## Anti-diuretic and Oxytocic Substances liberated by the Digestion of Plasmatic Proteins with Pepsin

DIGESTION of human, ox and horse plasma or digestion for 5 hr. at 37° C. of hypertensinogen (alpha-2 globulin) at $p$H 2·5–3·5 with crystallized pepsin (50 mgm. per litre) leads to the liberation of several peptides. These substances have been shown to have similar pharmacological effects to those produced by neurohypophysial extracts. Croxatto and Croxatto[1] have demonstrated that digestion of hypertensinogen with pepsin produces, under certain conditions, pepsitensin. The latter substance behaves similarly to hypertensin with regard to the action of proteolytic enzymes and tissue extracts.

Hydrolysis of hypertensinogen or a second hydrolysis (with pepsin at $p$H 2·5) of the extracts which contain pepsitensin produces a substance which lacks any hypertensive effects but shows instead an intense anti-diuretic action in water-loaded rats (Burn's test). The substance shows chemical and pharmacological properties which are similar to those of vasopressin after being treated with sulphydrilic substances[2].

The sulphydrilic compounds used were thiosorbitol and thioglycollate, but mainly the former. The concentration of thiosorbitol used was 0·003–0·012 $M$ ($p$H 7·3, period of contact 6–12 hr., temperature 37°). Under these conditions, it can be shown by means of intravenous injections that the hypertensive (vasoconstrictor) effect of the vasopressin is destroyed and the antidiuretic potency is totally conserved or almost so. The effect of thioglycollate did not differ from that of thiosorbitol, though at the same concentrations a greater destruction of the antidiuretic properties was produced than with thiosorbitol.

The anti-diuretic substance liberated by pepsin is soluble in both methyl and ethyl alcohol and also in acetic acid. It is also adsorbed by 'Norit', from which it is easily eluted with acetic acid. Afterwards, it is easily precipitated by adding a mixture of equal parts of petroleum ether and absolute alcohol. Also, it may be precipitated by adding either ether or benzol. It is not destroyed by boiling in an acid environment. It is not precipitated by adding trichloroacetic acid. Also, it can be dialysed through 'Cellophane' membranes. It resists the prolonged action of pepsin, but it is destroyed by chymotrypsin.

The anti-diuretic substance is not produced by a simple acid hydrolysis of plasma (pH 2·5) obtained by adding hydrochloric acid to plasma proteins.

The substance is capable of inhibiting diuresis of hypophysectomized rats with diabetes insipidus when injected intravenously or intraperitoneally. Its action on diuresis of the cat anaesthetized with 'Dial' is similar to that of vasopressin treated with thiosorbitol. Extracts adsorbed by 'Norit', eluted with acetic acid and precipitated with ether, produce (at a dose of 10 mgm. in a rat of 200 gm.) in the hyperhydrated rat an effect that is comparable to that of 500–1,000 μ of vasopressin.

It is possible to identify in the same extracts another substance which has marked oxytocic effects and which acts on the uterus of both guinea pigs and rats. This substance is destroyed by chymotrypsin, but resists the action of crystallized pepsin and trypsin. When hypertensinogen is treated previously with renin, in order to eliminate the production of hypertensin, it produces (after further digestion with pepsin) an increase of the anti-diuretic factor and a decrease of the oxytocic factor. Several tests with the different fractions separated from the hydrolysed hypertensinogen demonstrate that the oxytocic and the anti-diuretic effects are independent. This fact suggests that they are different substances.

It is evident that hypertensinogen potentially contains certain peptide fractions which are liberated by hydrolysis with pepsin. These fractions have pharmacological effects which are similar to those of hypertensin and those of the oxytocic and anti-diuretic hormones.

These facts confirm previous deductions about the chemical similarity of hypertensin and of the hormones from the neurohypophysis[3] and suggest that probably the hormones from the hypophysis are bound to certain blood proteins. Another possibility would be that proteins contain some chemical precursors which would be utilized by the hypophysis in the synthesis of hormones[4].

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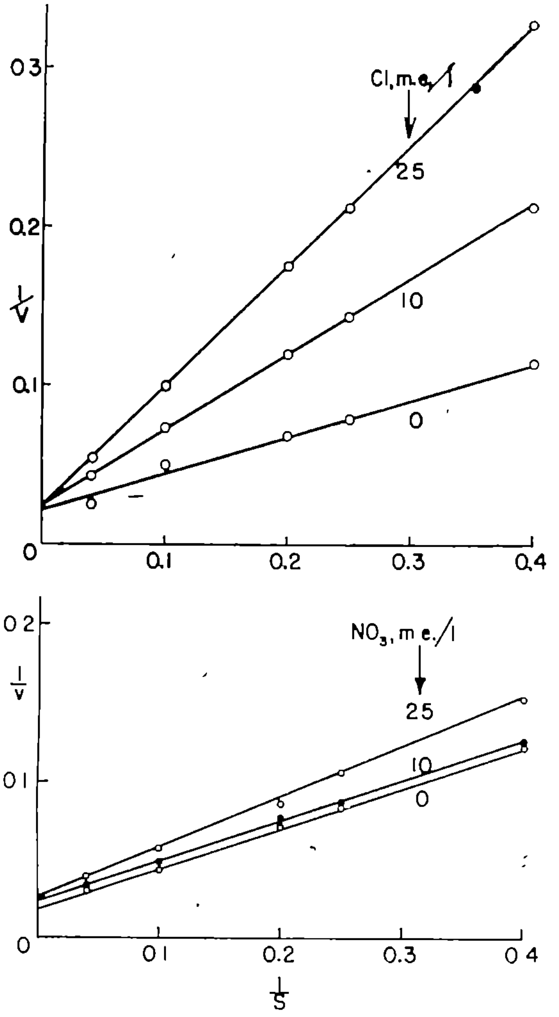
## Mechanism of Ion Absorption by Roots

THE absorption of anions by barley roots has been studied in a manner similar to that adopted in a recent study[1] of the absorption of alkali cations. The earlier paper considered the effect on the rate of absorption of varying (1) the concentration of the ion whose absorption was being measured (arbitrarily called the 'substrate ion'), and (2) the concentration of another alkali cation present (the 'interfering ion'). The anion was chloride throughout. The results were shown to be consistent with the view[2,3] that the absorption of potassium and rubidium involves the formation and subsequent breakdown of an intermediate labile complex, *MR*, of the cation, *M*, with an ion-binding carrier, *R*. It was assumed that a membrane impermeable to the free ions is traversed by *MR*. Upon arriving at the inner surface, *M* is released through a chemical change in the carrier, *R*.

This scheme of the formation and subsequent breakdown of a complex is analogous to the accepted mechanism of enzyme action, which assumes the formation of an intermediate labile complex, *ES*, of the substrate, *S*, with the enzyme, *E*. The kinetic treatment of enzymatic reactions based on this assumption[4,5] was shown to be applicable to ion transport. It was found that potassium and caesium interfere competitively with absorption of rubidium, indicating identical binding sites on the carrier, *R*, for these three ions. Sodium (except at relatively high concentrations of rubidium or sodium) and lithium did not interfere competitively with absorption of rubidium, indicating different binding sites.

The mechanism outlined in the earlier paper[1] and briefly indicated above has now been found to apply in the absorption of anions as well. The methods, in all essentials, were those already described[1]. Briefly, seeds of the Sacramento variety of barley were germinated in aerated water for 24 hr. in the dark, following a 20-min. treatment with 10 per cent hydrogen peroxide to improve germination. The seedlings were grown for five days in the dark at 24° C., over a solution of $10^{-4}$ *M* calcium sulphate, which was renewed once during that time. The roots were then excised and used in the absorption experiments under the following conditions: roots, 1·00 gm. fresh weight per sample; volume of solution, 50 ml.; temperature, 30° C.; duration, 3 hr. The cation was potassium throughout.

The 'substrate ion', the rate of absorption of which was being measured, was bromide tagged with bromine-82. Its concentration, *S*, was varied from 2·5 to 25 m.equiv./litre, both in the presence and absence of chloride and nitrate as interfering ions. The rate, *v*, of absorption of bromide was expressed as m.equiv./3 hr. Upon plotting the reciprocal of the absorption rate, $1/v$, against the reciprocal of the substrate concentration, $1/S$, according to Lineweaver and Burk[6], straight lines are obtained (see diagram). When the interfering ion is chloride, the slopes of these lines are increased, with little or no change in the ordinate intercepts, indicating competitive interference, that is, identical binding sites. With nitrate as the interfering ion, all other conditions being identical, the line for nitrate = 10 m.equiv./l. is parallel to that obtained in the absence of interfering ions. This is characteristic of 'un-competitive' interference (cf. Wilson[7]), which involves combination of the interfering ion with the carrier-ion complex, *RA*, at a site different from that which binds the substrate ion, bromide. At the higher concentration of nitrate (25 m.equiv./l.) both slope and intercept increase, the slope by a smaller factor than the intercept. This case is intermediate between 'un-competitive' and 'non-competitive' interference: the interfering ions combine with *RA*, and to a smaller extent with free *R* as well, at sites different from those with which the substrate combines. The 'Michaelis constants' $K_{\mathrm{Br}}$, which denote the affinity of the bromide ion for the



Double reciprocal plot of interference by chloride and nitrate with absorption of bromide

binding site, were 11·00 and 14·22 m.equiv./l. in the experiments plotted in the graph. The constants, $K_{Cl}$, for chloride found were 12·57 and 13·42 m.equiv./l. at 10 and 25 m.equiv./l., respectively. Hence, the affinity of bromide and chloride ions for the binding-site of the halides is essentially the same.

According to the theory of salt transport advanced by Lundegårdh[7], there is a fundamental difference in the mechanism of cation absorption and anion absorption: "An active accumulation of anions produces potentials which attract cations". The absorption of anions, unlike that of cations, is a primary metabolic process mediated by a component of the respiration referred to as "anion respiration". "The anion respiration thus acts as the promoter of salt accumulation even if the cations are more passively dragged through the protoplasm".

It seems doubtful whether the present findings, together with the earlier ones[1] concerning the absorption of alkali cations, can be reconciled with this dual view. The results imply that cations as well as anions are accumulated by a mechanism involving their temporary combination with binding compounds. Instead of following "general principles of exchange-power, well known from soil colloids", the affinity of cations (as well as of anions) for the various binding sites is governed by their chemical characteristics. It would seem, in fact, that all active transport of ions must needs implicate their combination with protoplasmic constituents, and that this forms the chemical basis for selectivity.

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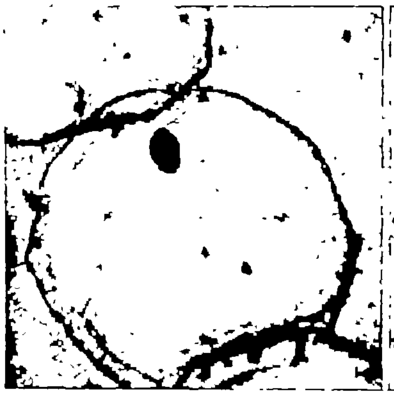
## Nature of Heinz Bodies

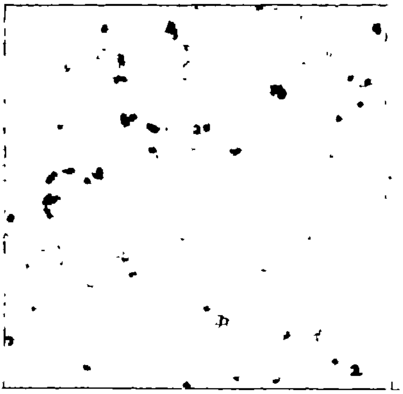
A great number of hæmolytic agents have been found to produce, besides methæmoglobinæmia, certain highly refractive inclusion bodies, the so-called 'Heinz bodies', in the erythrocytes[1]. The connexion between methæmoglobin and Heinz bodies, however, is not clear. Most agents producing Heinz bodies belong to the group of aromatic amines and include such important drugs as sulphonamides and thiosemicarbazones[2,3]. The reports on the formation and chemical nature of Heinz bodies are contradictory[4]. There are reports indicating that these bodies consist of iron-containing compounds[5–7]. Recently it has been stated that[8] Heinz bodies are identical with denatured globin, isolated by Warburg *et al.*[9] from blood in phenylhydrazine poisoning. This conclusion has since been attributed erroneously[4] to Warburg *et al.*

Electron micrographs made of erythrocytes containing Heinz bodies, however, cast some doubt on the latter interpretation. Thus, the inclusion bodies appear as unusually opaque structures (Fig. 1), similar to those shown by Jung[10] earlier. The electron micrographs strongly suggest that the Heinz bodies contain atoms heavier than those contained in globin. Therefore, a separation of Heinz bodies from the denatured globin was undertaken.

Cats were given 30 mgm. aniline per kgm. body-weight in 0·9 per cent sodium chloride intravenously. The development of Heinz bodies within the erythrocytes was followed by the electron microscope in order to observe their first appearance. Blood smears were prepared on glass slides before injecting the aniline, and at intervals up to four days after the injection. The smear was covered with a 'Formvar' film and floated off on to water. After hæmolysis it was transferred on to the grids and examined in the electron microscope. This procedure should remove the denatured globin from the corpuscles since, according to Warburg, hæmolysis frees denatured globin from erythrocytes[9].

Shortly following the injection of aniline, one or two black, irregular bodies, about 0·1–0·2 μ in diameter, appear in approximately one-third of the erythrocytes. The incidence of these bodies and their size apparently increase, so that after 24 hr. almost all the erythrocytes contain one, or occasionally two large, black Heinz bodies. The bodies range in size from 0·5 to 1 μ and have a marginal position.





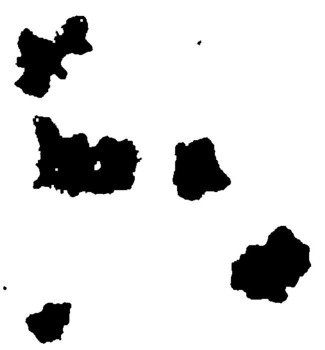


Fig. 1. Electron micrograph of a hæmolysed erythrocyte containing a Heinz body. (× 5,200)
Fig. 2. Isolated Heinz bodies stained with gentian violet. Light microscope. (× 1,000)
Fig. 3. Isolated Heinz bodies. Electron micrograph. (× 6,700)

For the isolation of the Heinz bodies, about 40–50 ml. of blood were drawn from the heart of an animal anæsthetized with nembutal, and heparinized. The chilled blood was centrifuged and the corpuscles were washed twice in 0·9 per cent sodium chloride and hæmolysed with 20 volumes of distilled water. The insoluble matter—which includes the denatured globin at neutral *p*H[8] and which imparts marked turbidity to the suspension—was washed repeatedly with distilled water in the centrifuge until colourless. In the last washing, the sediment was stirred rapidly in a small amount of distilled water to destroy the membranes completely and then was centrifuged at 1,000 *g* for three minutes. At this point a greyish, very heavy precipitate sediments first. The heavy fraction was separated from the overlying bulk of the precipitate, and both were taken up in ten volumes of 0·1 *N* hydrochloric acid.

Most of the insoluble matter other than the rapidly sedimenting fraction went into solution in 0·1 *N* hydrochloric acid, as does denatured globin[9]. This solution, separated from the insoluble material, gave a precipitate when neutralized. Neither the bulky fraction separated from the heavy fraction nor the precipitate formed after neutralization of the acid solution showed Heinz bodies when stained with gentian violet. Moreover, no structure was apparent in these preparations possessing such a high degree of opacity as the Heinz bodies in the electron micrographs.

The heavy, grey precipitate remained insoluble in 0·1 *N* hydrochloric acid. This precipitate was washed several times with the same acid and finally in distilled water. It showed innumerable bodies in the light microscope (Fig. 2), which stained characteristically with gentian violet; and it revealed typical bodies in the electron microscope (Fig. 3), which were identical with the Heinz bodies observed within the erythrocytes. The heavy, grey precipitate dissolves in 0·1 *N* sodium hydroxide. The ultra-violet absorption spectrum of this alkaline solution (Fig. 4) is not that of a pure protein such as globin. The absorption at 280 mμ is indicative of a small amount of protein which may be present as an integral part of the Heinz body or as a contaminant. Gross *et al.*[5] previously found iron in a fraction identified as Heinz body material, and we have confirmed this, using 2.2′-dipyridyl. Although some reservation exists because of the great sensitivity of the dipyridyl reaction, the presence of iron would account for the high opacity of Heinz bodies seen in the electron micrographs. Therefore it is concluded that the grey precipitate consists of Heinz bodies which are distinct and separable from the denatured globin.

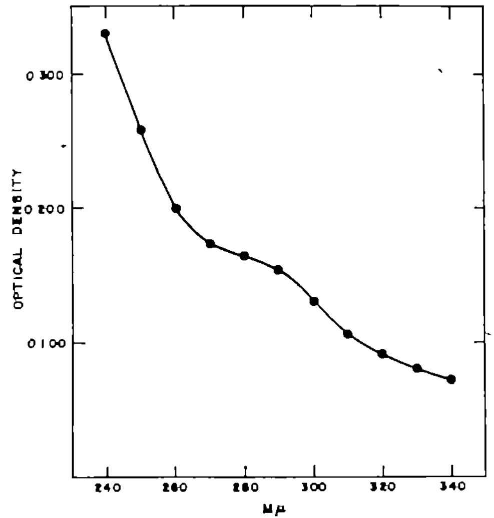


Fig. 4. Ultra-violet absorption spectrum of isolated Heinz bodies in 0·1 *N* sodium hydroxide

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## Rates of Combustion of Solid Fuel Particles

DURING the combustion of liquid fuel drops, the chemical oxidation occurs in the vapour phase. The rate-controlling process is thus the transfer of the heat necessary for the evaporation of the drop[1].

In the case of solid fuel particles, the primary combustion occurs at the surface of the particles. If the surface temperature is high enough (experimental evidence published by Tu, Davis and Hottel[2] suggests a threshold temperature of about 850° C.), the rate of the gas–solid reaction is so high that the chemical resistance is negligible, and thus the rate-determining process is the rate at which oxygen is transferred through the gas film surrounding the particle.

Methods of calculating this mass transfer-rate have been proposed by several authors, making use of the analogies between fluid friction, heat transfer and mass transfer[2,3]. It should be emphasized here that in calculating the fluid friction it is only the skin friction component of the total drag that is of significance. Furthermore, in cases in which a laminar boundary layer exercises a controlling influence, the simple turbulent flow forms of the analogies need modification by a function of the Prandtl number in the case of heat transfer[4] and of the Schmidt number in the case of mass transfer[5]. In cases where the Prandtl and Schmidt numbers approach unity, as can occur in gas-phase systems, these modifications may, in fact, be numerically small.

Some notes have been written recently by Edmondson[6], making particular reference to the equations based on Reynolds's analogy proposed by Silver[3] for the combustion-rates of solid particles, and presenting an analysis in these terms of published experimental results. Some reference was made in Edmondson's notes to the influence of laminar conditions, but the equations as applied were those based on the original form of Reynolds's analogy appropriate to the turbulent flow range.

However, rather than making use of the analogies between fluid friction, heat transfer and mass transfer, there is a more direct method of undertaking the calculation for the case of individual particles. There are already available several theoretical and experimental results on the transfer of mass to and from spherical surfaces. In particular, Froessling[7] has presented a semi-empirical equation expressing the mass transfer as a function of the Reynolds number and the Schmidt number. The range of Reynolds numbers examined experimentally was from 2 to 800.

It is suggested in the present communication that Frössling's equation be used, with appropriate values of the physical constants, for calculating the transfer of oxygen to burning spherical solid surfaces and hence the burning-rates.

For example, for carbon spheres in air, assuming that the main primary product of the heterogeneous reaction is carbon monoxide[8,9], it can be shown that the reaction-rate at a representative mean gas-film temperature of 1,200° C. may be expressed by the non-dimensional equation:

$$F = 0{\cdot}347\ (1 + 0{\cdot}272\ Re^{1/2}).$$

In this equation, $Re$ is the Reynolds number, and $F$, a non-dimensional reaction-rate factor, is equal to $Sd/\rho D$, where $S$ is the specific reaction-rate at the surface of the sphere (gm. sec.$^{-1}$ cm.$^{-2}$), $d$ is the diameter of the sphere (cm.), $\rho$ is the density of the gas (gm. cm.$^{-3}$), and $D$ is the coefficient of diffusion of oxygen in the gas (cm.$^2$ sec.$^{-1}$).

It may be noted that the value of the numerical factor 0·347 in the above expression for $F$ is directly proportional to the partial pressure of oxygen in the free gas stream. Over the range of at least 800°–1,400° C. at any given Reynolds number, the influence of the gas-film temperature on the numerical form of the above non-dimensional equation for $F$ is slight.

Comparison of theoretical values of the rates of burning calculated in this manner with published experimental measurements on the rates of burning of carbon spheres[2,10] shows evident agreement. This being so, the theoretical equation may be used to calculate in particular the effects of Reynolds number and partial pressure of oxygen on the rates of combustion.

Acknowledgment is made to the Chief Scientist, Ministry of Supply, for permission to publish this communication.

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## Effect of Irradiation on the Intensity Distribution of the Second Positive Nitrogen Bands excited in a Nitrogen Ozonizer

MORE exact measurements have now been made of the changes in the relative intensities of several bands of the second positive system of nitrogen, brought about by irradiation with the 3650–3660 A. group of mercury radiations, using an ozonizer discharge tube excited under conditions yielding the maximum negative Joshi effect when the pressure of the gas is 20 mm. These confirm, in general, the results of preliminary investigations[1] and show further that the percentage decreases of intensity are in the following order of bands:

In sequences: (1,4) > (0,3); (1,3) > (0,2)
In progressions. (0,3) > (0,2) > (0,1); (1,4) > (1,3).

The results show that a change in the relative intensity distribution of the second positive bands of nitrogen is thus brought about, not only in sequences but also in progressions.

A detailed study of the band systems and their intensities developed in the ozonizer tube, excited as above, has revealed that the excitation of the nitrogen molecule is brought about not only by electron collisions but also that collisions with particles of atomic or ionic masses play an important part[2]. Since the variations in electron collisions are less likely than those of atomic or ionic collisions to bring about an alteration in the relative intensity distribution of these bands[3], the present results, in the case of sequences, show that the atomic or ionic collisions are affected by irradiation. Further evidence on this point is afforded by the observation in the present investigation that external irradiation alters the intensity distribution of the bands in a manner similar to the substitution of air for nitrogen as recorded in experiments[4] on low-pressure induction-coil discharges through nitrogen and air.

The effect observed in the two progressions has to be attributed to an induced perturbation of the low $v''$ levels brought about by irradiation. A somewhat similar perturbation of these levels brought about by changes in discharge conditions has been observed in the first positive system of bands by Kaplan[5] and others[6].

Details are being submitted for publication elsewhere.

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## Microwave Spectrum and Structure of Iodosilane

IT has come to our notice that independent studies of pure-rotation spectra of the symmetric-top molecule $H_3SiI$ have been made in our two laboratories. The $J = 2 \rightarrow 3$ and $J = 3 \rightarrow 4$ transitions of $H_3{}^{28}SiI$ were observed at Schenectady with a Stark modulation microwave spectrograph, and the $J = 3 \rightarrow 4$, $J = 4 \rightarrow 5$ and $J = 5 \rightarrow 6$ transitions were observed at Birmingham with a microwave spectrograph of the 'video' type operating between about 20,000 Mc./sec. and 40,000 Mc./sec. Good agreement exists between the results of the two investigations. The hyperfine structures of the spectra can be well fitted to patterns calculated for the nuclear quadrupole coupling of the iodine nucleus, second-order effects being allowed for[1]. For $H_3{}^{28}SiI$, $B_0$ is 3,215·6 Mc./sec., the corresponding moment of inertia, $I_B$, is $260{\cdot}90 \times 10^{-40}$ gm.cm.², and the nuclear quadrupole coupling factor, $eqQ$, for $^{127}I$ is $- 1{,}240 \pm 30$ Mc./sec.

If we assume the Si—H distance to be 1·55 A., and the angle H—Si—H to be 111°, which is a configuration for the $SiH_3$ group close to that found in $H_3SiCl$ [2] and $H_3SiBr$ [3], the Si—I distance in iodosilane is found to be 2·433 A. This result is not very sensitive to reasonable variations in the assumed parameters; for example, the calculated length of Si—I is increased by only 0·004 A. if the angle H—Si—H is increased by 2°, or if the Si—H bonds are shortened by 0·04 A. The Si—I distance found agrees with that reported[4] in $SiI_4$ by electron diffraction, which appears to be the only previously determined length for such a bond. The length found is slightly less than that predicted by the Schomaker–Stevenson rule[5]. Iodosilane therefore falls into line with $H_3SiCl$ [2] and $H_3SiBr$ [3], in which Si—Cl obeys the rule and Si—Br is slightly shorter than predicted, whereas in the corresponding methyl halides the carbon–halogen bonds are longer than predicted by the rule[6]. The nuclear quadrupole coupling of $^{127}I$ in $H_3SiI$ is only about 64 per cent of that in methyl iodide, which also indicates that the Si—I and C—I bonds here differ in ways similar to those in which the silicon–halogen bonds in $H_3SiCl$ and $H_3SiBr$ differ from the corresponding bonds in the methyl halides[3,4].

More detailed measurements on these spectra, as observed in the 'video' instrument, are in progress, and it is hoped that these will make possible the determination of distortion coefficients for this molecule, and perhaps somewhat more closely determined values of $B_0$ and $eqQ$. It is also expected that the spectra of $H_3{}^{29}SiI$, $H_3{}^{30}SiI$ and deuterated iodosilanes will be observed and make possible a fuller determination of the molecular structure.

The work at the University of Birmingham is part of a programme of microwave spectroscopy in collaboration with the Physics Department of the Telecommunications Research Establishment, Malvern, and grateful acknowledgment is made to the Ministry of Supply for the loan of much of the equipment.

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## 'Giant' Fibres in Dragonfly Nymphs

A PRELIMINARY study of transverse and horizontal sections through the ventral nerve cord of late instar nymphs of *Anax imperator* (Anisoptera) has revealed several notable features. Accurate counts of the number of fibres within the commissures have shown that these range continuously from 0 to 16 µ, as set out in the accompanying histogram (Fig. 1). The total number of fibres is approximately the same for the two commissures. Measurements of axon diameters show that some of the larger fibres (12–16 µ) are comparable with the 'giant' fibres of the cockroach[1] and locust[2]. As in the nerves to the stellate ganglia of *Sepia*[3], these fibres form part of a continuous size spectrum and do not appear to differ in nature from the smaller ones. The 'giant' fibres are almost certainly the same as fibres *a*, *b* and *c* described by Zawarzin[4] in his classical studies of *Aeschna* nymphs using a methylene blue technique. The 'giant' fibres pass through all the abdominal

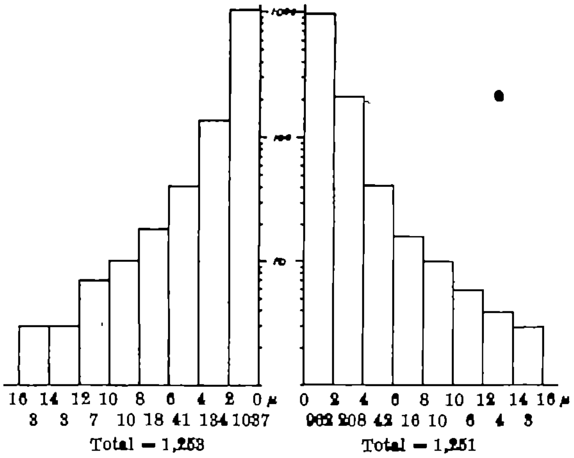

Fig. 1. *Anax.* Histogram to show sizes and frequencies of nerve fibres in the right and left commissures between the 3rd and 4th abdominal ganglia. The number of fibres is plotted on a logarithmic scale

ganglia and send off collaterals into the neuropile of each. Their course through the closely associated metathoracic and first abdominal ganglia to the other thoracic ganglia is more complicated, and has not been fully traced as yet.

Histologically, the 'giant' fibres are of interest because they are surrounded by a definite sheath with well-defined nuclei (Fig. 2). Numerous sheath nuclei have also been observed in sections of the segmental nerves of *Anax*, *Dytiscus* and *Periplaneta*, so that it is probable that at least some insect peripheral nerve fibres are surrounded by such a sheath. In addition to these membranes, there is a distinct sheath (perilemma) enveloping the whole chain of ganglia in these insects (Fig. 2). This sheath is also visible in sections of locust ganglia[4] and it is probably common to all insects. Transverse sections of whole *Periplaneta*, *Dytiscus* and *Calliphora* have clearly shown that the perilemma extends over the peripheral nerves, the neural lamella staining bright blue with Mallory's triple stain. This suggests that the striking tolerance of insect nervous systems to changes in the ionic content[5-7] of the surrounding fluid is partly due to a sheath surrounding the central nervous system in addition to the one which protects the peripheral nerves[8]. The properties of the sheaths around individual axons might similarly be important.

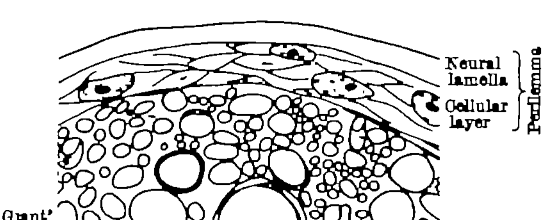

Fig. 2. *Anax.* Part of a transverse section through a commissure shortly after leaving the 3rd abdominal ganglion, showing perilemma and 'giant' fibres with their nucleated sheath. Fixation: 0·2 per cent osmic acid in saturated picric acid. Stain: iron hæmatoxylin. Tracing from a photomicrograph

Electrical activity recorded from electrodes hooked under the abdominal nerve cord includes many different types of action potential, some of which are larger than the others and are presumably from the 'giant' fibres. Mechanical stimulation of the abdomen or anal appendages is followed by bursts of activity in which the large spikes are prominent. Stimulation of the head, however, elicits a different pattern of discharge which does not include the large spikes.

It seems probable that these 'giant' fibres are concerned in the neuromuscular mechanism involved in the rapid expulsion of water from the rectal chamber which brings about jet propulsion in Anisopterid nymphs. The muscles involved are the longitudinal, oblique and dorso-ventral abdominal muscles together with the intrinsic musculature of the hind gut. Water is ejected at a considerable velocity and may reach a height of three feet in air. Simultaneously with the synergic contraction of the abdominal muscles, the legs are drawn into the side of the body and so the resistance to forward movement is decreased. Electrical stimulation (50/sec.) of the abdominal nerve cord in normal and decapitated insects produces this characteristic movement of the legs in addition to active contraction of the abdominal musculature.

No invariable way of evoking swimming has been discovered; but a stream of water is usually expelled when attempts are made gently to grasp the abdomen. The insects must be freely suspended, as swimming is inhibited if the legs are holding pieces of weed, etc. On the other hand, nymphs seized by the head react in a different way. The abdomen is generally flexed laterally and the assailant attacked with the anal appendages, which form a spear-like weapon when closely apposed to one another. These two different responses of the whole animal invite comparison with the two types of electrical discharge recorded from the abdominal nerve cord.

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## Endogenous Buds in *Ophioglossum vulgatum* L.

ROOT buds are known in several species of *Ophioglossum* and are the common means of propagation[1-3]. In an experimental investigation of bud formation in *Ophioglossum vulgatum*, root buds have been induced in both entire and decapitated isolated roots. While some buds may be formed from a segment of the root apical meristem, as described by Rostowzew[4], those which occur at random along the root develop from parenchyma cells of the middle cortex and are endogenous. Endogenous buds have also been induced in the pith parenchyma of shoots from which the apex had been excised (Figs. 1–3). In the formation of these endogenous root and shoot buds the following developments have been observed: the inception of a growth centre in a group of deeply seated parenchyma cells; the rapid division of one or more of these cells to form a spherical or ellipsoidal

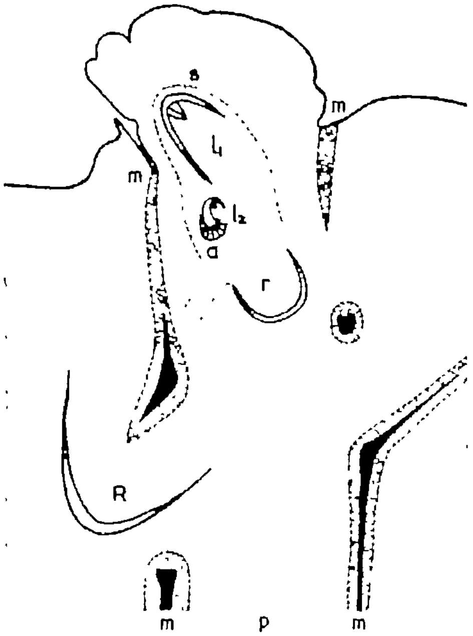

Fig 1. Endogenous bud in the pith at the distal end of a decapitated shoot (Semi-diagrammatic, based on three superimposed camera-lucida drawings). *m*, Meristeles of parent shoot, *p*, pith; *R*, root of parent shoot; *a*, bud apex, $l_1$, $l_2$, leaf primordia, *r*, bud root, *s*, sheath of first leaf, consisting of modified pith parenchyma. (× 40)

meristematic cell mass (Fig. 2); the formation of an upwardly directed nascent shoot apex by the elongation and longitudinal division of a group of cells within this mass (Fig. 3); the lysis and distension of the adjacent cells above, so that the upper surface of the nascent apical meristem becomes freely exposed to the small air space thus formed; the early formation of a rapidly growing first leaf and first root (Fig. 1); a concentric organization of the meristematic and parenchyma cells surrounding the apex so that they constitute a protective sheath which resembles a normal stipular sheath; and the basipetal development of an incipient vascular strand by the longitudinal division of the parenchyma cells situated below the bud (Fig. 1), phloem and xylem being eventually differentiated in this strand. Root buds are not formed by the transformation of incipient lateral roots—these, in fact, do not occur in *O. vulgatum*—and they bear no obligate relationship to the orientation of the root stele. The subsequent developments leading to the formation of a young plant, with a shoot-apex and several leaves and roots, are as in the normal development.

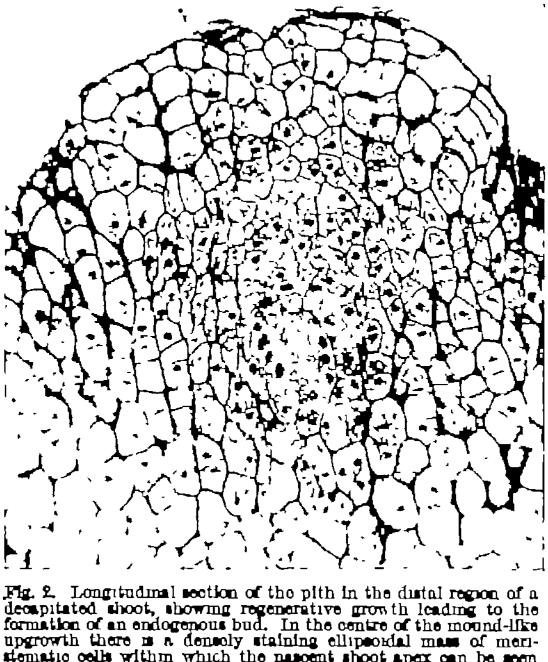

Fig. 2. Longitudinal section of the pith in the distal region of a decapitated shoot, showing regenerative growth leading to the formation of an endogenous bud. In the centre of the mound-like upgrowth there is a densely staining ellipsoidal mass of meristematic cells within which the nascent shoot apex can be seen (*see also* Fig. 3). (× 80.) (*Photo* *Ernest Ashby*)

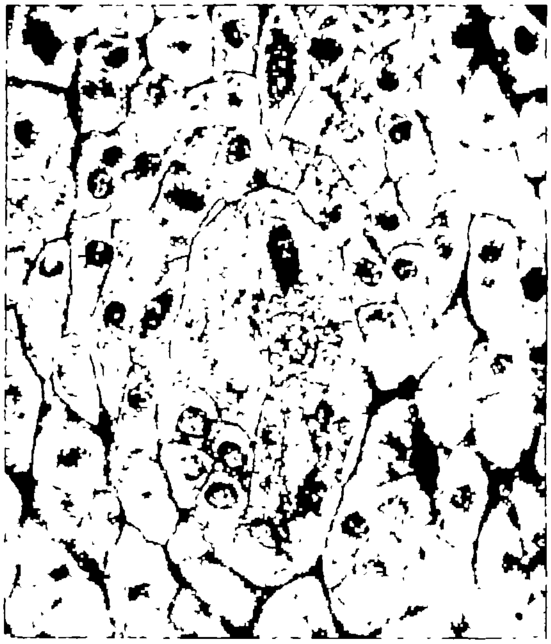

Fig 3. Part of Fig. 2, showing the nascent bud apex. Some of the meristematic cells have elongated and divided by longitudinal walls. The surrounding cells are being thrust outwards and are dividing by walls which are anticlinal to the new apex (× 225) (*Photo*. *Ernest Ashby*)

These developments are very different to those observed in the embryogeny. In the young sporophyte the first distinguishable organs are the foot and the root, the latter being well developed before any apical bud can be discerned; moreover, the first leaf is rudimentary whereas the second is said to take several years before it appears above ground. These differences between bud formation on roots and shoots and the development of the sporophyte on the prothallus illustrate the importance of nutritional factors in morphogenesis. In the inception of buds a nascent shoot apex is the first organ to become apparent and, like other shoot apices, it functions as a self-determining, organizing region, its effects extending into the surrounding parenchymatous tissue within which the endogenous bud is enclosed.

These observations will be described and discussed in greater detail elsewhere.

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## Growth of Influenza Virus in the Chick Chorion

HOYLE[1] found that, following inoculation of influenza virus into the allantoic cavity of fertile hens' eggs, complement-fixing 'soluble' antigen became detectable in suspensions of chorio-allantoic membranes before the virus itself. He suggested[1,2] that the 'soluble' antigen was an intracellular form of the virus or a virus precursor. Henle and Henle[3] and Fulton[4], working on similar lines, concluded that 'soluble' antigen and virus antigens appeared together; and Cairns[5] has shown that Hoyle's interpretation of his own results is not necessarily correct, since there are differences in the sensitivity of the experimental methods in this particular situation.

One assumption underlying work of this type is that the cells of the chorio-allantoic membrane respond uniformly to infection by influenza viruses. A test of this assumption has been made by comparing the response to infection of the chorionic surface of the membrane with that of the allantoic. Fertile hens' eggs (10–11 day) were inoculated on the chorionic surface of the 'dropped' membrane[6], or intra-allantoically. The virus used was the *PR*8 strain of influenza *A*; the inoculum was given in 0·5-ml. amounts, diluted in 50 per cent broth-saline. At appropriate intervals after inoculation the allantoic fluids were harvested and the chorio-allantoic membranes removed and stored at – 70° C. until required. Usually, six eggs were tested in each group; all membranes were treated and tested individually. They were frozen rapidly and thawed slowly three times, spun lightly and the supernatant fluids (membrane suspension) removed. The allantoic fluids were titrated for hæmagglutinin and the membrane suspensions titrated for infectivity in eggs, complement-fixing 'soluble' antigen and hæmagglutinin (following treatment with sufficient receptor-destroying enzyme[7] to remove all inhibitor present). The variables in these experiments were the route of inoculation—chorionic or intra-allantoic—the size of inoculum and the time of incubation.

Following intra-allantoic inoculation, hæmagglutinin appeared in the allantoic fluid in high titre, and membrane suspensions showed high titres of infective virus, 'soluble' antigen and hæmagglutinin. The results with different sizes of inoculum and different times of incubation followed the pattern expected from the work of Henle and Henle[3] and von Magnus[8]. By contrast, the behaviour of eggs injected by the chorionic route was strikingly different. In general, no agglutinating virus was detected in the allantoic fluid, even following inoculation of $10^{3}$–$10^{6}$ $ID_{50}$ of virus. This statement needs qualification, since in early experiments a proportion of eggs (14/44) showed high titres of agglutinin in the allantoic fluid. It was suspected that these anomalies may have resulted from minor injuries to the membrane during 'dropping', and in later experiments membranes were 'dropped' 24 hr. before chorionic inoculation of virus in order to allow for healing of small lesions. This change in technique was rewarded by a sharp drop in the number (7/104) of eggs showing agglutinin in the allantoic fluid. Since the latter behaved in all respects like eggs injected intra-allantoically, they will be excluded from the description which follows.

Membrane suspensions from eggs inoculated chorionically showed low infectivity titres following injection of 100 $ID_{50}$ of virus. The titres showed only a slight rise (10 to 100-fold) in infectivity over the amount of virus inoculated and were much lower ($10^{-4}$ to $10^{-5}$-fold) than those of membranes from corresponding eggs inoculated intra-allantoically. Agglutinin and 'soluble' antigen were not detected. With large inocula (approximately $10^{6}$ $ID_{50}$ of virus) traces of agglutinin were detected, but only following treatment of the suspensions with receptor-destroying enzyme. However, high titres of 'soluble' antigen were found. The titre of 'soluble' antigen in membrane suspensions was roughly proportional to the amount of virus inoculated, although there was considerable variation in the titre of individual eggs given the same inoculum.

In those eggs in which it was measurable, agglutinin was first detected four hours after chorionic inoculation of $10^{6}$–$10^{6.5}$ $ID_{50}$ of virus; it was still detectable up to 24 hr. but not at 48 or 72 hr. Complement-fixing antigen was first detected at 3 hr. in 6/12 eggs after inoculation of the same amount of virus. This proportion is higher than that of allantoically inoculated eggs, where complement-fixing antigen was detected in only 1/12 eggs at 3 hr.; however, the difference is barely significant ($p < 0{\cdot}10 > 0{\cdot}05$). In eggs inoculated by the chorionic route, the 'soluble' antigen titre rose to reach a maximum at 24 hr. and had declined considerably by 72 hr. Since eggs injected by the chorionic route behaved in some respects as if they supported only a single 'cycle' of virus multiplication, it was interesting to note that the decline in 'soluble' antigen titre could be prevented by repeated chorionic inoculations of virus.

The possibility was considered that the different behaviour of chorionic and allantoic cells might depend on the different physiological conditions in the two layers. Experiments were therefore carried out with chorio-allantoic membrane *in vitro*, using the principles of a technique previously described[9] and now modified to allow infection of one layer at a time only. Infection of chorionic and allantoic layers separately was carried out with the *BAR* (*A'*) strain. 16/18 pieces of membranes infected on the allantoic surface showed high-titred agglutinin in the supernatant fluid; only 1/18 pieces infected on the chorionic surface showed agglutinin, and on inspection an obvious tear was found in the single positive piece. These results support those obtained by egg techniques, and confirm the essential difference in response to infection of chorionic and allantoic cells.

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July 21.

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[2] Hoyle, L., *J. Hyg.*, 48, 277 (1950).

[3] Henle, W., and Henle, G., *J. Exp. Med.*, 90, 23 (1949).

[4] Fulton, F., *Nature*, 164, 189 (1949).

[5] Cairns, H. J. F., Symposium on Virus Multiplication; Society of General Microbiology, Oxford (April 1952).

[6] Beveridge, W. I. B., and Burnet, F. M., Med. Res. Council Spec. Rep. Ser. No. 256 (1946).

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# FORTHCOMING EVENTS

(*Meetings marked with an asterisk * are open to the public*)

## Monday, January 12

British Society for the History of Science, Philosophy of Science Group (in the Joint Staff Common Room, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Prof. R. J. Pumphrey "The Evolution of Thinking".

Manchester Literary and Philosophical Society (in the Reynolds Hall, College of Technology, Manchester), at 5.30 p.m.—Prof. F. E. Simon, F.R.S.: "The Absolute Zero of Temperature" (Wilde Memorial Lecture).*

University of London (at University College, W.C.1), at 5.30 p.m.—Prof. J. Cathala (Toulouse): "Fundamental Concepts in Chemical Engineering". (Further lectures on Jan. 14 and 16.)*

University of London (at King's College, W.C.2), at 5.30 p.m.—Dr. R. Matalon "Colloid Science and some of its Industrial Applications". (Further lectures on Jan. 22, Feb. 10, 24 and March 10.)*

Pharmaceutical Society (at 17 Bloomsbury Square, London, W.C.1), at 7.30 p.m.—Mr. D. Train: "Pharmaceutical Engineering Science".

British Psychological Society, Social Psychology Section (in the Department of Psychology, University College, Gower Street, London, W.C.1), at 8.15 p.m.—Mr. B. M. Foss: "A New Sociometric Technique"; Dr. F. Kraupl Taylor: "Sociometric Dimensions".

Royal Geographical Society (at 1 Kensington Gore, London, S.W.7), at 8.15 p.m.—Dr. Anton Bruun: "Danish Deep Sea Expedition, 1951–52".

## Tuesday, January 13

Institution of Chemical Engineers (in the Great Hall, Caxton Hall, Caxton Street, London, S.W.1), at 2 p.m.—Symposium on "Bursting Discs".

University of London (at the Royal Veterinary College and Hospital, Camden Town, London, N.W.1), at 4 p.m.—Prof. S. A. Asdell (Cornell University): "Mammalian Reproduction".* (Further Lectures on January 14 and 15.)

Institution of the Rubber Industry (at the Royal Society of Tropical Medicine and Hygiene, Manson House, 26 Portland Place, London, W.1), at 5.30 p.m.—Lecture on "Calendering"; at 7 p.m.—Dr. R. G. James: "Some Aspects of Latex Thread Coagulation"; Dr. H. J. Stern: "Latex for Surface Coatings".

University of London (at the Senate House, Malet Street, London, W.C.1), at 5.30 p.m.—Sir James Scott Watson: "Soil and Food" (Sanderson-Wells Lecture).*

## Wednesday, January 14

Society for Applied Bacteriology (joint meeting with the Microbiology Group of the Society of Chemical Industry, at the Institution of Civil Engineers, Great George Street, London, S.W.1), at 10.15 a.m.—Scientific Papers; at 2.15 p.m.—Symposium on "Recent Advances in Microbiological Methods".

Royal Sanitary Institute (at 90 Buckingham Palace Road, London, S.W.1), at 2.30 p.m.—Discussion on "Fluorides in Water Supplies" (to be opened by Dr. Roy C. Hoather).

Royal Society of Arts (at John Adam Street, Adelphi, London, W.C.2), at 2.30 p.m.—Mr. W. H. P. Johnson: "Use and Abuse of Fuels".

Geological Society of London (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Scientific Papers.

Physical Society, Acoustics Group (in the Physics Department, Imperial College of Science and Technology, Imperial Institute Road, London, S.W.7), at 5.15 p.m.—Dr. K. Tamm and Dr. G. Kurtze: "Sound Absorption in Aqueous Solutions of Electrolytes—(a) Measuring Techniques, (b) Results and Explanation".

Institute of Petroleum (at Manson House, 26 Portland Place, London, W.1), at 5.30 p.m.—Mr. H. C. Rampton: "Methods of Hydrocarbon Type Analysis".*

Royal Statistical Society, Study Section (at the R.I.M.A. Theatre, 2 Savoy Hill, London, W.C.2), at 6 p.m.—Mr. D. L. Lamberth: "Forms with Many Functions".

## Thursday, January 15

University of London (in the Anatomy Theatre, University College, Gower Street, London, W.C.1), at 1.15 p.m.—Mr. P. H. R. James: "Recent Experiments in the Psychology of Vision".*

Institution of Mining and Metallurgy (at the Geological Society of London, Burlington House, Piccadilly, London, W.1), at 5 p.m.—Scientific Papers.

Society of Chemical Industry, Road and Building Materials Group (at the Building Centre, Store Street, London, W.C.1), at 6 p.m.—Mr. A. R. Smee and Mr. L. Mullins: "The Use of Rubber in Bituminous Road Surfaces".

British Institute of Radiology (at 32 Welbeck Street, London, W.1).—Discussion on "The Technical Problems affecting Radiology".

## Friday, January 16

Institute of Navigation (at the Royal Geographical Society, 1 Kensington Gore, London, S.W.7), at 5 p.m.—Mr. L. S. le Page and Mr. A. L. P. Milwright: "Radar and Ice".

Institution of Mechanical Engineers (at Storey's Gate, St. James's Park, London, S.W.1), at 5.30 p.m.—Mr. H. N. Pemberton: "Welding in Marine Engineering" (Thomas Lowe Gray Lecture).

## Friday, January 16—Saturday, January 17

Institute of Physics, Industrial Radiology Group (joint meeting with the Hospital Physicists' Association, at the Royal Institution, 21 Albemarle Street, London, W.1).—Discussion on "Radiation Protection".

Friday, January 16

At 7 p.m.—"Medical and Industrial Aspects".

Saturday, January 17

At 9.30 p.m.—"Monitoring".

## Saturday, January 17

Biochemical Society (in the Department of Physiology and Biochemistry, King's College, Strand, London, W.C.2), at 10.30 a.m.—Scientific Papers.

# APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

University Graduate with first- or second-class honours in pure or applied science for the Department of Pedology, Soil Survey (Scotland) Section—The Secretary, Macaulay Institute for Soil Research, Craigiebuckler, Aberdeen (January 17).

Physicist at the Central Research Establishment, Worton Hall, Isleworth, to lead a small team engaged in research on the structure of solids and on the mechanism of brittle fracture and abrasive wear—The National Coal Board, Establishments (Personnel), Hobart House, Grosvenor Place, London, S.W.1, endorsed TT/576 (January 19).

Keeper in the Department of Natural History, City Museum and Art Gallery, Birmingham 3—The Director (January 26).

Lecturer (honours graduate) in Inorganic and Physical Chemistry—The Principal, Heriot-Watt College, Edinburgh (January 26).

Chemist and Bacteriologist—The Clerk to the Bucks Water Board, 7 Temple Square, Aylesbury, Bucks (January 30).

Chair of Fuel Technology—The Registrar, The University, Sheffield (January 31).

Senior Research Officer or Research Officer (with university degree with honours in agriculture or science and experience in research in plant nutrition) for investigations into plant nutrition and biological problems, with particular reference to the cultivation of fruit trees, including citrus, in the Murrumbidgee Irrigation Area (Ref. 3940), and a Senior Research Officer or Research Officer (Chemist) (with university honours degree in science or equivalent qualification) to conduct research into various chemical aspects of plant growth and soil problems on the Murrumbidgee Irrigation Area (Ref. 3941)—The Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting the appropriate Ref. No. (January 31).

Lecturers (2) in Botany, and a Lecturer in Organic Chemistry—The Secretary, Queen's University, Belfast (February 25).

Senior and Junior Fellowships for fundamental research in aerodynamics or aeronautical structures—The Director, Royal Aircraft Establishment, Farnborough, Hants (March 1).

Broodbank Fellowship for research in biochemistry or biophysics, with special reference to the principles and practice of food preservation—The Registrary and the University Registry, The Old Schools, Cambridge (March 31).

Will Edmonds Fellowship for clinical research in hospitals in the Metropolitan area of London—The Assistant Secretary, Royal College of Physicians, Pall Mall East, London, S.W.1 (March 31).

Chemist or Chemical Engineer at Salwick, near Preston, to lead a team on pilot plant experimental work, and for interpreting fundamental scientific information and providing design data—The Ministry of Supply, Division of Atomic Energy (Production), Risley, Warrington, Lancs, quoting 409.

Senior Chemist (Senior Scientific Officer grade) for research laboratories at Salwick, near Preston—The Ministry of Supply, Division of Atomic Energy (Production), Risley, Warrington, Lancs, quoting 400.

Experimental Officer at Torry Research Station, Aberdeen, for research into the physics of fish preservation, involving investigations of properties of smoke, measurement of moisture, high vacuum techniques, colorimetry, and servo-control methods—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting A.116/52A.

Scientific Assistant (with a degree in agriculture or natural science, a knowledge of French and German, and the ability to write clear, concise abstracts in English) for examining and abstracting world scientific literature on grassland and field crop research—The Director, Commonwealth Bureau of Pastures and Field Crops, Aberystwyth.

Scientific Officer (with first- or second-class honours degree or equivalent in chemistry) with sound knowledge of electrochemistry and electrodeposition of metals, at the Ministry of Supply Establishment, Aldermaston—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting F.317/52A.

# REPORTS and other PUBLICATIONS

(*not included in the monthly Books Supplement*)

## Great Britain and Ireland

Association of Universities of the British Commonwealth. United Kingdom Postgraduate Awards (Fellowships, Scholarships, Grants, etc.), 1952–53. Pp. 94. (London: Association of Universities of the British Commonwealth, 1952.) [1211

Annual Report of the British Interplanetary Society. Pp. 301–364. (London: British Interplanetary Society, 1952.) [1811

Question: a Journal. Edited by H. Westmann. Vol. 5, No. 1: Conflicts of Loyalties. By Prof. M. Polanyi, J. H. Oldham, Prof. W. R. Niblett, H. Westmann and Herbert Read. (Published for the Present Question Conference, Ltd.) Pp. 112. (London: Hammond, Hammond and Co., Ltd., 1952.) 3s. 6d. [1811

Department of Scientific and Industrial Research. Report of the Hydraulics Research Board for the Years 1947–1951 with the Report of the Director of Hydraulics Research for the Years 1948–1951. Pp. iv+40+12 plates. (London: H.M. Stationery Office, 1952.) 3s. net. [1811

Department of Agriculture: Fisheries Branch. Report on the Sea and Inland Fisheries for the Year 1951, incorporating Statistics of the Capture of Salmon, Sea Trout and Eels. (Pr. 1344.) Pp. 47. (Dublin: Stationery Office, 1952.) 2s. 6d. [1911

British Hat and Allied Feltmakers Research Association. Fifth Annual Report of the Director of Research for Year ending August 1952. Pp. 20. (Manchester: British Hat and Allied Feltmakers Research Association, 1952.) [2011

Department of Scientific and Industrial Research. Report of the Mechanical Engineering Research Board with the Report of the Director of Mechanical Engineering Research for the Year 1951. Pp. iv+88+4 plates. (London: H.M. Stationery Office, 1952.) 2s. net. [2011

Select List of Standard British Scientific and Technical Books. Edited by H. R. McColvin. Compiled at the request of the British Council. Fourth edition revised and enlarged. Pp. 72. (London: Aslib, 1952.) 7s. 6d.; to members of Aslib, 6s. [2011

Report from the Select Committee on Nationalised Industries together with the Proceedings of the Committee. Pp. xxiv. (London: H.M. Stationery Office, 1952.) 9d. net. [2411

National Physical Laboratory. Notes on Applied Science, No. 2: The Industrial Application of Aerodynamic Techniques. Pp. vi+37. (London: H.M. Stationery Office, 1952.) 3s. 6d. net. [2011

Angry Prayers: a Report on the Convention of British Animal Protection Societies. Edited by Keidrych Rhys. Second edition. Pp. viii+64. (London: National Canine Defence League, 1952.) 2s. 6d. net. [2611

City of Leeds. Annual Report of the Sub-Libraries and Arts (Museums) Committee to the Council for the Year ended 31st March, 1952. Pp. 10. (Leeds: City Library, 1952.) [2611

Ultrasonic Examination of Axles of Railway Rolling Stock. By Dr. Erich Martin. (Report No. 776 of the Committee on Materials of the Verein Deutscher Eisenhuttenleute.) Translated. Pp. 24. (London: Solus-Schall, Ltd., 1952.) [2611

## Other Countries

New Zealand Department of Scientific and Industrial Research. Geophysical Memoir 1: Magnetic Resurvey of New Zealand at Epoch 1st July 1945. By H. F. Baird and A. L. Cullington. Pp. 54. (Wellington: Government Printer, 1952.) [1111

Cawthron Institute. Annual Report, 1951–52. Pp. 42. (Nelson, N.Z.: Cawthron Institute, 1952.) [1111

United States Department of Commerce: National Bureau of Standards. Applied Mathematics Series 25: Tables of the Bessel Functions $Y_0(x)$, $Y_1(x)$, $K_0(x)$, $K_1(x)$, $0 \leq x \leq 1$. Pp. ix+60. (Washington, D.C.: Government Printing Office, 1952.) 40 cents. [1111

Annals of the New York Academy of Sciences. Vol. 55, Article 2: The Chick Embryo in Biological Research. By David A. Karnofsky and 27 other authors. Pp. 37–344. 4 dollars. Vol. 55, Article 3: Shock Syndrome. By John Scudder and 25 other authors. Pp. 345–542. 3.75 dollars. (New York: New York Academy of Sciences, 1952.) [1111

Government of India: Meteorological Department. Report on the Administration of the Meteorological Department of the Government of India in 1950–51. Pp. ii+46. (New Delhi: Meteorological Department, 1952.) [1211

Proceedings of the Eighth Meeting of the Crops and Soils Wing of the Board of Agriculture and Animal Husbandry in India, held at Patiala from 28th to the 31st March, 1950. Pp. iii+307. (Delhi: Manager of Publications, 1952.) 12 rupees; 19s. [1211

Proceedings of the Eighth Meeting of the Animal Husbandry Wing of the Board of Agriculture and Animal Husbandry in India, Mysore, 17th to 22nd February, 1949. Pp. xii+260. (Delhi: Manager of Publications, 1951.) 11.14 rupees; 18s. 6d. [1211

Indian Forest Bulletin (New Series). No. 101 (Cellulose and Paper): Indigenous Cellulosic Raw Materials for the Production of Pulp, Paper and Board, Part 11, Chemical Pulps from *Andropogon contortus*, Linn. (*Kusal* grass.) By R. V. Bhat and M. G. Karnik. Pp. ii+8. (Delhi: Manager of Publications, 1952.) 10 annas; 1s. [1311

Indian Forest Records (New Series). Vol. 1, No. 1 (Composite Wood): Weathering Trials on some Synthetic Resin Bonded Aircraft Components. By D. Narayanamurti, Joseph George, N. Subramanyan and N. R. Das. Pp. 8+10 plates. (Delhi: Manager of Publications, 1952.) 12 annas; 1s. [1311

Indian Forest Leaflet. No. 130 (Silviculture): General Formulae for Measurement of Heights of Trees. By V. S. Krishnaswamy. Pp. 9. (Delhi: Manager of Publications, 1952.) 10 annas; 1s. [1311

Chemical Apparatus in the U.S.A. Technical Assistance Mission No. 23. Report by a Group of European Experts. Pp. 224. (Paris: Organisation for European Economic Co-operation; London: H.M. Stationery Office, 1952.) 20s. net. [1811

Koninklijk Nederlands Meteorologisch Instituut. No. 102 (Mededelingen en Verhandelingen Serie A, 57): Klimaat en Brouwgersteteelt in Nederland; een Bijdrage tot de Oecologie van de Zomergerst. Door Dr. C. Kramer, Dr. J. J. Post en W. Wilten. Pp. 149. 2.25 f. No. 106a: Upper Air Data, 34, 1949. Pp. 90. 12 f. No. 108: Seismic Records at De Bilt, 35, 1947. Pp. vii+30. 1 f. ('s-Gravenhage: Staatsdrukkerij- en Uitgeverijbedrijf, 1951–1952.) [1811

Commonwealth Scientific and Industrial Research Organization. Bulletin No. 269: A Comparative Study of *Pisum*, *Vicia*, *Lathyrus* and *Lupinus* Varieties grown in Buckingham Sand in the Coonalpyn Downs, South Australia. By D. S. Riceman and J. K. Powrie. Pp. 36+3 plates. (Melbourne: Commonwealth Scientific and Industrial Research Organization, 1952.) [1811

Publications de l'Institut National pour l'Étude Agronomique du Congo Belge. Hors Série, 1952. Pp. 436. (Bruxelles: Institut National pour l'Étude Agronomique du Congo Belge, 1952.) 160 francs. [1811

Coryndon Memorial Museum. Occasional Papers, No. 3: Notes on African Gomphidae, by Lieut.-Colonel F. C. Fraser, and Three New Species of Odonata, by E. C. G. Pinhey. Pp. 16. (Nairobi: Coryndon Memorial Museum; Cambridge: Deighton, Bell and Co., 1952.) 5s. [1811

Goteborgs Kungl. Vetenskaps- och Vitterhets-Samhalle. Reports of the Swedish Deep-Sea Expedition, 1947–1948. Vol. 5: Sediment Cores from the East Pacific. By Gustaf Arrhenius. Fasc. 1. Pp. 227. 75 kr. Vol. 5, Part 2: Description of the Sediment Cores. By Gustaf Arrhenius. Appendix: Description of Plates. Pp. 4+plates 2.6.1–2.62. (Goteborg: Elanders Boktryckeri A.B., 1952.) [1911

Unesco: International Bureau of Education. Publication No. 139: XVth International Conference on Public Education, convened by Unesco and the I.B.E., Geneva, 1952. Teaching of Natural Science in Secondary Schools. Pp. 216. (Paris: Unesco; Geneva: International Bureau of Education; London: H.M. Stationery Office, 1952.) 5 francs; 8s. 6d. [1911

Scientific Council for Africa South of the Sahara. First Report, November 1950 to June 1952. Pp. 48. (Kikuyu: Scientific Council for Africa South of the Sahara, 1952.) 2s. 6d. [2011

Bulletin of the American Museum of Natural History. Vol. 99, Article 8: The Neotropical Genera *Procornitermes* and *Cornitermes* (Isoptera, Termitidae.) By Alfred E. Emerson. Pp. 475–540. (New York: American Museum of Natural History, 1952.) 80 cents. [2011

University of California Publications in Zoology. Vol. 52, No. 1: Distribution and Variation of the Brown Towhees. By John Davis. Pp. 120. 1.25 dollars. Vol. 52, No. 2: A Comparison of Variation, Behavior and Evolution in the Sea Bird Genera *Uria* and *Cepphus*. By Robert W. Storer. Pp. 121–222+2 plates. 1.25 dollars. (Berkeley and Los Angeles: University of California Press; London: Cambridge University Press, 1951–1952.) [2611

Report of the International Scientific Commission for the Investigation of the Facts concerning Bacterial Warfare in Korea and China. Pp. 665. (Prague: World Council of Peace, 1952.) [2611

Colony and Protectorate of Kenya. Report of the Forest Department for the Years 1948, 1949, 1950. Pp. 62. (Nairobi: Government Printer, 1952.) 3s. [2611

Transactions of the American Philosophical Society. New Series, Vol. 42, Part 3: Three Revolutionary Architects, Boullée, Ledoux and Lequeu. By Emil Kaufmann. Pp. 429–564. (Philadelphia: American Philosophical Society, 1952.) 2 dollars. [2611

Beach Erosion Board: Corps of Engineers. Technical Memorandum No. 28: Source of Beach Sand at Santa Barbara, California, as indicated by Mineral Grain Studies. By Parker D. Trask. Pp. ii+24. (Washington, D.C.: Government Printing Office, 1952.) [2611

Report on Federal Forest Administration in the Federation of Malaya for the Year 1951. By J. P. Edwards. Pp. 67+4 plates. (Kuala Lumpur: Government Printer, 1952.) 2 dollars; 4s. 8d. [2611

Bulletin of the American Museum of Natural History. Vol. 99, Article 9: A New Fossil Tortoise from Mona Island, West Indies, and a Tentative Arrangement of the Tortoises of the World. By Ernest Williams. Pp. 541–560+plates 44–47. 50 cents. Vol. 99, Article 10: A Pseudosuchian Reptile from Arizona. By Edwin H. Colbert. Pp. 561–592+plates 48–49. 50 cents. (New York: American Museum of Natural History, 1952.) [2611

American Journal of Science. Bowen Volume. (Geophysical Laboratory, Carnegie Institution of Washington, Publication No. 1200.) Part 1. Pp. viii+318. Part 2. Pp. iv+319–627. (New Haven, Conn.: American Journal of Science, 1952.) [2611

Skrifter udgivne af Kommissionen for Danmarks Fiskeri- og Havundersøgelser. Nr. 14: Kommissionen for Danmarks Fiskeri- og Havundersøgelser, 1902–1952. Af Erik M. Poulsen. Pp. 78. (København: C. A. Reitzels Forlag, 1952.) 6 kr. [2011

Meddelelser fra Danmarks Fiskeri- og Havundersøgelser. Ny Serie, Bind 1, Nr. 1: Undersøgelse af Industrifisk-Fiskeriet i Danmark, Saerlig I, 1949–51. Af Aage J. C. Jensen. Pp. 81. 15 kr. Serie Plankton, Bind 5, Nr. 5: Investigations on the Phytoplankton in the Southern North Sea in May 1947. By Jul. Grøntved. Pp. 50+1 plate. 10 kr. (København: C. A. Reitzels Forlag, 1952.) [2611

State of California: Department of Fish and Game, Bureau of Game Conservation. Game Bulletin No. 6: A Survey of California Deer Herds, their Ranges and Management Problems. By William M. Longhurst, A. Starker Leopold and Raymond D. Dasmann. Pp. 136. (San Francisco: Department of Fish and Game, 1952.) [2011

## Catalogues

Michrome Brand Organic Laboratory Chemicals. Pp. 4. (London: Edward Gurr, Ltd., 1952.)

Philips Industrial Catalogue. (PD.3444.) Pp. 32. (London: Philips Electrical, Ltd., 1952.)

A Catalogue of Works on Zoology, Botany and Geology, including many Entomological Classics from the Library of the late J. H. Jurriaanse, also a further selection of Books on Pigeons. (No. 708.) Pp. 122. (London: Bernard Quaritch, Ltd., 1952.)

Industrial Plant in Glass. Pp. 4. (London: Quickfit and Quartz, Ltd., 1952.)

X-Ray Accessories. Pp. 52. (London: Solus-Schall, Ltd., 1952.)

Refractory Shapes. Pp. 8. (Kegworth, Derby: Refractory Mouldings and Castings, Ltd., 1952.)

General Guide to Capacitors. (C/13.) Pp. 28. (London: Standard Telephones and Cables, Ltd., 1952.)

Standard Suppressors for Marine Applications conforming to British Standard Specification 1597:1949. Pp. 8. (London: Standard Telephones and Cables, Ltd., 1952.)

Philips Electronic Measuring Instruments for the Laboratory and Test Bench of the Radio and Television Engineer. Pp. 8. (Pl. 3301.) Philips Variable Transformers. (Pl. 3409.) Pp. 2. (London: Philips Electrical, Ltd., 1952.)

Portable Laboratory Meters. Pp. 2. (London: Parkinson and Cowan (Gas Meters), Ltd., 1952.)

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# PROFESSIONAL STANDARDS IN THE WELFARE STATE

A LIVELY chapter in Mr. R. Lewis and Mr. A. Maude's survey "The English Middle Classes", three years ago, discussed the position and problems of the professions in the society of to-day. That discussion has now been expanded into a full-length study*, written with the same charm as well as scholarship, and pervaded with wit, sometimes a little tinged with malice. It covers a wider field than the earlier book by Carr-Saunders and Wilson, to which it is a natural complement, glancing at the Church and the Armed Services, which they excluded. The detailed historical account which occupies the bulk of that book is the natural starting point for this new survey, which reviews and analyses the trends of the past two decades with a lucidity and vivacity that should commend it far outside the range of the widest definition of the professional classes to whom it, presumably, is primarily addressed.

To professional organizations, indeed, it offers a clear challenge; it sounds a ringing call to the humblest members of a profession to face the implications and responsibilities of a situation in which their position threatens to continue to deteriorate. No less it is a challenge to thought, and to action, on the part of all who are concerned about the effectiveness of our social, and indeed our industrial organizations, from a national as well as from a personal or professional point of view. The authors have the courage to ask questions that have hitherto been evaded; and the issues confronting us in shaping educational policy and social services, especially the national health services, are described frankly and realistically. Criticism is constructive as well as penetrating. The professional man, be he scientist or technologist or otherwise, is summoned to work much harder to strengthen an influence already waning, and, accepting the responsibilities and implications of what Mr. Lewis and Mr. Maude describe as an aristocracy of talent, to seek, personally and through his professional associations, to protect himself and defend his ideals.

Mr. Lewis and Mr. Maude unhesitatingly defend the professional ideal. They are convinced that it has an essential place in the world to-day, and that, in fact, the institutions of democracy and of social service cannot function unless the traditions and standards of professional men are respected and upheld. But they are equally clear as to the price that has to be paid; and loose claims to be regarded as a profession are analysed and rejected with a ruthlessness verging at times on contempt. The validity of the claim thus trenchantly analysed of some of the newer specialisms to be regarded as professions, leading to the consideration of the question of what is a profession, is one of the three major issues raised in the book. The second is that which arises through the increasing extent to which the State has become the client of the professional man. The implications of this position, the impact of nationalization and the position of what are termed the socialized professions—in Britain, medicine and dentistry, with the other auxiliaries of the National Health Service, such as opticians, pharmacists and nurses, and teaching and law—are reviewed in three successive chapters. The third issue is that of professional education. This is considered in close relation to the other problems and to the factors which may determine supply and demand for practitioners.

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* Professional People. By Roy Lewis and Angus Maude. Pp. viii+284. (London: Phoenix House, Ltd., 1952.) 18s. net.

On the first question, Mr. Lewis and Mr. Maude reach no hard-and-fast definition of what constitutes a profession. They incline to accept that of the "Oxford English Dictionary" which Carr-Saunders and Wilson quoted with approval: "a vocation in which a professed knowledge of some department of learning or science is used in its application to the affairs of others or in the practice of an art founded upon it". Unlike Carr-Saunders and Wilson, they reject very firmly the claims of management or administration to be considered as a profession. Equally they question the conclusion that the control of business or industry is likely to pass into the hands of those marked by professional outlook. The business instinct, they remark, will remain indispensable, and the extent to which it is influenced by the professional ideal will depend on the extent to which management passes into the hands of those who also, whether as lawyers, scientists or technologists, accept loyalty to some professional tradition

Nevertheless, the authors insist on the value to-day of the professional outlook or spirit, marked at least by some measure of personal integrity on the part of the practitioner and some relationship of trust between practitioner and client or employer. The vital issue to-day is the extent to which professional people can remain professional in this sense, in the face, on one hand, of what is essentially dilution and, on the other, of the increase of professional employment by the State. It is the free, rather than the controlled, professions which set the standard and justify professional prestige. "The moment that the state organises, trains, and employs all the members of a profession, we can no longer speak of it as a profession. We can only speak of a body of expert officials. Such officials might, or might not, have high standards of conduct—but those standards would depend on the state of society, not the professional spirit; and any freedom they enjoyed would be on sufferance from those who held power."

This was foreseen by Carr-Saunders and Wilson. In such circumstances the professional man can no longer find in his vocational organizations the permanent anchorage and shelter regarded as the prerequisite for independent professional service to society. We are thus led to the second main issue raised in this book. Here the picture painted of the frustrating and depressing effect of State service and nationalization on the professional spirit is profoundly disturbing. Sometimes the deterioration of standards is for the time being obscured or mitigated, as in the National Health Service, by the possibility of living on the tradition of the past. When that is no longer possible, Mr. Lewis and Mr. Maude clearly do not believe that the traditional professional attitudes and standards can be maintained.

The third, and related, problem is that of professional education. The State, Mr. Lewis and Mr. Maude point out, is in a hurry to get more and more experts: simultaneously it seeks to encourage them to get a better training, and to reduce the period of training to get qualified men from anywhere, anyhow; at the same time it is trying to curb rising costs. Bluntly and specifically they write (of the nursing profession): "The root cause of the trouble is, quite simply, that (unless all other professions and jobs for girls are to be further raided for recruits) there are not enough young women of adequate intelligence and education in the country to staff both the schools and the hospitals, at the present level of services provided, without lowering standards".

It is idle at this stage to indict those who, introducing the new national services, failed to heed the scriptural advice first to count their resources, nor do Mr. Lewis and Mr. Maude allow themselves to stray from the point. They emphasize the way in which professional education itself depends on the quality of primary and secondary education, and thus on our ability to maintain the standards of teaching at that level. They indicate some of the implications of the situation for the professional institutions and the universities, and there is forthright criticism of some professions, notably of the excessive specialization of engineering. They insist that the solution of the present problem of professional education depends, above all, on genuine interest and sacrifice on the part of the best and most highly paid members of the engineering and scientific professions. They must teach; and at the same time, throughout the field of professional training, teachers must be helped and encouraged to vary their employment between practical work and teaching.

This brief chapter on professional education has some biting remarks on professional organizations, particularly in regard to technological education; and it places the responsibility for the dangers into which professional education is drifting—both over-specialization and inadequacies in the supply of the right type of talent and character—fairly on professional people themselves, as members of learned institutions and universities. Personal sacrifice as well as clear thinking will be required, and the authors add that professional people will never solve these problems by sitting on government committees, for even to accept membership of one of these is to deny ultimate responsibility for action.

That the State is setting the professions tasks beyond their powers is the real danger; but it does not follow that those demands inevitably involve dilution and the lowering of standards. The demands are not likely to be checked merely in the interests of the professions; nevertheless, this book gives some convincing reasons why it is in the general interest to diminish the present strain on the Civil Service and certain professions, even at the cost of postponing further nationalization measures or developments in social welfare until resources are more commensurate with requirements. The lowering of standards can be avoided if professional bodies will devise clear definitions of professional ideals and standards, and limit the maintenance of high standards to situations in which the nature of the work makes it really necessary.

We are not left in doubt as to what such a policy demands of professional institutions. Institutional 'stiffneckedness' alone, the authors remark, will not preserve the professional tradition; and even in teaching it may be possible to utilize the auxiliary 'technician' once the opposition to salary differentials for graduates is discarded—an opposition to which is attributed largely the decline in academic standards in grammar schools. To distinguish between technician and technologist, between strictly professional work and non-professional, whether administrative or of the ancillary technical type which can be done by a laboratory assistant or other trained technician, requires clear thinking. Such decisions must be taken by the professional institutions and none other, and they must equally take account of the legitimate aspirations of the technicians, providing means and opportunity for those who have the ability to qualify for the professional grade. It means ruthlessness, as well as a clear conception of the nature of a profession, in dealing with some of the newer claimants to that title; and, quite possibly, a good deal more flexibility, as well as internal reform, in some existing professions.

"Only the doctors themselves," remark Mr. Lewis and Mr. Maude, "can preserve the integrity of their own profession"; and fundamentally the maintenance of standards is thus linked with the question of the proper use of the professional man or expert. This further reminder to the administrator and legislator that the supply of brains and ability in Britain is strictly limited, and that much of it is at present being wasted on work that could be done by less-qualified people, is also a challenge to the professional institutions to give adequate thought to the means of eliminating such waste and to the implications of the growth of modern administration for their own members. It is a stern warning of what may follow if professional institutions, on the other hand, disregard such constructive work and responsibilities, and become preoccupied exclusively with their protective or purely economic functions.

These economic functions are not ignored in this book. On the contrary, full weight is given to the difficulties which the deterioration in the economic position of the professions place in the way of recruitment of men and women of the requisite ability. The primary problem is none the less that of maintaining standards where the nature of the work demands high professional standards, and that in itself plays its part in attracting men and women of the ability and character required. Paraphrasing a passage from a recent Croonian Lecture by Dr. T. F. Fox, which they quote with approval, Mr. Lewis and Mr. Maude maintain that a professional man is a practitioner first and an employee second and incidentally.

A main argument of this book is that the basis of professional life is the contract between practitioner and client—an essentially ethical relationship—and that this fiduciary and confidential relationship lies not merely at the heart of the great professions of medicine and law, and their derivatives, but also, by the power of example and co-practice in the same environment, at the heart of all professions. The body of private practitioners and consultants sets the tune for professional life; in the last resort, the devotion which characterizes the Civil servant and which might be regarded as the ethic appropriate to an age of 'socialized' professions and nationalized industries, is also very largely derived from the conduct of the free professions. Reasonably enough, the authors suggest that service and selflessness are founded ultimately more on direct personal relations—ties of honesty, trust, honour and loyalty—between a professional man and his client, as they have been practised over generations, than upon any natural or instinctive urge in man to serve the community under irksome restraints, with a load of responsibility and for limited rewards.

To preserve this personal responsibility to the client in the professions of law and medicine is regarded by Mr. Lewis and Mr. Maude as the primary task, and it has to be achieved within the framework of partly 'socialized' administration and finance. They insist, too, that financial freedom must go with professional freedom, and that the professions, like the universities, should so far as possible be free from Treasury dominance. Linked with this is the question of administration, particularly as presented by the dangers which the growth of centralized organizations offers to the survival of professional traditions. Here they comment briefly on the question of leadership from a novel angle; and a remark as to the possibility of administration becoming the happy hunting ground of the second-rate mind is a shrewd hit at some current discussions and theories.

Through this book blows a refreshing air of common sense. Its realism is inspiring and persuasive. It deals some shrewd blows, and may provoke some irritation, even anger. But the professions have been warned, and also shown that they have some effective replies if they have the courage to take the right action. They could, for example, well afford to ignore the charge that by upholding educational standards they are failing to provide the experts in the numbers required by the nation: they would do better to refute the charge by emphasizing the effect on quality, or by pointing to the present prodigious waste of professional talent in government departments and in nationalized industry. "Those who claim to possess something of vital importance to the community should be prepared, not only to state clearly what it is, but also to fight to preserve it for the community's good."

That challenge must be met by professional people with vision as well as energy and courage. The book under discussion indicates also some of the steps that could be taken by professional people to adapt their institutions, both for the preservation of professional traditions and standards and for the more effective discharge of their professional functions and responsibilities to their clients, and to the society in which both client and profession have a vital part to play.

# HISTORY OF GEOLOGY IN GREAT BRITAIN

Geological Survey of Great Britain
By Sir Edward Bailey. Pp. xii+278+4 plates. (London: Thomas Murby and Co., 1952.) 22s. 6d. net.

THIS account of the history of the Geological Survey of Great Britain, written by a former director of the Survey, is a noteworthy publication. Although it follows a centenary volume by one of his predecessors published still far short of twenty years ago, it will not surprise those who have known both authors that the two books differ in many respects. The present volume is one that should find a place in every geological library, and it is worthy to be added to books devoted to the history of the subject.

The Geological Survey is the oldest organization of its kind in the world, dating its institution from 1835; there was, of course, official but discontinuous geological mapping before that date in Great Britain and elsewhere. The Survey has been taken as a pattern for the organization of similar work by many countries. This book contains an account of the problems met with through this long history, and of the ways in which they have been dealt with. Each chapter (though they are not called by that name) deals with the work of one of the successive directors and with his more important achievements and difficulties. Alongside this history of Survey activities, there is some account, especially in the earlier years, of the development of geological ideas both in the Survey and outside. To the student this volume will thus supply a valuable introduction to the history of the science as a whole. As the Geological Survey grew, there was a considerable degree of similarity between the development of ideas among its members and of those who were not attached to its staff. The numbers of those geologists engaged in the Survey and in the universities have always been small—smaller than those in most sciences—and, leaving aside the very important band of amateurs whose contribution to some fields of geology have been outstanding, the Survey has held on an average about one-half of the employed geologists in Britain. It is not surprising, therefore, to find that in many ways its history is to a great extent the history of British geology.

The Geological Survey was founded in order to expedite the provision of one-inch maps with geological boundaries, and the production of such maps (each with an accompanying memoir containing a description of the geology of the area which is summarized on the map) has continued to be one of the Survey's most important tasks. Several diagrams show very clearly the progress towards this objective. But with greater demands the work became slowed down very considerably, even so long as seventy or eighty years ago. Thus the reader is shown on p. 84 how the rate of completion of English one-inch maps became less than half as rapid under Ramsay as it had been in a corresponding period under his predecessor Murchison. The rate rose again with the next director, Archibald Geikie, to exceed that reached under Murchison. This variation is partly accounted for by the use made of six-inch maps as a basis of surveying. This was officially ended by Geikie in the 'eighties, though it had been in existence for some twenty years.

Geikie was anxious to complete the geological mapping of Great Britain, having more or less undertaken on his appointment "to wind up most of the activities of his office". How many since that time have demanded to know how long it would be before the primary task of the Survey was accomplished? All one can now say, unless there is a large expansion in numbers, with the demand for greater detail and for the need for frequent revision (at least in some areas), is that the geological survey will never be complete, for new tasks are added more rapidly than they can be overtaken. Geikie would find an organization much larger than in his day, but with its responsibilities continually expanding.

So many topics are discussed in this volume, especially in those sections relating to later years, that a reviewer can only indicate the wide range of problems. The linkage with other government services is traced from the days when the Geological Survey was one of the very few scientific bodies established under the Government (many may read with amazement that in 1871 a director's funeral was joined by royal carriages and that a Prime Minister followed the bier), to its present position as one of the divisions since 1919 of the Department of Scientific and Industrial Research. The glimpse of the Geological Survey's relation to water-divining, or dowsing, in the Second World War is one of the many reminders of present activities.

Altogether this is a book from which few will not be able to learn. Other writers would perhaps have chosen differently, but with so much available, particularly of recent history, the author must make some selection. Little of importance appears to have escaped his notice, however. The book is illustrated with plates and line-drawings, many of the latter reproduced from memoirs of dates ranging from near its foundation until more than a century later and illustrating some of the more important conclusions reached in that time.

A. E. Trueman

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# ANCIENT EGYPT

Ancient Egypt
By J. E. Manchip White. Pp. xii+217+48 plates. (London: Allan Wingate (Publishers), Ltd., 1952.) 21s. net.

THE history of Egypt is unlike that of any other country in the world. For centuries, indeed for millennia, geography imposed so complete an isolation on the region that the evolution of Egyptian culture, especially that of Upper Egypt, became rigidly circumscribed and unaffected by influences from the outside world. The thought of the people throughout centuries of existence seems to have been conditioned by their peculiar natural environment, canalized, almost solidified, and but little influenced by ideas germinated in other civilizations. It is true that, during periods of exceptional governmental weakness, invasions of foreigners did take place; but their effect seems not to have been permanent, and when the central authority once again became strong the invaders were turned out. Perhaps the Biblical account of the ejection of Adam and Eve from Eden is a poetical remembrance of the ejection of the Shepherd Kings from the Nile Delta.

Only when Egypt under the kings of the Eighteenth Dynasty tried to found an empire in Nearer Asia, and for a time succeeded, were the seeds of future final decadence sown. From then onwards, in spite of brilliant flashes of returning vitality, the end became inevitable, and Alexander had few difficulties when he invaded the country—nor had his captain Ptolemy after his death. The contacts with outsiders and their ideas following on these foreign conquests of the earlier years of the New Kingdom sapped fatally the strength of the old Egyptian culture.

The volume under review is written by a poet who has studied archæology, and particularly Egyptology, thoroughly. We get, therefore, the best of both worlds—a knowledge of the available facts and a sensitive appreciation of what old Egyptian life and culture must have been like. The book is not meant for the specialist wanting every detail, but for the informed individual who wishes to realize what life and ideas were like in the remote past in this interesting land. The history of the dynasties is given very briefly in three chapters, but far more pertinent are those on the environment, the Pharaoh, the priest, the aristocrat, the architect, the craftsman and the commoner. There are a number of well-chosen illustrations and the work is an excellent introduction to the study of Egyptology.

MILES BURKITT

## "A IS HAPPY—B IS NOT"?

### British Scientists of the Twentieth Century

By J. G. Crowther. Pp. xiv+320+8 plates. (London: Routledge and Kegan Paul, Ltd., 1952.) 25s. net.

THE theme of this book may be taken in the author's own words: "The parallelism of trends in biology and physics is noticeable, how the Mendel–Morgan genetics and the prostitution of Rutherford's nuclear physics are seen to flourish in the same place, side by side; and, in contrast, how sounder biological theories, together with beneficent applications of atomic energy, are flourishing elsewhere in great constructive works for the dignity and happiness of man".

This *motif* is varied with studies of the lives and works of J. J. Thomson, Rutherford, Jeans, A. S. Eddington, Gowland Hopkins and William Bateson. Excellent portraits of each of these are used to illustrate the book, and a photograph of Academician T. D. Lysenko also appears. With regard to the last, in view of the title of the book, the reader may well ask "Que diable fait-il dans cette galère ?", but a study of the text will soon show why.

The book gives the impression that it is the work of two authors. There is *A*, the gifted writer with a neat and clear style, and with a wide reading in the literature of science, particularly in the biographies and publications of his characters; and there is *B*, the Marxist philosopher, ever seeking an opportunity to despise British intelligence, British institutions and British theoretical physics. Most of the writing is done by *A*, but *B* always has the last word. Some examples will show how this schizophrenic method of biography works itself out.

J. J. Thomson. *A*: "J. J. was not only a teacher and discoverer, he was a creator in the method and organization of research. . . . This world-wide movement of research students to Cambridge was stimulated by the need for science teaching. . . . Unique in the galaxy of J. J.'s collaborators was C. T. R. Wilson. This most admired and Scottish of Scotsmen". *B*: "The cost to mankind as a whole of a leisured life for Newton, Clerk Maxwell and the scores of geniuses who created the subtlety and depth of the Cambridge tradition was great. . . . It is impossible to overlook the adolescent, uncultivated, unintellectual aspects of his mind and school".

Rutherford. *A*: "Rutherford departed suddenly in the midst of a healthy, happy, triumphant and glorious life". *B*: "An unconsciously tragic social figure".

Jeans. *A*: "Why was Jeans so successful as a popular writer? Because he was clear, vivid, confident". *B*: "The enormous circulation of 'The Mysterious Universe' owed much to its meretricious style and shallow philosophical thought. . . . Somehow or other, though, Jeans extracted £256,000 out of society. . . . The character of his writing for the people, revealed the intellectual bankruptcy of the British educated bourgeoisie".

Eddington. *A*: "He regarded his expositions as harmonious works of art and he made them so. It [Eddington's 'unified theory'] may prove to be the boldest, the most imaginative work of the twentieth century". *B*: "It seems probable that it will prove to be an extreme individualist aberration, a product of the weak side of Quaker solitary quietism and obstinacy, which remained uncorrected through the absence of an adequate system of mutual scientific criticism, because of a defect in social organization".

The reader can take what he pleases; but he may be left wondering how the work of Rutherford and Thomson could have been improved had they had the advantages of "an adequate system of mutual scientific criticism" in that Utopia of social organization so beloved by the author. It is, of course, possible that, instead of their superb achievements in experimental physics, they might only have succeeded in developing electric power and illumination had they been subjected to the demands of the party line; similarly, Faraday might have confined his attention to the improvement of the Leyden jar.

> "See how the Fates their gifts allot,
> For A is happy—B is not.
> Yet B is worthy, I dare say,
> Of more prosperity than A".
>
> *The Mikado.*

W. L. SUMNER

## MANAGEMENT AND BIOLOGY OF LIVESTOCK RANGES

### Range Management

Principles and Practices. By Prof. Arthur W. Sampson. Pp. xiv+570. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1952.) 60s. net.

THIS book deals with a subject which, on the surface, might appear to have little interest to the British reader, but there is much in the book to interest students of many sciences as well as agriculturists to whom the book is of especial interest.

A vast subject is covered, and it is impossible to deal in minute detail with every section; but great credit must be given to the writer for the way in which he has selected his material, giving just enough of the scientific background to explain each point sufficiently for the practical man and at the same time to allow the student, who may not be so familiar with the practical aspects, to orientate himself. For the latter who wishes to pursue any section further, there are comprehensive lists of references at the end of each chapter.

The book is divided into four main parts. Part 1, entitled "Range Management in Perspective", deals with the general concept of range management and gives a very concise picture of grazing practices throughout the world and problems which should be of interest to all concerned with the supply of meat and animal products. There follows a consideration of the scientific principles, mainly physiological and ecological, which have an important bearing on range problems, and one is struck by the similarity of many of the problems to some encountered in Britain. This leads to a consideration of some of the aspects of United States grazing, followed by a historical survey.

Part 2 is mainly botanical and deals with the many species of plants which go to make up the range, giving adequate details of the value or otherwise of each. These are classified according to natural orders, and mention must be made of the excellent line illustrations of the plants, many, but by no means all, not commonly seen in Britain. Part 3 deals with the improvement and management of range and stock, starting with the improvement of the herbage, both by natural and artificial reseeding, and the control of noxious woody vegetation. This leads, by way of management and considerations common to both range and range livestock, to livestock choice and management, followed by two chapters on general range management. Again one is struck by the broad similarity of many aspects of the subject to the management of rough grazings in Britain. The final section of the book deals with such subjects as timber and its place on the range, poisonous plants and their control, wild life on the range, soil erosion and, finally, the administration of public grazing lands.

The book will be a useful reference work for advanced students of agriculture, and certain sections will be of more than passing interest to geographers, economists and biologists.

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# PLANT CELL WALLS

## The Molecular Architecture of Plant Cell Walls

By Dr. R. D. Preston. Pp. xii+211+10 plates. (London: Chapman and Hall, Ltd., 1952.) 36*s.* net.

THE advancing study of the fine structure of plant cell-walls now has an evident relevance to problems of growth, and may also have taxonomic implications; it thus commends itself to general botanical interest. A concise account, from Dr. R. D. Preston, of the essentially botanical (as distinct from the technological) aspects of cell-wall micro-structure is thus a welcome addition to botanical literature.

To the non-specialist, however, his subject presents certain difficulties of approach, derived from its basis in unfamiliar research techniques and modes of thought. Dr. Preston therefore devotes about a third of his book to outlines of the salient features of the chemical and physical structure of cellulose and other cell-wall substances and of the techniques applicable to their study. Special attention is given to the methods of X-ray crystallography and polarization optics, which have proved most fruitful in cell-wall studies. Modern views of the micellar structure of cellulose are explained and discussed in the light of these and other techniques.

Against this physico-chemical background the main theme of the book is developed, largely by reference to the researches of the author and his colleagues. Facts and hypotheses of cell-wall structure and growth are considered in relation to the evidence, and described in terms of the mean orientation, angular dispersion and dimensions of cellulose micelles and microfibrils, and of the nature, proportion and distribution of non-crystalline material in the wall.

Thick cell-walls, having a dense, well-oriented cellulose framework, are described first, by reference to algæ, especially *Valonia*, *Cladophora* and related forms, and to cells of higher plants, especially conifer tracheids and bamboo and other fibres. Such diverse examples, while differing in detail, nevertheless exhibit a certain unity of structure; helical organization, and lamellation of the wall, in varying degrees, are common features. Primary walls are considered separately: here again different examples have a common type of structure; the cellulose framework is more diffuse than in secondary walls and less highly oriented; and protein is present among the non-cellulosic components.

From features of wall structure the author passes to processes of wall growth, of which, as yet, we know little. The growing primary wall is regarded not as a membrane separate from the protoplast, but rather as a differentiated outer layer of the latter, consisting perhaps largely of carbohydrase systems, within which cellulose deposition takes place. It is possible that deposition of the secondary wall may also occur in this way; the complexity, in *Valonia*, of growth in area of an already multi-lamellate wall, without apparent disturbance of its astonishing regularity of structure, seems especially to demand some such relationship. The concept of a definite interface between the protoplast and the wall may thus have to be abandoned. It might be added that cellulose-synthesizing systems external to the protoplast (in the ordinary usage of that term) appear in the activities of *Acetobacterium xylinum* and in the growth of the stalk of the sorocarp of *Dictyostelium*; they may well thus be of wider occurrence.

Further problems arise in the relationship between wall structure and cell shape. A detailed consideration shows that they are not simply related mechanically as has sometimes been supposed, but must be regarded as consequences of different aspects of cytoplasmic organization of which our appreciation is as yet speculative, but towards an understanding of which future cell-wall studies will extend.

In its conception, and in the broader aspects of its presentation, this is a valuable and stimulating book. The detailed exposition is, however, marred by a certain lack of coherence and an inexactness of style which make for unnecessary difficulties. This appears in the arrangement of the physical sections and in ambiguities such as the conflicting statements on pp. 48 and 71 concerning molecules and micelles; the confusion on p. 67 between $n_\gamma$ and $n_\gamma'$ (not apparently a mere misprint) in relation to the degree of crystallinity; and the reference on p. 140 to "cellulose micelles . . . (of) low cellulose content"—to cite but three examples among many. There are also some misprints which lead to confusion.

The book is generously illustrated, though in some instances the half-tone reproduction is inadequate. There is a bibliography of some hundred and twenty titles.

K. Wilson

# THE SECOND CŒLACANTH

By Prof. J. L. B. SMITH

South African Council for Scientific and Industrial Research, Fellow in Ichthyology, Rhodes University, Grahamstown

IT is my great privilege to announce the discovery of a second Cœlacanth. There are few biologists who do not remember the amazement engendered by the appearance of *Latimeria* Smith, 1939, as well as the acute disappointment in learning that all the soft parts of the fish had been lost.

For these various reasons it became a self-appointed task to endeavour to find a complete specimen, and for almost fourteen years I have constantly pursued that aim. There was overwhelming evidence that the fish was a stray, so that the first essential was to attempt to trace the habitat.

The only overseas scientist to venture an opinion on this matter was E. White, of the British Museum, whose statement that it was "almost certainly" from "the deeper parts of the sea, to which its kind have retreated in the face of fierce competition with the more active modern types of fish", scarcely took into account that numbers of successful modern fishes, some quite numerous, appear less well equipped for survival than the Cœlacanth, and a fish from the depths so well armoured would from our present knowledge indeed be a phenomenon.

From my study of fishes the Cœlacanth appeared to be a denizen of moderately deep water, living in and about rocks, presumably in an area not easily fished or commonly fished with efficiency.

My studies led me to regard the Mozambique channel about Madagascar as the most likely area, and plans for an expedition to search for more were well advanced, but fell through. I then decided on another method, and a leaflet, in English, French and Portuguese, was prepared, giving a brief account, and a photograph of the Cœlacanth, as well as offering a reward of £100 for each of the first two specimens caught.

By co-operation of the respective authorities, thousands of these leaflets were distributed throughout the coastal regions of the Western Indian Ocean, in such fashion that they reached and were explained to the native fisherfolk in even the most remote parts. During the past six years my wife and I have carried out expeditions along a considerable part of the East African coast, covering many otherwise inaccessible parts on foot. We continually spoke of the Cœlacanth and emphasized its importance, to all classes and races, and distributed leaflets. It is more than gratifying that this has led directly to the discovery, at the Island of Anjouan in the Comoro Archipelago, of the new Cœlacanth described below. The European responsible for saving the specimen was Captain E. E. Hunt, to whose trading schooner it was brought. Circumstances were such that I was compelled to fly to Pamanzi Island to retrieve the specimen, a military Dakota aircraft being provided by order of the Prime Minister, Dr. D. F. Malan. The return journey from and to Durban was completed in thirty-seven hours.

The native recipient of the £100 reward caught the fish in the evening of December 20, 1952, on a fish-baited hook, at a depth of about eight fathoms on rocky ground some 200 metres from shore off the village of Domoni, at about lat. 12° 15′ S., long. 44° 33′ E. He killed it by blows on the head. At the market next day the fish was saved from being cut up by a native who recognized it from our leaflet. It was then carried across the Island to Hunt, then at Mutsamudu village.

Having no formalin, he ordered his natives to cut it for salting, which they unfortunately did by slicing it all along the back from snout tip to tail, thereby destroying the brain and other soft parts of the head, and cutting through the gullet and axial structures. Hunt then went to Pamanzi, where he got and injected formalin. During my short time at Pamanzi he informed me that the specimen was intact, that no part had been removed. I have only in the past few days had time to examine the creature more carefully, and it is most disturbing to find that the head is shockingly battered and the body roughly and widely lacerated. On the other hand, it is apparently only the soft parts of the head, chiefly the brain, that have been lost.

This is not as disastrous as may appear, for it is more than counterbalanced by the fact that the home of at least one species of Cœlacanth has been found. The natives there know the Cœlacanth well and assert that one or two a year have been caught in that same locality regularly as far back as they know. It is likely, therefore, that over the whole archipelago more must be caught, and it should not be long before a perfect specimen can be obtained. The natives speak also of a constantly smaller Cœlacanth, which may well prove to be different, and it will in any event not be surprising if further species exist; nor is there any reason why they should not occur in other parts of the world as well. From what can be ascertained, the Cœlacanths can scarcely be regarded as degenerate fish. They are apparently full of vigour.

This fish clearly represents a new genus, and *Malania* nov. gen. is proposed, in honour of the Prime Minister of South Africa, Dr. D. F. Malan, whose prompt decision and commendable action at that late stage saved the fish. I had intended to name the species after Captain Hunt, but he preferred that it should mark the locality where the fish was caught, hence *Malania anjouanae* gen. et sp. nov.

Owing to a printer's error, *Melania* Perry, 1811, appeared as *Malania* in Preston, *Rev. Zool. Afric.*, 1913. As there is no connexion whatever between *Melania* and *Malania*, it appears reasonable that the latter should be valid, as a generic name, for the present fish. If *Malania* is ruled as invalid, I propose the generic name *Malanius* to replace it.

## Family Latimeriidæ

The specimen of which an outline account follows resembles *Latimeria* Smith, 1939, in general facies, but is only provisionally referred to this family. A more detailed investigation may lead to other conclusions. Of interest is the presence of a well-developed spiral valve, the presence of which had been suspected in forms now regarded as extinct.

## Genus *Malania* nov.

### Genotype *anjouanae* sp. nov.

This genus superficially resembles *Latimeria* Smith, 1939, and is clearly derived from the same ancestral

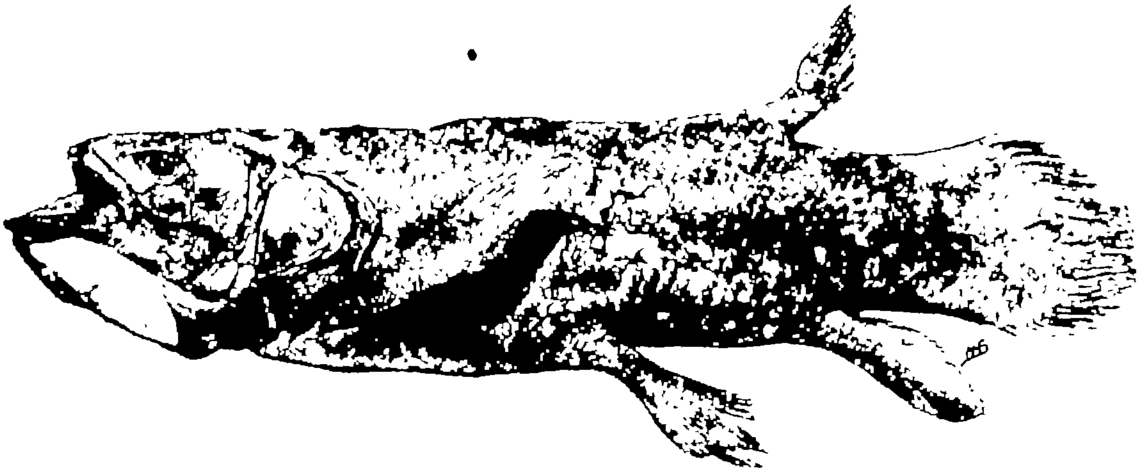

Fig. 1. *Malania anjouanae* gen. et sp. nov Type Male Actual length, 1,385 mm.

type. As far as may be determined, the main surface bones of the head are very much like those of *Latimeria*; but there are differences in the smaller structures.

Immediately apparent is the absence of a supplementary caudal and of a first dorsal. The basal plate of the latter fish is present, and it is at least possible that the fin itself may have been lost by injury in early youth. That particular area of skin was mutilated in cutting; but the adjacent scaling has the appearance of having grown abnormally, as would occur in covering a scar.

The ossifications in this fish appear to be less dense than in *Latimeria*.

The whole fish is extremely oily, especially the dermal structures.

There are numerous other structural distinctions, as yet not fully worked out, which may necessitate separation by family rank for this form. These will be described later in a more detailed monograph on the specimen.

The scales are much like those of *Latimeria*, but smaller, and the tubercles are not so marked. There are 33 series to the level of the origin of second dorsal, 56 to caudal origin and 68 to caudal base.

*The Head*

The major dermal ossifications appear to be much the same as in *Latimeria*, the opercular, the post-orbital, the squamosal, the preopercular and the lacrimo-jugal being almost identical in shape and position. There is no trace of the small ossification provisionally identified as an inter- or sub-opercular in *Latimeria*.

*Mouth Parts*

The dentigerous structures are in every way comparable with those of *Latimeria*, but the anterior tooth plates are smaller and less clearly distinct from one another. The teeth on the whole are smaller, and there are more granular than sharp teeth.

### *Malania anjouanae* sp. nov.

The specimen has a total length of 1,385 mm. The body is robust and moderately compressed, increasingly so posteriorly.

The first dorsal is represented only by the basal plate beneath the skin. The second dorsal is relatively smaller than in *Latimeria*, while the pectoral is somewhat similar. The pelvic in *anjouanae* is broader than in *Latimeria*, and there is a fringe of separate elongate rays along the inner hinder margin, the hindmost few again connected by membrane, forming a slight lobe that folds back over the anus and is in some respects reminiscent of the elasmobranch 'clasper'.

The anal fin is much like that of *Latimeria*.

The caudal is almost symmetrical and lacks any sign of the axial supplement. The rays are all spinose, increasingly so anteriorly.

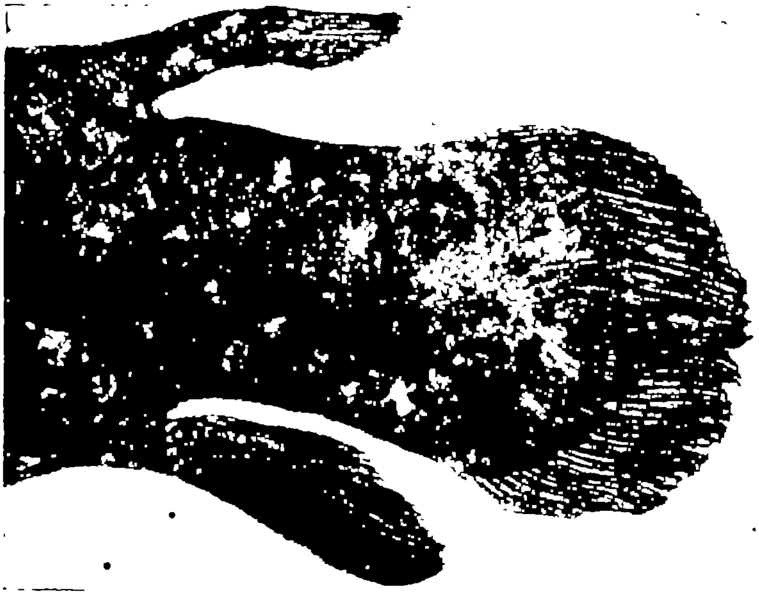

Fig. 2. *Malania anjouanae* gen. et sp. nov. Caudal Actual length, 560 mm.

The suspension of the lower jaw appears to diverge considerably from that of *Latimeria*, but time does not permit of more detailed investigation at present.

There is no sign of any internal narial opening.

*Copula and Gills*

The copula is much like that of *Latimeria*, and situated much as deduced for that fish[1]. There are five gill-arches, but, as deduced for *Latimeria*, only four are attached to the copula; the smaller fifth is behind. There is no slit behind the last gill. Well-marked pseudo-branchiæ are present. The gill-arches are hollow, flat, boomerang-shaped plates, the lamina formed by inverted U-shaped, thin, but strong bone, with a rod-like bony structure running inside along the dorsal margin. The outer arch is 35 mm. wide at the angle and about 8 mm. in thickness. Each side of the top of each arch bears two series of numerous fairly small plates, each beset with stout sharp spines. Mostly there is one large spine, almost a canine tooth, on each plate, together with small spines of varying size and number. The large spines on the outer face of the first gill-arch point upwards. The gill filaments are attached to the approximating but not touching lower edges of the bone, and at the angle are about 30 mm. in length, longer on the hinder limb of the arch.

*Rostral Papilla*

This is almost exactly as in *Latimeria*.

*Brain Case*

In regard to the nature and structure of the median rostral cavity and the relation of the three external "narial openings", described for *Latimeria*[1], doubts have been expressed about the accuracy of those observations by Jarvik[2]. *Malania* has exactly the same system in every respect as that described for *Latimeria*. The three external openings communicate directly with the median rostral cavity, and with nowhere else, and that cavity appears to have no direct connexion whatever with the brain.

The lateral fossæ of this median cavity, leading to the lateral openings, are completely filled with an oily jelly-like substance, and the mouth of each of the fossæ appears to have been completely closed by a stout membrane, cutting off all connexion with the outside. My observation on *Latimeria* of the possibility of water passing through the cavity is thus invalid.

Jarvik's statement[2] that I maintained this system as having something to do with the olfactory system of Cyclostomes is not correct.

The actual brain cavity is almost exactly as for *Latimeria*, and so far as may be observed at present, the 'olfactory' lobes of the brain do not communicate directly with any aperture on the snout.

*Axial Skeleton*

The notochord is massive and entirely cartilaginous, the walls being quite soft and about 8 mm. thick. The tube is about 40 mm. internal diameter at its widest part, tapering posteriorly. It had been hacked through roughly by Hunt's natives, so the contents are lost. The anterior end curves up, then down, to end in an imperforate fossa in the posterior ossified cranial wall.

On the anterior and on the posterior parts of the sheath are neural and hæmal processes, the shape of which there has been no time to determine, but they seem to be cartilaginous. They appear to be few or absent along most of the central part of the sheath.

*Abdominal Viscera*

Brief examination shows that the intestinal canal is comparatively short. The gullet merges into a long stomach the posterior end of which is well behind the anus. Near the anterior end of the stomach is a wide pyloric aperture, leading to a comparatively short and slender 'duodenum' about 7 in. in length, which runs anteriorly from the pylorus. At its anterior end there is a sharp reverse flexure, which is the anterior part of a 9-in. long, fairly slender, more or less fusiform spiral valve, of apparently complex structure, with six or seven revolutions in its length. The gut issuing from the valve is about 9 in. in length, slender and simple, running direct to the anus. Attached to almost the whole length of the spiral valve is an elongate sub-nodular organ, a pancreas, or its antecedent, apparently discharging into the anterior end of the spiral valve.

The fish is a male, the paired testes being about 7 in. in length, long, slender subfusiform, and partly segmented and entirely posterior to the anus. I can discern no clear indication of any structure which may be regarded as an intromittent organ, but on the external parts of the genital opening there appear to be two large flat fleshy papillæ. The urogenital opening is large and lies immediately behind and between the pelvic bases.

In the intestine were found the two eyeballs of a fish and some scales. The former indicate a fish prey of possibly 2 ft. in length.

The liver is of curious appearance, almost black, elongate, sub-cylindrical, the left lobe reaching two-thirds of the length of the cavity, the right shorter, about three-fifths of the left. This has not yet been investigated.

I wish to pay tribute to our Prime Minister, Dr. D. F. Malan, for his prompt response to my appeal for assistance to fetch this fish from the Comoro Islands. Also to M. Pierre Pierre Coudert, Governor of the Comoro Archipelago, for his cordial co-operation. Captain E. E. Hunt deserves every credit, first for having taken the trouble to learn as much as possible about Cœlacanths, and also for having saved what he did under great difficulties.

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[1] Smith, *Trans. Roy. Soc. S. Africa*, 28, 54 (1939).

[2] *Zool. Bidrag. Fran. Upsala*, 21, 591 (1942).

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# A. A. MICHELSON, 1852–1931

By Prof. R. S. SHANKLAND

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THE Cleveland Physics Society met on December 19, 1952, to commemorate the centenary of the birth of Albert A. Michelson and to dedicate a plaque in memory of the Michelson–Morley experiment. The plaque was presented by the Case Institute of Technology and the Western Reserve University, and is to be erected in Cleveland, Ohio, on the line between their adjacent campuses near the spot where the Michelson–Morley experiment was performed.

Michelson was born on December 19, 1852, in Strelno, Germany, now Strezelno, Poland. When he was two years old the family moved to California, where Michelson finished his high-school education in San Francisco, and in 1869 he entered the United States Naval Academy at Annapolis on a special appointment from President Grant. He graduated in the class of 1873 and, following the usual cruises as a past midshipman, served during 1875–79 as instructor in physics and chemistry at the Naval Academy.

While at Annapolis in 1877, Michelson made his first measurement of the speed of light, employing an important improvement which he had made on Foucault's rotating-mirror method. This work led to his association, in 1880, with Simon Newcomb at the Nautical Almanac Office, Washington, D.C., where they collaborated in further measurements of the speed of light. In September 1880 Michelson went to Europe and for two years studied and carried out research at Paris, Heidelberg, Berlin and Potsdam, and it was while at the Collège de France in 1880 that he invented the Michelson interferometer as a means for measuring the earth's motion through the æther. His interest in this problem had been aroused by a letter from James Clerk Maxwell to D. P. Todd, who was director of the Nautical Almanac Office during Michelson's appointment there. Maxwell had emphasized that all experiments attempting to observe the earth's motion through the æther, which depended on measuring the first power of the ratio of the earth's speed to that of light, were doomed to failure. He went on to say that no terrestrial experiment for measuring the velocity of light could detect the earth's motion in space, since "in the terrestrial methods of determining the velocity of light, the light comes back along the same path again, so that the velocity of the earth with respect to the ether would alter the time of the double passage by a quantity depending on the square of the ratio of the earth's velocity to that of light, and this is quite too small to be observed"[1]. Michelson's interferometer and the 'Michelson experiment' which he devised were the direct results of this challenge by Maxwell. The first trial of the experiment was made in Helmholtz's laboratory in the University of Berlin; but street traffic made observations impossible. The interferometer was therefore removed to Potsdam where, in April 1881, a second trial was made at the Astrophysical Observatory. The experiment gave a null result[2]; but, as the expected effect due to the motion of the earth in its orbit was only a shift of 0·04 of a fringe when the interferometer was rotated through 90° in the horizontal plane, this result was never considered conclusive, especially by Michelson himself[3].

In September 1882 Michelson went to Cleveland and began his duties as professor of physics in the Case School of Applied Science (now Case Institute of Technology). He had been appointed on March 28, 1881, but had been granted leave to remain in Europe until his researches there were completed. During his first two years in Cleveland, Michelson made further measurements on the speed of light, obtaining 299,853 ± 60 km./sec. for the value reduced to a vacuum, which was the most reliable measure until 1927. He also discovered the difference between phase and group velocities of light in carbon disulphide, this being the first experimental confirmation of Lord Rayleigh's dispersion theory for this effect[4].

Interest in the æther problem was revived when Michelson and Edward W. Morley, professor of chemistry and natural history in the Western Reserve University, Cleveland, attended the series of lectures by Lord Kelvin (then Sir William Thomson) on "Molecular Dynamics and the Wave Theory of Light" given at the Johns Hopkins University, Baltimore, during October 1884. Lord Rayleigh was also present for part of these lectures, and both he and Kelvin urged that a new trial of the Potsdam experiment be undertaken. Thus began the collaboration of Michelson and Morley. Their first work together, however, was not to repeat the Potsdam experiment, but to carry out in greatly improved fashion Fizeau's experiment on the speed of light in moving water[5]. At that time Fizeau's result was considered to be in conflict with Michelson's Potsdam experiment, and there seems to have been considerable doubt as to its validity. As all theoretical treatments of the æther problem involved Fizeau's 1851 measurement of the Fresnel dragging coefficient, it was felt that a new experiment should be performed to subject this question to a decisive test. By employing a modified form of the Michelson interferometer, greatly improved optics, compared to those available to Fizeau, were brought into play, and with other refinements for controlling and measuring the water flow they obtained a result[6] in very close agreement with the Fresnel theory and also with the more precise and satisfying formulation given by the Lorentz "Theory of Electrons"[7].

After completing this work in 1886, Michelson and Morley undertook the investigation which has since been known as the Michelson–Morley experiment, employing for this a greatly improved Michelson interferometer compared to that used at Potsdam. The optical paths were lengthened by multiple reflexion of the light beams so that the expected effect due to the earth's orbital motion was increased from 0·04 to 0·4 of a fringe. For greater stability, freedom from vibration and ease of rotation, the optical system was mounted on a sandstone slab 150 cm. square and 30 cm. thick, which was supported on an annular float in an annular trough full of mercury. The work with this apparatus continued from 1886 until July 1887 and was conducted in buildings on the adjacent Case and Western Reserve campuses. The definitive null result obtained in these experiments[8] led to profound changes in the development of physics. The contraction hypothesis of G. F. FitzGerald was the first serious attempt to explain the result of Michelson and Morley, and this contraction, together with the concept of 'local time', was elaborated in Lorentz's revised "Theory of Electrons" to provide an adequate but rather artificial interpretation for the Michelson–Morley experiment[7]. It is needless to say that the most direct and now universally accepted explanation for the Michelson–Morley experiment, as well as for the Fizeau experiment and the phenomena of astronomical aberration, is provided by the special theory of relativity given by Albert Einstein in 1905 [9].

The collaboration of Michelson and Morley continued during 1887–89 when they established the feasibility of making the light wave the ultimate standard of length, a programme which was carried to completion by Michelson in Paris in 1892. In the course of this investigation, they discovered the fine structure of the red hydrogen and other Balmer lines and the hyperfine structure in the spectrum of mercury[10]. Later, Morley conducted his notable determinations of the atomic weights of oxygen and hydrogen, and Michelson, first at Clark University and then for many years at the University of Chicago and at the Lick and Mount Wilson Observatories, carried on his many famous investigations in spectra and optical metrology.

[1] Maxwell, J. C., *Nature*, 21, 314 (1880).
[2] Michelson, A. A., *Amer. J. Sci.*, 22, 120 (1881); *Phil. Mag.*, 13, 236 (1882).
[3] Michelson's letter to Lord Rayleigh from Cleveland, March 6, 1887.
[4] Lord Rayleigh, *Proc. London Math. Soc.*, 9, 21 (1877).
[5] Fizeau, H. L., *C.R. Acad. Sci., Paris*, 33, 349 (1851); *Ann. Phys. Chim.*, 57, 385 (1859).
[6] Michelson, A. A., and Morley, E. W., *Amer. J. Sci.*, 31, 377 (1886).
[7] Lorentz, H. A., "Theory of Electrons".
[8] Michelson, A. A., and Morley, E. W., *Amer. J. Sci.*, 34, 333 (1887); *Phil. Mag.*, 24, 449 (1887).
[9] Einstein, A., *Ann. d. Phys.*, 17, 891 (1905).
[10] Michelson, A. A., and Morley, E. W., *Amer. J. Sci.*, 38, 181 (1889).

# INTERACTION OF CHLORINE DIOXIDE WITH FLOUR: CERTAIN CHEMICAL ASPECTS

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FOLLOWING the discovery that agene-treated flour could produce hysteria in dogs and certain other animals, the whole question of flour improvers is being very carefully considered in many countries. It is clearly essential that an improver should not only meet the technical requirements necessary for present-day methods and standards of bread-making, but should also be completely acceptable from the point of view of public health. In the United States, chlorine dioxide has replaced agene as the more commonly used improver. This decision was taken after extensive feeding experiments with dogs, rabbits, rats, monkeys and human beings[1,2] had shown no clinical evidence of acute toxic symptoms or abnormalities in any of the species tested.

The feeding trials carried out in the United States are reassuring; such investigations are an essential first step in deciding whether or not the interaction of flour with chlorine dioxide could lead to the formation of deleterious substances. In a problem of this character, however, there are certain limitations in such animal-feeding tests. The gaseous flour improvers are applied at very low concentrations; chlorine dioxide at about 30 parts per million. They may interact with a number of the constituents of flour and not exclusively with one. There is the possibility, therefore, that flour treated with an improver may contain traces of a number of unknown substances, without necessarily reducing significantly the amount of any one essential metabolite. In these circumstances the overall composition of the experimental diet used in the tests may be decisively important. A certain diet may, for example, accentuate the effect of a deleterious factor or it may neutralize it. Thus, in our work with methionine sulphoximine, the agene toxic factor, we encountered an example[3] of a change in the dietary of rabbits neutralizing the toxic effect of sulphoximine. Again, since the chemical nature of any new substance is unknown, it is not possible to plan dietaries with which neutralizing or masking effects will be minimized.

In our opinion, it is important, in studies on the effect of chemical treatment of food, to supplement the essential biological tests with biochemical investigations. If it is possible to identify modified substances, then these may be studied in animal-feeding trials and their effect observed on isolated enzyme systems. Because of the importance of flour as a staple article of diet, we consider both types of investigation—tests with animals and chemical studies—to be essential. In addition to animal-feeding tests, which are continuing, we have investigated some of the interactions which occur between chlorine dioxide and flour and fractions derived from flour. This article summarizes the observations we have so far made. It is hoped to publish elsewhere a more detailed account of the methods and techniques used. Both pure chlorine dioxide and chlorine dioxide containing approximately 30 per cent chlorine have been used.

## Interaction with the Lipoids of Flour

The lipoids of flour interact readily with chlorine dioxide and with chlorine. With pure chlorine dioxide, the unsaturated fatty acids are the initial sites of an oxidative process which appears to include some degree of polymerization. The iodine number of fat extracted from 81 per cent extraction flour is about 112, whereas that of fat extracted from similar flour treated with chlorine dioxide, at ten times the commercial level, is about 103. If a solution of this 'treated' fat in petroleum ether is kept at room temperature, there is a slow deposition of an insoluble rubber-like polymer. The initial oxidation reaction with unsaturated fatty acids is observed both at commercial levels of treatment and at higher levels. This has been demonstrated by an adaptation of the method of Wilbur, Bernheim and Shapiro[4], who have shown that thiobarbituric acid is a sensitive reagent for detecting autoxidation and catalysed oxidation of unsaturated fatty acids in biological material. The products of oxidation when treated with the thiobarbituric reagent give a pink colour with a characteristic absorption spectrum. Table 1 records observations made with flour treated with a number of improvers, and with untreated flour.

From these results it will be noted that untreated flour three months old may have an oxidation value, as shown by the thiobarbituric test, either less or greater than that of flour treated with chlorine dioxide at the commercial level. Different flours apparently vary in this respect, presumably because

Table 1

| | Material tested: 81 per cent extraction flour | Colour with thiobarbituric reagent |
|---|---|---|
| (I) All the same Manitoba flour | (1) Treated with chlorine dioxide at 10 times commercial level | Strong orange pink |
| | (2) Treated with agene at 10 times commercial level | Strong orange pink |
| | (3) Treated with bromate at 10 times commercial level | Very faint pink |
| | (4) Treated with persulphate at 10 times commercial level | Slight pink (> No. 3) |
| | (5) Treated with chlorine dioxide at the commercial level | Pink (< No. 1 but > No. 4) |
| | (6) Untreated flour 3 months old | Similar to No 3: very faint pink |
| (II) Mixed grist flour | (7) Treated with chlorine dioxide and chlorine at the commercial level | Very faint pink (< No. 9) |
| | (8) Treated with chlorine dioxide and chlorine at 10 times commercial level | Strong orange pink |
| | (9) Untreated flour 3 months old | Very faint pink |
| Manitoba flour as in (I) | (10) Untreated flour 12 months | Pink (> No 9) |

of varying content of natural anti-oxidant substances. An untreated flour, twelve months old, has a considerably higher value than flour treated with chlorine dioxide at the commercial level. Whether the polymerization effect, noted with fat extracted from flour treated at ten times the commercial level, is also observed with an aged flour, for example, nine to twelve months old, has not yet been investigated.

There is no significant chlorination of the fat when pure chlorine dioxide is applied to flour, and most of the chlorine originally bound in the chlorine dioxide molecule appears ultimately in the form of water-soluble chloride. If the gas applied contains free chlorine, there is chlorination of the fat. As much as 40 per cent of the chlorine applied may be found in the fat extractable from the flour with petroleum ether.

The oxidation (or peroxidation) of lipoids by chlorine dioxide or air may be an important primary step in a sequence of oxidative changes affecting other flour constituents. In this connexion, if the fat from flour treated with chlorine dioxide at ten times the commercial level is deposited on kieselguhr together with methionine and the mixture kept in the dark, the methionine is oxidized almost completely to methionine sulphoxide with a little of the sulphone. With fat from untreated flour under similar conditions there is no significant oxidation of the methionine within the same period of time. This observation, of a non-enzymatic transfer of oxygen, may be of interest in other fields of work connected with food and nutrition. In relation to the present problem it has led us to pay particular attention, in the work on protein fractions, to the lipo-protein complexes which may be obtained from petroleum ether extracts of flour.

## Reaction with Tocopherols

Flour containing wheat germ, for example, flour of 81 per cent extraction, is a useful source of vitamin E. In view of the oxidative effect of chlorine dioxide on fat, and the sensitivity of this fat-soluble vitamin to oxidation, some observations have been made on the stability of tocopherols in flour to treatment with chlorine dioxide. These have been made on the flour stream rich in germ from a commercial mill before and after chlorine dioxide treatment under commercial conditions. A chemical estimation of total tocopherols has been used, based essentially on Parker and McFarlane's[4] adaptation of the Emmerie–Engell method but modified by using the last stage of the Wall and Kelley[5] procedure. The tocopherol content of the treated flour was reduced by about 70 per cent compared with the untreated flour. The nature of the oxidation products has not been investigated, and we have not yet carried out tests with animals to examine whether or not they have retained any biological activity similar to that of vitamin E.

## Interactions with Proteins

Many of the amino-acids readily react with oxidizing agents and halogens. When they are linked together by peptide bonds, as in proteins, their reactivity may differ, compared with when they are free, and the type of reaction may be different. Only those residues at the end of peptide chains will have free α-amino or carboxyl groups. Reaction with the side-chains may also be influenced by the presence and nature of the neighbouring groups, by the spatial configuration of the various residues in the peptide chains, and by interchain bonding. In this connexion it is interesting to recall that the agene toxic factor, methionine sulphoximine, is not formed when free methionine reacts with nitrogen trichloride but only when methionine is a component residue in a protein. It also follows that similar residues or groups within a given protein may differ in their reactivity and also, of course, in their reactivity in one protein compared with another. It is therefore useful to examine hydrolysates from different types of proteins which have interacted with chlorine dioxide.

For the immediate purpose it would suffice to consider the total protein of flour, as this would include a variety of types of protein. But this would involve hydrolysis of whole flour, and the presence of so much carbohydrate leads to losses of an unknown order and favours the production of artefacts. Another approach would be simply to compare the gluten from treated and untreated flour. It is not, however, possible to wash out a gluten, from flour treated with chlorine dioxide at ten times the commercial level, which is comparable with that from untreated flour. For these reasons we have, in addition to comparing fractions from treated flour with similar fractions from untreated flour, also isolated fractions and then treated them directly with chlorine dioxide. There are a number of limitations to be noted. First, we have worked with totally hydrolysed protein fractions. Therefore we should not detect any modified amino-acids which are unstable to conditions of total acid hydrolysis. Secondly, our final observations have been made with paper chromatograms using ninhydrin. We should not, therefore, detect any substances present which do not give a colour on the paper chromatogram with this reagent.

Hydrolysates have been fractionated by ionophoresis in a four-compartment cell of the type described by Synge[7], displacement chromatography on ion-exchange resins and, occasionally, on kieselguhr partition chromatograms. Fractions at different stages have been examined on two-way paper chromatograms. In all cases the appropriate untreated fraction has been examined by the same procedure as the treated fraction. Table 2 records amino-acids observed in treated material but not in untreated material. Methionine sulphoxide is only noted if present in significantly greater amount than in the control.

In some of the examples given in Table 2 we have calculated the amounts of modified amino-acids formed (see Table 3). This has been done by comparisons, on paper chromatograms, with known amounts of the appropriate substances. The calculations are admittedly rough but they give an idea of the order.

The levels of treatment with chlorine dioxide which have been employed in this work are considerably higher—in some cases fantastically higher—than those normally used in the commercial mill. This, however, is a reasonable first approach in investigations which have a toxicological aspect, and it was used successfully in our work on the isolation of the agene toxic factor[8]. Furthermore, the present study has been chiefly concerned with noting the types of reaction which are most likely to occur and which are most readily detected. It has also been our experience that the same reactions occur at different levels of treatment, though of course they are progressively less as the level of treatment is reduced. At commercial levels of treatment the production of modified amino-acids, for example, will

Table 2

| Protein fraction | Treatment | Modified amino-acids found |
|---|---|---|
| (1) *Gliadin* prepared from untreated flour (75% extraction) | Gliadin preparation saturated with ClO$_2$/Cl$_2$ absorbed 2,400 mgm./100 gm. | Monochlortyrosine, dichlortyrosine, methionine sulphone, methionine sulphoxide |
| (2) *Gliadin* extracted from treated flour (75% extraction) | Flour treated with ClO$_2$/Cl$_2$ at 7·9 mgm./100 gm. | Methionine sulphoxide |
| (3) *Gliadin* extracted from treated flour (81% extraction) | Flour treated with pure ClO$_2$ at 29·6 mgm./100 gm. | Methionine sulphoxide |
| (4) *Gliadin* prepared from untreated flour (81% extraction) | Gliadin preparation treated with ClO$_2$ containing 0·08% Cl$_2$ at 560 mgm./100 gm. | Methionine sulphone, monochlortyrosine |
| (5) *Zein* (Corn Products Co.) | Saturated with ClO$_2$/Cl$_2$ absorbed 2,400 mgm./100 gm. | Methionine sulphoxide, methionine sulphone, monochlortyrosine |
| (6) *Lipoprotein complex* extracted from treated flour (81% extraction) | Flour treated with pure ClO$_2$ at 79 mgm./100 gm. | Methionine sulphone |
| (7) *Lipoprotein complex* extracted from treated flour (81% extraction) | Flour treated with pure ClO$_2$ at 29·6 mgm./100 gm. | Methionine sulphone |
| (8) *Lipoprotein complex* extracted from untreated flour | Lipoprotein preparation treated with ClO$_2$ containing 1% Cl$_2$ at 2,730 mgm./100 gm. | Methionine sulphone, monochlortyrosine |
| (9) *Lipoprotein complex* extracted from untreated flour (81% extraction) | Lipoprotein preparation treated with pure ClO$_2$ at 2,900 mgm./100 gm. | Methionine sulphone, cysteic acid, one unidentified substance |
| (10) *Lipoprotein complex* extracted from treated wheat germ | Wheat germ saturated with ClO$_2$/Cl$_2$ | Methionine sulphone cysteic acid, monochlortyrosine, dichlortyrosine, one unidentified substance.<br>Ethanolamine reduced by about 50% |
| (11) *Lipoprotein complex* extracted from treated flour (81% extraction) | Flour treated with ClO$_2$/Cl$_2$ at 40 mgm./100 gm. | Methionine sulphone, monochlortyrosine |
| (12) *Lipoprotein complex* extracted from germ-rich stream from commercial mill | Flour stream had been treated with ClO$_2$/Cl$_2$ at usual commercial level for this stream | Monochlortyrosine, methionine sulphone, cysteic acid |
| (13) *Albumin-type protein* extracted from treated wheat germ | Wheat germ saturated with ClO$_2$/Cl$_2$ | Methionine sulphone, cysteic acid, monochlortyrosine, dichlortyrosine |

The normal commercial treatment of flour averages 3 mgm./100 gm. flour

be of an extremely low order, and therefore difficult if not impossible to detect with the experimental techniques at our disposal.

The amino-acid residues which are attacked, in a variety of protein fractions, and which give ninhydrin-positive modifications which are stable to total acid hydrolysis, are methionine, cysteine and tyrosine. These may, in fact, be the most susceptible in the intact protein; but this cannot be considered as completely established by the present work, as other amino-acid residues may be equally susceptible to attack, though, as already stated, the products may be either unstable to acid hydrolysis or may fail to give a colour with the ninhydrin reagent. If pure chlorine dioxide is used, oxidation reactions predominate, with the formation of cysteic acid and the oxides of methionine. If free chlorine is also present, then halogenation occurs, and in these circumstances we have usually noted the presence of monochlortyrosine and, at higher levels, dichlortyrosine. In none of the protein fractions treated with chlorine dioxide, or derived from treated flour, have we observed the presence of the agene toxic factor—methionine sulphoximine.

It would obviously be easier to comment on the practical significance of this work when more results have been accumulated by other workers and by ourselves. As, however, the question is regarded as of urgent national importance, we have considered that we should record the results we have so far obtained. If, however, they are presented without some expression of our opinion of their significance, they may be given interpretations to which we should not necessarily subscribe. This possibility arises because the whole question of chemical additions to food is controversial and widely debated. For these reasons a brief comment appears desirable.

Table 3

| Fraction as described in Table 2 above | Modified amino-acid found | Estimated amount of modified amino-acid present | |
|---|---|---|---|
| | | per cent of protein fraction | p.p.m. in flour |
| 6 | Methionine sulphone | 0·1 | 0·12 |
| 8 | Monochlortyrosine | 0·1 | |
| 9 | Methionine sulphone | 2·0 | |
| | Cysteic acid | 1·0 | |
| 12 | Monochlortyrosine | 0·01 | 0·001 |

At commercial levels of treatment with chlorine dioxide, the production of the modified amino-acids which we have observed is quantitatively so small that the reduction in the content of the parent amino-acids is certainly negligible. Again, because of the very low concentration of these modified amino-acids, it also follows that they are unlikely to induce toxic symptoms unless they are extremely potent anti-metabolites such as methionine sulphoximine. So far as we have been able to ascertain from our own limited feeding trials, they have no such acute toxic properties. Methionine sulphoxide is the most readily produced modification of those we have observed, and we have noted that this substance is present, at concentrations approaching those to be expected with commercial chlorine dioxide treatment, in *untreated* samples open to ordinary atmospheric oxidation. The chlortyrosines have not been observed when chlorine dioxide free from chlorine was used.

Judged by the thiobarbituric acid test, the degree of oxidation of unsaturated fatty acids by chlorine dioxide, applied at commercial levels, may be no greater than is observed with some flours (untreated) which are three months old, and considerably less than with untreated flour twelve months old. We do not yet know whether the fat extracted from such aged flour undergoes polymerization similar to that observed with fat from flour treated with chlorine dioxide at ten times the commercial level.

The reduction in tocopherol content should be assessed, by the appropriate authorities, in relation to the overall supply of vitamin E in the dietary. We consider that this aspect of the work requires further investigation, using biological tests, primarily to ascertain whether or not the oxidation products may have an anti-vitamin E activity.

[1] Minutes of Hearing on "Proposal to amend the definition and standards of identity of flour, etc." before the Administrator, Federal Security Agency, United States of America, Oct. 1948.

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[4] Wilbur, K. M., Bernheim, F., and Shapiro, O. W., *Arch. Biochem.*, 24, 305 (1949).

[5] Parker, W. E., and McFarlane, W. D., *Can. J. Research*, B, 18, 405 (1940).

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# FORTIETH ANNIVERSARY OF THE DISCOVERY OF X-RAY DIFFRACTION

WHEN Max Laue, then a young *Privatdozent* at the University of Munich, saw, early in 1912, the successful result of the attempt made at his request by Friedrich and Knipping to diffract X-rays by a crystal grating, he could scarcely have imagined the effect that this success would have on so many and so varied branches of science, followed as it was to be by the opening up of X-ray spectroscopy and crystal structure analysis by W. H. and W. L. Bragg. A tribute to this fundamental work of Laue was given by the X-ray Analysis Group of the Institute of Physics, at the instance of the British National Committee for Crystallography, by the arrangement of a special meeting held in London at the Royal Institution during October 24–25[*], with an anniversary dinner in London. Many famous figures were able to attend this meeting, and many of them spoke, either during the meeting or at the dinner, including Prof. von Laue himself, Sir Lawrence Bragg, Sir Charles Darwin, Prof. J. D. Bernal, Prof. J. M. Bijvoet, Dr. C. Sykes, Dr. Dorothy Hodgkin and Prof. G. V. Raynor. To complete the picture, a congratulatory message from the American Crystallographic Association, sent by Prof. P. P. Ewald, himself one of those associated with the early work of Laue, was read out by the chairman of the Group, Dr. W. H. Taylor, before the meeting began.

The first session began with an account, given by Sir Lawrence Bragg, of the early days of X-ray diffraction. He told of how Laue's interest in the X-ray problem was aroused by a problem of Ewald's on the double refraction of light, and how Friedrich, somewhat against Sommerfeld's wishes (who thought that he should be getting on with other work), was persuaded, with the help of Knipping, to try the now famous experiment with a copper sulphate crystal. The various stages of the work were described in some detail, and Sir Lawrence mentioned that the early papers had recently been reprinted in *Die Naturwissenschaften* (16, 361; 1952). Sir Lawrence went on to describe the early work of his father and himself and to tell how he first hit upon the now famous idea of the 'reflexion' of a continuous spectrum (rather than one composed of discrete wave-lengths as Laue had supposed) by atomic planes, and the part played by the conception of a crystal lattice, which was then new to him. He outlined some of his early results on crystal structures and traced the development of X-ray spectroscopy by his father, following this by a mention of the early theoretical work of Darwin on the scattering of X-rays by perfect and imperfect crystals, which was so much in advance of experiment that it was overlooked and afterwards worked out in another form by Ewald. He ended by pointing out how many of the later developments had, in fact, been foreshadowed in the first three years.

Sir Lawrence was followed by Prof. von Laue, who spoke about his own experiences in those early days; this was not on the programme, and the pleased surprise of the audience was obvious. Speaking in German, apart from a few introductory remarks in English, he told of the first experiments in Munich and of his own contributions to the work, confessing that, like W. L. Bragg, he too was unfamiliar at the time with the conception of a crystal lattice. He characterized the German contribution as one concerned with 'principles' and the British as one concerned with 'models'. The former approach had been in danger of causing the subject of X-ray diffraction to run into a dead end, from which it had been saved by the latter; and Prof. von Laue pleaded for a collaboration between the two nations in political matters which should be as effective in the cause of peace as it had been in the cause of science. A summary of his remarks was then given in English by Dr. W. F. Berg.

After Sir Lawrence Bragg's historical review, and following Prof. von Laue's remarks, Prof. J. D. Bernal gave a talk in which, after some reminiscences of his own concerning his early days at the Royal Institution with Sir William Bragg, he discussed the future of X-ray crystal analysis in the light of recent developments. He showed how the real crystal, rather than the ideal, is becoming more and more the main object of study and forecast that we should, as a consequence, be led to a greater understanding of such phenomena as epitaxy, adsorption and catalysis, followed ultimately by an explanation of the phenomena of plastic deformation, creep, hardening and fatigue. Turning to methods of structure analysis, he hoped that the time would come when information justifiable on chemical grounds—the known mutual arrangement of constituent atoms in the structure, known ionic or atomic dimension, etc. —could be added to the X-ray data in a rigorous way. Prof. Bernal foresaw that, with the help of electronic and other computing machines, the heaviest part of crystal structure analysis would ultimately be automatic; he even foresaw that the reduction of observations might become so, the output being linked directly to the computer. But, as he said, we are still a long way from being able to drop a crystal down a hopper and receive a table of atomic coordinates or an electron density map within a short time.

The second session, on the morning of October 25, was devoted to 'review' papers on various present-day applications of X-rays, Dr. Dorothy Hodgkin dealing with chemical problems, Prof. G. V. Raynor with problems of the metallic state and Sir Lawrence Bragg with the application of X-rays to protein structure.

Dr. Hodgkin dealt mainly with recent developments in the analysis of organic structures and

[*] See "Forty Years of X-ray Diffraction", by Prof. J. M. Bijvoet, Prof. J. D. Bernal, Prof. A. L. Patterson and Sir Lawrence Bragg (*Nature*, 169, 949; 1952).

described, among other things, the way in which it is now possible, in certain instances, to determine the positions of hydrogen atoms. She then traced the way in which our knowledge of stereochemistry has been increased by our ability to study the effects of such factors as the repulsive forces between non-bonded atoms in addition to those of the classically directed valencies. Finally, she referred to the analysis of such complex compounds as vitamin $B_{12}$ and the problems set for the theoretical chemist by the molecular configurations recently found in substances such as the boron hydrides.

Prof. Raynor, after surveying the part played by the electron theory of metals in the development of our ideas of the metallic state, discussed Pauling's suggested valencies and described how, by making absolute measurements of X-ray scattering power, a check might be obtained on these. He added that such an attempt, recently made in Chicago, favoured, if anything, the conventional valencies. Other points dealt with by Prof. Raynor concerned the examination of the diffuse X-ray background, on one hand to determine the local distortions around dissolved atoms in alloys and, on the other, to measure the elastic constants of metals.

In the final talk of the conference, Sir Lawrence Bragg dealt with his recent work at Cambridge on hæmoglobins, carried out in collaboration with Dr. M. F. Perutz. He said that a systematic attempt is being made, based on an extensive series of intensity measurements of the diffraction by a hæmoglobin crystal at various stages of shrinkage, to see just how much could be discovered without making any structural assumptions; and he described a series of ingenious steps by which not only the size and shape of the protein molecule has been established, but from which also the distribution of scattering matter within the molecule is beginning to be understood. When it is realized that the volume of the molecule is 83,000 A.$^3$ dry and 116,000 A.$^3$ hydrated, the magnitude of this task will be appreciated; but Sir Lawrence gave every hope that, as he put it, we are now in sight of the promised land.

Space does not permit a detailed discussion of these or the previous papers, but a fuller report of the conference will appear in the *British Journal of Applied Physics*.

An account of the conference would be incomplete without a further reference to the dinner held on the evening of October 24, at which Prof. von Laue, replying to the toast of "X-ray Diffraction and the International Union of Crystallography", proposed by Sir Charles Darwin, made what is believed to be his first public speech in English. He began by referring to his early days in Strassburg and ended by hoping, as Röntgen had done before him, that, even if those younger workers present were not as lucky as he had been, they would derive as much enjoyment from their work as he had done from his. In a final gesture, he drank their health in a personal toast which was all the more appreciated for being so entirely and so obviously spontaneous.

In conclusion, a few words must be said about the historical exhibits at the Royal Institution which were shown during both days of the conference. Among other things on view were the original Bragg spectrometer, reproductions of Laue's original photographs, correspondence and note-books of the two Braggs, letters written by Barlow, Moseley and others, and even a (correct) model of rock salt constructed from balls of wool and knitting needles by Prof. Crum-Brown in Edinburgh in 1883. No one who attended the conference could fail to be impressed by the tremendous vitality of X-ray crystallography as well as by its versatility and power in application. He would indeed be a bold man who would guarantee what the next forty years of X-ray diffraction will bring forth.

J. Thewlis

# OBITUARIES

## Dr. C. H. Kellaway, F.R.S.

Charles Halliley Kellaway, director-in-chief of the Wellcome Research Institution, London, died on December 13 at the age of sixty-three. He was born in Victoria, and was educated at Melbourne Church of England Grammar School. A brilliant student, always the head of his year, he graduated at Melbourne in 1911, and after holding house appointments at Melbourne Hospital, became resident medical tutor at Trinity College, Melbourne, and then acting professor of anatomy at the University of Adelaide. During the First World War he served as a regimental medical officer with the 13th Australian Infantry Battalion in the Middle East and won the M.C. At the end of the War he worked at the Lister Institute in London under Dr. H. H. (now Sir Henry) Dale for a short period, and then became acting professor of physiology at Adelaide for a short time. In 1920 he was in England again as a Foulerton Scholar of the Royal Society. He worked at the National Institute for Medical Research and at University College Hospital, London. He returned to Australia as director of the Walter and Eliza Hall Institute, Melbourne, in 1923. During the Second World War he was director of pathology for the Australian Medical Services and later scientific liaison officer with D.G.A.M.S. In 1944 he retired with the rank of brigadier and became director-in-chief of research to the Wellcome Foundation, Ltd.

Kellaway's main interest in scientific work was initiated by his collaboration with Dale on the mechanism of anaphylaxis, and through most of his work he returned to the problem of cell damage and the associated release of histamine and similar substances. He was a pharmacologist working in the field of experimental pathology. The Hall Institute was closely connected with the Melbourne Hospital, to which Kellaway was appointed specialist physician, and consequently most of his research there was related with practical medicine. He worked on hydatid antigens and intradermal tests in the diagnosis of hydatid disease, on renal infection and hypertrophy. He studied intensively the pharmacology of the venom of the numerous Australian colubrid snakes, including many not previously studied, and extended his researches to the venom of spiders, the bee and the duck-billed platypus. He produced antivenoms in horses to several of the larger Australian snakes and collected venom from the snakes himself. In the course of this work he was once bitten by a tiger snake. His life was probably saved by the injection of antivenom; but he nearly died from serum reaction. He was one of the world's leading authorities on snake venoms. He continued his work on anaphylaxis and the histamine problem; one of his last personal investigations was conducted with collaborators on the pharmacological action of the toxins of the *Clostridium welchii* group, particularly in reference to the action on the pulmonary circulation. This was a good example of the application of physiological methods to experimental pathology; evidence was obtained that histamine, or a substance pharmacologically similar, was a link in the chain of action of the toxin.

Concurrently with all his personal research, Kellaway steadily developed the work of the staff of the Hall Institute. He had a gift for choosing able workers, and for fostering them. In the 'thirties, virus work was started under the present director, Sir Macfarlane Burnet; research on the *Q* fever virus is one of the outstanding examples of the growing importance of the Hall Institute. All the time Kellaway had considerable anxiety for the Institute on the financial side, for its original endowment was not large by modern standards; but by unceasing efforts he persuaded the Government, the Rockefeller Institute and other semi-official bodies and various private donors to increase the resources at his disposal, and before he left he had succeeded in getting erected for the Institute a beautiful modern building in close proximity to Melbourne Hospital. In addition to all this, with the growth of his personal reputation, his wise counsel was increasingly sought on pathological matters for the Government. He was, for example, appointed chairman of the commission which investigated the death of some children at Bundaberg from poisoning with the until then unknown staphylococcal toxin, which had developed in an accidentally contaminated injection of prophylactic.

Kellaway was elected a Fellow of the Royal College of Physicians in 1928, Foundation Fellow of the Royal Australasian College of Physicians in 1938 and Fellow of the Royal Society of London in 1940. He received the Walter Parfitt Prize of the Royal Society of New South Wales in 1932.

During the Second World War, the Hall Institute diverted its work into researches on influenza, scrub typhus, Asiatic schistosomiasis, blood typing and transfusion, drying of serum and other problems of direct importance in war; and in spite of his official duties with the Army, Kellaway continued to control its activities. When he accepted the post of director-in-chief of research to the Wellcome Foundation, Ltd., in 1944, he had the satisfaction of having brought the Hall Institute into the front rank of the world's medical institutes, and he had complete confidence that he was leaving the Institute to the care of an outstanding successor—one of his own men.

In the Wellcome Foundation, Kellaway was responsible for the research policy of the organization in Great Britain, and acted in an advisory capacity for the research activities of the American subsidiary company in Tuckahoe, U.S.A. He had under him the directors of the Wellcome Laboratories for Tropical Medicine, of the Research Laboratories at Beckenham and of the Museum of Medical Science and of the Museum and Library for the History of Medicine. While delegating much to his colleagues, as was inevitable, he kept very close interest in all their activities. He found time to serve on outside scientific committees, where he was often in demand because of his own reputation. His particular interest in the Foundation was the development of chemotherapeutic research; an intensive drive for the discovery of new compounds of therapeutic importance was started. What is perhaps the most important result so far is the drug sold as 'Daraprim', which seems likely to be of considerable importance as a suppressive drug for malaria. This came as a result of collaboration between the Foundation laboratories in Tuckahoe and London. It was Kellaway who first brought these laboratories to close collaboration.

The field in which he now worked was very different from that in which he had worked. But the way in which he adapted himself to his new responsibilities was a tribute to his wide knowledge and versatility, and he carried the organization successfully through some very trying times.

Kellaway was an attractive character. His boyish enthusiasm, his kindness to his colleagues and his discerning courtesy to his lowliest subordinate, combined with his resoluteness and reliability and his power to see another point of view, stirred affection and respect in all who worked with him. His courage in his last illness will be an abiding memory for those who witnessed it. Our sympathy goes out to his wife and three sons. J. W. TREVAN

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We regret to announce the following deaths:

Prof. W. H. Hobbs, emeritus professor of geology in the University of Michigan, aged eighty-eight.

Prof. F. E. Weiss, F.R.S., emeritus professor of botany in the University of Manchester, on January 7, aged eighty-seven.

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# NEWS and VIEWS

## Royal Astronomical Society: Awards

The following awards of medals have been made by the president and Council of the Royal Astronomical Society: *Gold Medal of the Society*: Prof. S. Chandrasekhar, for his contributions to mathematical astrophysics; *Eddington Medal*: Canon G. Lemaître, for his work on the expansion of the universe; *Jackson-Gwilt Medal and Gift*: Mr. J. P. M. Prentice, for his contributions to the study of meteors.

## Royal Photographic Society: Centenary Celebrations

On January 20 the Royal Photographic Society will celebrate the hundredth anniversary of its formation, and to mark the day there will be a special ceremony at 11 a.m. in the Society's house at 16 Princes Gate, London, S.W.7, when the president of the Society will receive the representatives of a large number of other societies and kindred organizations. At 3.30 p.m. in the house of the Royal Society of Arts in John Adam Street, London, W.C.2, exactly a hundred years later to the very hour and in the same place where the inaugural meeting of the Royal Photographic Society was held, Mr. Bertram Sinkinson, vice-president, will give a lecture entitled "The Centenary of the Royal Photographic Society", in which he will reconstruct the atmosphere surrounding the Society's inception and give historical details of the incidents which led to these events. Mention will be made of the great part played by the first officers of the Society, namely, Sir Charles Eastlake, president, and Roger Fenton, honorary secretary, and the support given to them by the many ardent pioneers of photography at that time, including

W. H. Fox Talbot. The main theme of the lecture will be based on two papers delivered at the first ordinary meeting of the Society, which were, in point of fact, pronouncements of policy: Sir William J. Newton delivered a paper on "Photography in an Artistic View and its Relation to the Arts", and Roger Fenton made pronouncements on "The Mode in which it is Advisable that the Society should conduct its Labours". After discussing the main principles of these two papers and illustrating, with the use of lantern slides, the effect they had on the later development of the Society, Mr. Sinkinson will explain how, during the past century, the early policies of the Society, mainly based on our artistic concepts, have been adapted to meet the growing ramifications of the photographic process as they are now applied in their many forms to the service of the community through the arts and sciences. Admission to this lecture will be by ticket, obtainable from the Secretary of the Society. Finally, in the evening of the same day the Society will hold a banquet at Claridge's Hotel, London, at which T.R.H. the Duke and Duchess of Gloucester will be the guests of honour; included among the guests will be the president of the Royal Society, the president of the Royal Academy of Arts, and the presidents or vice-presidents of twenty-seven other learned and cultural societies.

### Scientific Research in British Industries during 1951–52

FOR the Royal Society Empire Scientific Conference in 1946 there were prepared "Some Notes on Current Scientific Researches in the United Kingdom" which included, besides particulars of academic research at the universities, some notes on research in progress at the Royal Technical College, Glasgow, the College of Technology, Manchester, the Royal Botanic Gardens, Kew, the Rothamsted Experimental Station, the John Innes Horticultural Institution, the Wellcome Research Institution and some other research establishments directly attached to government departments. This list was appended to the Conference report and was later used as the basis for the first edition (1948) of the British Council's "Scientific Research in Britain". This was intended only for the use of the British Council; but, in view of the interest aroused and requests received for copies, it was arranged that the Department of Scientific and Industrial Research would sponsor future editions and that the British Council would collect the material. The edition for 1949–50 was entitled "Scientific Research in British Universities", the scope being limited to researches in British universities and university colleges; but neither this edition, nor the similar off-set litho edition for 1950–51, was made generally available. The report for 1951–52 is issued as an open publication on sale to the public (pp. 485; London: H.M.S.O., 1952; 8*s*. 6*d*. net).

The contents are arranged by universities and university colleges, and are classified by subjects under the laboratory or department concerned, with the name of the director of research or research worker. Work at colleges of technology is excluded, although the College of Technology, Manchester, appears under the Department of Technology, University of Manchester, and the inclusion of work of like standing in other major colleges of technolo would give the reader a more complete pict the lines of research being carried out in u

institutions throughout Great Britain. Only research which was pursued during the 1951–52 session and on which information has been published by the staff of the department within the past four years is included. An author index supplies information on the scientific activities of any particular research worker. The list constitutes a most useful reference volume for the industrial as well as the academic scientist and for libraries and information departments of research organizations.

### Technological Education in Great Britain

A REPORT on "A Policy for Technological Education", which has been issued by the Association of Scientific Workers, urges that, besides the creation of a technological university, it is necessary to extend further existing university departments of technology, particularly for students who have done two years of science, and to make more use of the existing technical colleges. For this purpose, the report considers that it is essential to place the financial responsibility of selected major technical colleges on a body of the standing of the University Grants Committee so that these colleges may become responsible degree-granting institutions, either through affiliation to universities or independently. Adequate facilities for research should be provided as well as further post-graduate courses and vacation courses, to facilitate contacts between industry and the universities. In making these recommendations, the report does not deal with the critical question of how many technical colleges should be developed in this way, nor in its recommendations for further financial assistance from the State to those technical colleges remaining under the financial jurisdiction of local authorities does it deal with the question of student numbers, either from the point of view of the number of technicians required or from that of the existence of students of the requisite intellectual capacity and other qualities. The recommendations for expansion here appear to assume that the supply of such students is unlimited. Stress is rightly laid on the provision of adequate maintenance grants for full-time students accepted in institutions of higher technology, but the content of higher technological education is briefly discussed without specific recommendation, other than the extension of the 'sandwich' type of full-time course and broadening the scientific basis of part-time courses, as well as extending them as far as possible.

### Bibliography of Science in Latin America

THE Centre of Scientific and Technical Documentation, an organization which, situated at Plaza de la Ciudadela 6, Mexico, D.F., was set up under the Unesco Programme of Technical Assistance, publishes monthly a *Bulletin* which contains translations int Spanish of the titles of all the original articles in th fifteen hundred scientific journals received regular in the Centre from all parts of the world. T arrangement is by broad subject and sub-divis within each subject, and then the listing is d alphabetically within each sub-division by the n of the first author. Papers published originall Latin America are specially with the September 1952 abstracts in French or papers.

The serie

Experts, held in Montevideo in 1948, and now two more volumes have been published: "Ecuador, No. 1" (pp. 74, 1952), and "Argentina, No. 3" (pp. 150, 1952). In these two volumes, which are published by the Unesco Centre of Scientific Co-operation for Latin America, Montevideo, the usual practice is followed of including first a list of institutions, indicating their scope and resources and giving the names of their chief officials, and then an alphabetical list of scientific workers, in which the publications and field of work of each worker are listed. Further volumes are promised for Argentina.

## Study of Psychology in the United States

A study of the development and status of research and education in psychology in the United States is being undertaken by the American Psychological Association and will be conducted in two parts: one part will be an evaluation of the status of psychological knowledge; and the other an analysis of occupational, educational and institutional relations of scientific psychology. The study will include a survey of methodology, theory and applications of psychology to determine the interrelationships among various branches of psychology and the importance of psychology to other scientific fields. Problems in psychological education, man-power, research support, communications and administration will also be examined. The project, which will cost about 40,000 dollars, derives its financial support from the National Science Foundation as another in the series of studies of specific fields of science which will assist the Foundation in developing a national science policy in the United States.

## Declassified Information on Atomic Energy Piles

A revised edition of a report from the Atomic Energy Research Establishment, Harwell, entitled "A Quantitative Study of Uranium-Graphite Lattices" (*R/R 922*; pp. 28+12 pl. London: H.M.S.O., 1952; 6*s*. net), by Profs. E. A. Guggenheim and M. H. L. Pryce, which was first issued on August 11, 1945, has recently been declassified and published. Calculations and results are given concerning piles of natural uranium rods arranged as a lattice in graphite. The quantity of uranium required for the pile to react steadily, the reproduction constant $k$, the square of the migration length $M^2$, and the Laplacian $(k - 1)/M^2$ are particular quantities specified. The calculations show the effect of varying the radius $a$ of the uranium rods and the radius $b$ of the moderator cell. Both $k$ and the Laplacian each have a maximum, while the critical mass of uranium has a minimum. For a cylindrical pile with height equal to diameter, composed of uranium rods sheathed in 1·15 mm. of luminium, arranged as a lattice in a graphite noderator and surrounded by a graphite reflector, e minimum quantity of uranium required is given 26 tons. In this case $a = 1{\cdot}25 \pm 0{\cdot}10$ cm., $= 11{\cdot}5 \pm 0{\cdot}50$ cm., and the width of the air-gap rounding each rod $= 1{\cdot}5 \pm 0{\cdot}25$ cm. The effect arying the air-gap is considerable, and the reasons this are discussed. In a homogeneous pile the proportion of uranium to to remain approximately $b$ and the air-gap. The hree diagrams illus- tribution

Rennie. Interested readers may well like to refer also to another A.E.R.E. report (*R/L 5*) by C. A. Rennie, entitled "Lecture Notes on Pile Theory" (*R/L 5*; pp. 29+3 pl. London: H.M.S.O., 1952; 5*s*. net), in which the basic nuclear design features of natural-uranium graphite-moderated thermal reactors are dealt with. This report includes references to published papers containing fuller treatment.

## Stomatal Behaviour in the Onion

Since the stomatal guard cells in the onion (*Allium cepa*) contain neither chloroplasts nor any visible quantity of starch, but do respond to changes in light intensity (which cannot be attributed to concomitant changes in temperature, etc.), the classical explanation of stomatal movement in terms of the starch $\rightleftarrows$ sugar mechanism cannot apply. Whether the hydrolysis of a soluble polysaccharide is involved has not yet been investigated. This interesting case of stomatal behaviour has recently been investigated by O. V. S. Heath (*New Phytol.*, 51, No. 1, 30; 1952), who has advanced various hypotheses to account for effects observed during the course of the relevant experiments.

## Conference on Plant and Animal Breeding

A one-day conference on "Plant and Animal Breeding" will be held under the auspices of the Joint Biology Committee and the Association of Agriculture at University College, London, on March 7. Mr. Alexander Hay, general secretary of the Association of Agriculture, will take the chair, and the speakers in the morning session will be Prof. L. S. Penrose, Galton professor of eugenics in University College, London, whose subject will be "Present-day Human Genetics", and Dr. Arthur Walton, deputy director of the Agricultural Research Council Unit of Animal Reproduction, Cambridge. The latter, in a talk entitled "Animal Genetics", will deal with the improvement of farm animals through modern breeding methods. In the afternoon Mr. W. B. Barker, of King's School, Wimbledon, will speak on "Teaching Genetics in School", and the conference will close with an address on "Plant Breeding Genetics" by Dr. G. D. H. Bell, director of the Plant Breeding Institute, Cambridge, who will describe the application of Mendelian principles to the work of increasing food production through crop improvement. The fee for the conference is 5*s*., and application should be made as early as possible to the Secretary, Joint Biology Committee, c/o British Social Biology Council, Tavistock House South, Tavistock Square, London, W.C.1.

## Discussion on Collagen

An informal discussion on the "Nature and Structure of Collagen", under the auspices of the Colloid and Biophysics Committee of the Faraday Society, will be held in the Wheatstone Physics Laboratory, King's College, London, W.C.2, during March 26–27. It is hoped that the response will be such as to allow for a small number of papers on the biological background to the subject, although the chief emphasis on this occasion will be given to physical and chemical studies of native and extracted or precipitated collagens. The biochemical studies of the amino-acid and polysaccharide contents of collagens of various origins now in progress in various oratories are essential to the understanding of obtained by means of the techniques of fraction, electron microscopy, and infra-red dichroism. It is hoped that researches in these fields will be reviewed and form the basis for discussion of models of the structure of collagenous fibres. Those wishing to attend or to take part in the discussion should communicate with Prof. J. T. Randall, King's College, London, W.C.2, as soon as possible.

## Medical Research Awards for Study Outside Britain

THE Medical Research Council is offering a number of fellowships and scholarships as follows: *Rockefeller* travelling fellowships (2,600 dollars a year or 3,600 dollars for married men) for graduates resident in Great Britain with previous research experience in medicine, to work at a centre in the United States or elsewhere abroad before taking up positions for higher teaching or research in Great Britain; *Eli Lilly* travelling fellowships of a similar nature to the Rockefeller awards; *Dorothy Temple Cross* research fellowships in tuberculosis (£650 a year or £900 for married men) for British subjects to devote themselves to the advancement of knowledge of tuberculosis at a centre outside Britain; *Alexander Pigott Wernher Memorial* travelling fellowships in ophthalmology and otology (£650 a year or £900 for married men) for suitably qualified medical graduates to study at a centre abroad before taking up positions for higher teaching or research in these subjects; and *French Government* exchange scholarships (45,000–90,000 francs a month, plus a marriage allowance payable in sterling) for young British graduates in medicine or science who have had some experience in a branch of medical science, to work in a research institution in France on some branch of medical science other than clinical medicine. All the above awards carry travelling allowances and other allowances, in addition to the stipend. Applications for the Rockefeller, Lilly and Cross fellowships must be received not later than March 15, and for the Wernher fellowships and French Government scholarships not later than March 31. Application forms and all further particulars can be obtained from the Secretary, Medical Research Council, 38 Old Queen Street, London, S.W.1.

## Colonial Service: Recent Appointments

THE following appointments have recently been made in the Colonial Service: C. W. Benson (administrative officer, Nyasaland), biologist, Department of Game, Tsetse Control, Northern Rhodesia; M. D. Ashwin and T. G. Gudgeon (agricultural assistants, Nyasaland), agricultural officers, Nyasaland; J. R. Curry (senior agricultural officer, Federation of Malaya), chief field officer, Agricultural Department, Federation of Malaya; D. L. Downie (botanist, Uganda), tea research officer, Nyasaland; L. J. S. Littlejohn (agricultural officer, Tanganyika), chief soil conservation officer, Tanganyika; A. K. F. Nicol (assistant conservator of forests, Nigeria), chief conservator of forests, Sierra Leone; I. P. Tamworth (forestry officer, Hong Kong), assistant conservator of forests, Federation of Malaya; E. H. Jaques (senior geologist, Aden), geologist, Federation of Malaya; C. S. Cree (senior assistant conservator of forests, Northern Rhodesia), conservator of forests, British Honduras; D. B. Fanshawe (deputy conservator of forests, British Guiana), principal scientific officer (forestry research officer), Northern Rhodesia; J. W. Macaulay (senior veterinary research officer, Northern Rhodesia), senior veterinary research officer, Kenya; K. M. Francis (government statistician, Sierra Leone), government statistician, Gold Coast;
D. P. E. Speldewinde (sub-assistant conser
forests, Federation of Malaya), assistant con
of forests, Federation of Malaya; H. D
agricultural officer, Gambia; E. B. Dennison
Pickering, R. B. Skinner and D. J. Wheele
cultural officers, Nigeria; A. V. Haddon
Tuley, botanists (plant breeders), Federat
Malaya; M. G. Hawson and M. J. Strickland
cultural officers, Federation of Malaya;
Howston, plant breeder, Tanganyika; A. D. F
agricultural officer, Uganda; D. C. Mackenz
F. P. Massey, agricultural officers, Sierra
H. J. McLean, agricultural officer, Tanga
A. R. McWalter, soil chemist, Federation of
A. B. Rains, pasture research officer, Nigeria
Hockey and H. J. Richards, geologists,
W. C. White, geologist, Somaliland Prote
W. Jackson, scientific officer, Sierra Leone
Stanton, senior scientific officer, Nigeria
Adlard and R. J. McEwan, assistant conser
forests, Nyasaland; D. K. Bailey, geologist,
Rhodesia; P. B. H. Bailey, geologist, Britis
P. R. Browning, statistician, East Africa H
mission; R. D. T. E. Chandler, chemist, F
of Malaya; Prince John Loewenstein, c
anthropology, Raffles Museum, Singapor
Stratton, statistical officer, Gold Coast; R.
biochemist, Federation of Malaya.

## Announcements

H.R.H. THE DUKE OF EDINBURGH h
election to honorary membership of the I
Metallurgists.

OWING to the rapid expansion of t
National Institute of Agricultural Bo
bridge, a new post there, that of dep
has been created, and Mr. A. Sandis
appointed to fill it. Mr. Sandison, who
assistant education officer for further
Buckinghamshire, was born in 1914 an
Whitgift School and Trinity Colleg
obtaining first-class honours in zoolog
the Natural Sciences Tripos.

THE British Welding Research A
hold its third summer school at Ash
Leamington Spa, Warwickshire, du
May 2, the general theme this yea
and fabrication. After introductory
welding processes and materials, in
given on welding design, modern
applications to productivity. In th
students will be split into five grou
lectures pertaining to, respectiv
industry, shipbuilding industry, st
ing, automobile and sheet-meta
general engineering. Further deta
from the Secretary, B.W.R.A. S
Welding, British Welding Res
29 Park Crescent, London, W.1.

THE Nuffield Foundation
Provincial Hospitals Trust, whic
12–13 Mecklenburgh Square, I
the National Corporation for th
at present at 33 Doughty St
will be moving on January 2
(formerly Grove House, oppos
Church), Regent's Park, Lo
Trust's Investigation into the
of Hospitals will be at 33 Do
W.C.1, from January 22 unt

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# RESEARCH IN BRITISH COLONIAL TERRITORIES

"COLONIAL RESEARCH 1951–1952"* follows the form of last year's report. Besides the brief report of the Colonial Research Council, to which are appended a list of schemes approved for research grants, April 1, 1951–March 31, 1952, and the report of the Director of the Colonial Products Advisory Bureau for 1951–52, it comprises the ninth annual report of the Colonial Products Research Council, the eighth annual report of the Colonial Social Science Research Council, the seventh annual reports of the Colonial Medical Research Committee and the Committee for Colonial Agricultural, Animal Health and Forestry Research, the fifth annual reports of the Colonial Insecticides and the Colonial Economic Research Committee and annual reports of the Colonial Fisheries Advisory Committee on Fisheries Research, of the Director of the Anti-Locust Research Centre on Locust Research and Control, and of the Tsetse Fly and Trypanosomiasis Committee: lists of publications are appended to the several reports. The Colonial Research Council's report is, as usual, confined to matters not covered by the specialist committees, and its most important feature is the warning it sounds as to the effects of the uncertainty regarding the provision of Colonial Development and Welfare funds after the present Acts expire in March 1956. As the Council here points out, such uncertainty both makes the planning of long-term research impossible and is also hindering the recruitment of research workers for the Colonial territories.

The Council's reasonable request for an early clarification of the position is one which should receive prompt response from the Government, and should be carefully noted by scientific workers as well as by the Parliamentary and Scientific Committee. Little is said in these reports about other difficulties in recruiting scientific workers; seventeen research appointments were made during the year, and about forty officers in some ninety posts in the Colonial Agricultural, Veterinary and Medical Services have been declared suitable for transfer to the Colonial Research Service. The Council in this report stresses the importance both of direct contact between research organizations and institutions in Great Britain and the Colonial territories, and of visits of members of the various research advisory committees to the territories where the schemes sponsored by the committees operate.

As was forecast in last year's report, there was a substantial reduction in the number and size of research schemes made during the year: some thirty-six new schemes and fifty-three supplementary schemes, involving grants totalling £868,851, brought the total allotted to Colonial Development and Welfare Schemes to a net expenditure and commitment of £10,140,000 at March 31, 1952, of which £9·94 millions is chargeable against funds provided under the 1945 and 1950 Acts. Additional assistance provided by Colonial Governments or industry since 1940 is estimated at about £3 millions. Of the gross allocation of £11,100,000, about 32·7 per cent has been for agricultural, animal health and forestry schemes, 13·9 per cent for medical research, 13·8 per cent for fisheries research, 11·7 per cent for tsetse and trypanosomiasis research, 8·8 per cent for social science and economic research, 6·2 per cent for insecticides research, 4·6 per cent for research sponsored by the Colonial Products Research Council and 3·5 per cent for anti-locust research. About 39·0 per cent of the gross allocation has been for schemes to benefit the East African territories, 18·3 per cent for the West African group, 11·1 per cent for the South-East Asian territories and Hong Kong, 8·7 per cent for the West Indian Colonies, British Guiana and British Honduras and 6·2 per cent for the Central African territories (Northern Rhodesia and Nyasaland). Schemes approved during the year besides those recently noted (cf. *Nature*, 170, 311; 1952) include £28,750 for the Anti-Locust Research Centre and its extra-mural research, £31,500 for physiological and biochemical research at Makerere College, Uganda, £26,620 for the East African Agriculture and Forestry Research Organization, £24,403 for the Nutrition Field Station, Fajara, Gambia, and £17,500 to enable clove research in Zanzibar to be extended until August 31, 1953.

Work under four of the Economic Co-operation Administration projects mentioned in last year's report was started or continued in 1951–52. An American plant-breeder visited Nigeria to investigate the breeding of improved grain sorghums and maize, and an entomologist was secured for research in Northern Rhodesia into the control of ticks affecting livestock. The African Studies Branch of the Colonial Office is undertaking surveys of particular subjects to meet current Colonial Office needs, and a complete survey of the development of local government in the African territories since 1947 began to appear as supplements to the *Journal of African Administration* in January 1952. Mr. Ian Small, the newly appointed director of the West African Building Research Organization, was proceeding to the Gold Coast in the summer of 1952, and Mr. G. A. Atkinson, the Colonial building research liaison officer, who has now visited twenty-five Colonial territories, visited Hong Kong and the South-East Asian territories and also Aden and Cyprus during January–May 1952. His report on his visit to the Caribbean area was presented during the year, and a review of aided self-help housing, based on information gained during the tour, was circulated to all Colonial governments. Mr. Atkinson reached the conclusion that little or no organized scientific research into building problems is possible in the area in the immediate future. Much could be done, however, to improve building materials by making technical information more readily available and by providing better facilities for training building technicians and for testing materials.

Publication of Volume 3 of the "Demographic Survey of the British Colonial Empire" is expected early in 1953. Censuses were taken during the year in North Borneo and Gambia and, for the non-African population and for Africans in employment, in Northern Rhodesia. The Directorate of Colonial (Geodetic and Topographic) Surveys moved into new headquarters at Tolworth in June 1951; but little progress is reported in recruiting field-survey staff. A chain of triangles has been reconnoitred, beaconed and observed from Eastern Uganda (near Mount Elgon) down the east side of Lake Victoria to Tanganyika. Most of the southern half of Basutoland has been covered with secondary triangulation. An additional twenty geologists were appointed during the year, and the strength of the overseas scientific staff was 180 in 1951, compared with 58 in 1947, although there is still a shortage of experienced geologists trained in mapping, petrology and mineralogy. The total area geologically mapped during the year increased considerably. Research continues at various institutions in the United Kingdom on the economic production of Columbian minerals, iron ore and apatite from the soils surrounding the Sukulu carbonatite ring-structure in Uganda. Good progress is being made in the examination of coalfields in Tanganyika, and the report welcomes the growing practical interest of the universities in Great Britain in Colonial geology.

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* Colonial Office. Colonial Research 1951–1952: Reports of the Colonial Research Council, Colonial Products Research Council, Colonial Social Science Research Council, Colonial Medical Research Committee, Committee for Colonial Agricultural, Animal Health and Forestry Research, Colonial Insecticides Committee, Colonial Economic Research Committee, Tsetse Fly and Trypanosomiasis Research Committee, Colonial Fisheries Advisory Committee, Director of Anti-Locust Research Centre. (Cmd. 8665.) Pp. ii+253. (London: H.M. Stationery Office, 1952.) 6s. 6d. net.

Investigations undertaken in Uganda by the British Paper and Board Industry Research Association on the suitability of local fibres for incorporation in a pulp for the manufacture of a kraft-type of paper for containers have given promising results, and a paper entitled "Some Notes on the Durability of Paint in Tropical Climates" has been prepared, with particular reference to the humid climate of Singapore. Progress continued in the installation of *radio-sonde*/radar wind stations for the study of upper-wind conditions, and regular observations to a height of 60,000 ft. are now made by stations established at Aden, Gibraltar, Lagos, Malta and Nairobi. In the oceanographic research to which the Colonial Office contributes, some new instruments are being developed, including a simple method of recording the changes in depth of a mid-water trawl, by measuring the changes in pressure in a rubber bag attached to the trawl, and connected to the ship by a reinforced hose-pipe. Discovery by the R.R.S. *William Scoresby* of the breeding ground of the pilchard (*Sardinops sagax*) enabled detailed information to be supplied to Colonial fishery officers in West Africa. The work of the Colonial Liaison Officer at the Road Research Laboratory in Britain is attracting increasing attention from Colonial engineers, and a report is being prepared on his visit in October and November 1951 to Northern Rhodesia and Nyasaland, where the same road problems, broadly speaking, were met as in East and West Africa, though the soils appear to present less difficulty than in East Africa. It is proposed to place the work of the Colonial Products Advisory Bureau, which covers much the same field as that of the Colonial Products Research Council, under a common directorship with the latter body early in 1953. During 1951–52 the Bureau has carried out work on the chromatographic separation of the active principles of pyrethrum, on distilled lime oil from Zanzibar, gum arabic from Tanganyika and the Somaliland Protectorate, cattle hides from East and West Africa, the drying of goat skins, the utilization of *Brachystegia* wood from Tanganyika for paper-making, and the tanning properties of the barks of *Eucalyptus robusta* and *E. saligna* from Uganda.

The ninth annual report of the Colonial Produc
Research Council stresses the value of the work
the Colonial Microbiological Research Institute a
of the work carried out there on the fermentation
the cocoa bean. The results already obtained
likely to prove of immediate value to plant-breed
as they enable commercial evaluation to be mad
small samples of beans. A provisional patent
been taken out to cover the preparation of the
biotic comirin. Although much work is requir
determine the most efficient method of prepa
and little is yet known of its chemical stru
clinical trials both in Trinidad and in Jamaica
indicated that the fungus skin infections
*corporis*, *T. cruris* and *T. interdigitale* resp
topical applications of comirin, and that it
effective in cases of 'tropical ear' infection
*Aspergillus flavus* or *Candida parapsilosis*,
when the infection was caused by a Gram-
motile or non-motile short rod. An investi
being undertaken on the possibility of gr
the tropics a yeast with a high ergosterol c

The Hankey Culture Collection now cont
than 500 specimens, of which 84 were iso
Trinidad sources during the year; 6
were supplied to scientific institutions and
firms. With the completion of the Sug
logical Laboratory in Trinidad, Prof. L.
has been able to examine the possible ec
of some of the products derived from
hydrocarbon solvents available locally
factory substitutes for benzene in extrac
from the filter mud, and by treating t
with fusel oil, a light yellow or grey
point 78°–80°, which appears to be suita
industrial purposes, can be readily c
possibility of utilizing, on a manufact
improved processes for the preparati
and lactic acids from sucrose worl
University of Birmingham is now l
Trinidad, and a successful process, v
solution, has been discovered for isola
from bagasse in a form suitable for
of paper.

Equipment has at last been supp
laboratory at the Forest Products
tory, Princes Risborough, and a se
with good properties has been obta
wood. Work on the constituent
woods being carried out in the Un
ham in collaboration with the
Laboratory is expected to throw
of the resistance of timbers t
attack. Further carbohydrate i
out in the University of Birmin
in preparing tripotassium α-
phate, which is already prov
enzymic syntheses of polygluc
work on polysaccharides, evide
that dextran is a mixture of
range of molecular weights,
dextran from *Betacoccus a*
average chain-length of six t
the cross-linking is not of the
tions on the production of b
sugar have reached the stage
are desirable.

Improved methods have be
isolation and purification of
enzymes, and a clearer definit
is now possible. The *R*-enzym

function of irreversible hydrolytic scission of the branch links in amylopectin. The *Z*-enzyme is a β-glucosidase, and with its aid it has been found that amylase contains branch linkages. The *Q*-enzyme has been recognized as a transglucosidase. An excellent oil has been extracted from the eighteen tons of heat-dried oil-seeds of *Tetracarpidium conophorum* received from Nigeria and is now being distributed in the paint industry for technical evaluation. Progress is reported in the study of the germination factor of *Striga*, and highly satisfactory results were obtained in Nigeria with a new machine for harvesting *Hibiscus cannabinus*, and accordingly further trials are being made with jute in British Guiana.

The eighth annual report of the Colonial Social Science Research Council refers to the great restraint which the Council has had to exercise in making new grants. Since October 1, 1951, the Council has had to operate within a limit of £325,000 until March 31, 1956, and on March 31, 1952, only some £200,000 was uncommitted. Accordingly, it was necessary to refuse applications for new grants which were not already receiving considerable financial support from other sources. Although the recruitment position for experienced research staff improved, difficulty is still being encountered in recruiting senior staff capable of organizing research, and in such special categories as demography and law. Much of the present report is occupied by a retrospect of the work of the Council since 1945, and there are appended to it annual reports for 1951–52 from the East African Institute of Social Research, Makerere College, the West African Institute of Social and Economic Research, Ibadan, the Rhodes–Livingstone Institute, and the Institute of Social and Economic Research, University College of the West Indies, as well as a list of publications by research workers assisted by the Council.

Commenting on the progress of Colonial studies in British universities, the Council refers to the work of the Department of Anthropology in the University of Manchester, which is closely associated with the work of the Rhodes–Livingstone Institute on Central African Studies, the work on race relations carried out under the auspices of the Department of Anthropology in the University of Edinburgh, and to the analysis of the social organization and types of society in the highlands of New Guinea and the studies of the appearance of cargo cults in the Pacific Islands and of the Pacific islander in commerce and industry being carried out by the Department of Anthropology of the Australian National University. The Survey of African Marriage and Family Life has been completed and is now in the press. Other reports in the press are Mr. J. N. D. Anderson's synoptic survey of the present position of Islamic law in the British African territories and Aden, Prof. C. M. Dohe's study of the Bantu languages of Southern Africa and the West Indian volume of the late Dr. Kuczynski's "Demographic Survey of the British Colonial Empire", while numerous other investigations are being prepared for publication. The East African Institute of Social Research has completed a survey of the European, Indian and African inhabitants of Jinja township and continued village surveys of immigrant labour in Buganda. A study of the present method of selection and training of African leaders in East Africa is proposed, as well as a survey of the Indian community in and around Kampala. At the West African Institute of Social and Economic Research, the inquiry into the Nigerian monetary and banking system is being completed and also that into Yoruba social and economic organizations. Definite proposals have been made regarding the functions of the Institute in relation to the Nigeria produce-marketing boards. The major event at the Rhodes–Livingstone Institute was the appearance of its first major publication, "Seven Tribes of British Central Africa". The Institute of Social and Economic Research, Jamaica, reports progress in the projects for the preparation of national income estimates, the determination of the trend in consumption patterns in Barbados and on experiences of management in the adaptation and training of Jamaican industrial workers.

(*To be continued*)

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# INDUSTRIAL RADIOLOGY GROUP OF THE INSTITUTE OF PHYSICS

## MEETING IN SHEFFIELD

THE summer meeting of the Industrial Radiology Group of the Institute of Physics was held at Crewe Hall, Sheffield, during July 3–5. The success of the meeting was in no small way due to J. F. Hinsley and H. S. Peiser, who were responsible for the local arrangements, and to the staffs at Crewe Hall and at the various companies and institutions visited.

A day and a half were devoted to lectures, the opening session on "Training in Industrial Radiology" being given in two parts, the first by Mr. J. C. Rockley, of the Aeronautical Inspection Directorate, Harefield, and the second by Mr. J. D. Hislop, of Solus-Schall, Ltd. Mr. Rockley pleaded for a longer training course than is at present available for industry, with a recognized award, and spoke of what is being done by the exploratory committee of the City and Guilds of London Institute, to which the Institute of Physics has made recommendations.

Mr. Hislop thought that the maximum tuition in the time available in a part-time course can only be given if a good deal of this is devoted to theoretical work. In dealing with the special problems of weld examination, he put forward a plea for standards of interpretation which could be incorporated in any final training scheme and stressed the importance of correct identification and of orderly reporting. He thought that the training of a radiographer is essentially a long-term one, and suggested that managerial staff should become more familiar with the limitations of the method.

The first paper during the afternoon was given by Dr. R. Jackson, of the British Coal Utilization Research Association, on "The Presentation of Results in Radiography with Special Reference to the Terminology of Casting Defects". Dr. Jackson stressed the need for as good a radiograph as could be obtained, followed by careful interpretation, with as full information about the casting as possible in advance. He concluded with a description of the many difficulties which had been met in drawing up the proposed British Standards Institution terminology.

The second afternoon paper had the title "Economic Aspects and Administration of an Industrial Radiology Department", and was a joint paper by E. W. Colbeck, F. Cousans, H. S. Peiser and J. R. Rait (all of Hadfields, Ltd.). Mr. Peiser, who delivered the lecture, dealt particularly with radiography in the laboratory of a steelworks. Radiography, he said, could be divided into three groups, namely, inspection, *ad hoc* problems, and investigations of manufacturing techniques. In the first, 100 per cent inspection is only justified if failure in service would cause destruction of a valuable engineering unit or endanger life. The chief economic considerations involved were briefly discussed. In dealing with *ad hoc* problems on which the X-ray department has come to the aid of the foundry, Mr. Peiser mentioned the determination in weld repairs of the extent of the defect and the quality of the repair when it has been made, and problems arising in the examination of inaccessible plant or equipment. In dealing with the investigation of manufacturing techniques, he said that this type of investigation is the most valuable economically and, in addition, from it better products usually result; he gave as an example from the hundreds undertaken the elimination of shrinkage cavities. Mr. Peiser concluded with some remarks on the economic operation of a radiographic department.

On the evening of July 3, Dr. O. Vaupel, of the Rontgenstelle, Material Prüfungsamt, Berlin, lectured on the subject of "The Standardization of Radiology in Germany". Dealing specially with X-ray and gamma-ray techniques, he said that new quality standards for X-ray and gamma-ray pictures would be published shortly under standard *DIN* 54110, which would replace the present standard *DIN* 1914. Dr. Vaupel next described the wire penetrameter, consisting of wires of the appropriate material embedded in thin rubber, four gauges being required to cover thicknesses up to 3¼ in. Since none of the orthodox types of penetrameter is capable of showing up small differences in defect sensitivity because the gaps (for example, between adjacent wires) were too wide, E. A. W. Müller in 1942 invented a more accurate penetrameter known as the 'bacillæ test', an ingenious device in which short lengths of randomly distributed wires are contained in nine boxes embedded in low-adsorption material, the whole containing thirty-one wires of the same diameter, for example, 0·4 mm. The observer draws the positions of the wires as seen on the film and compares the result with their true positions. This is repeated for wires of different diameter, and the number of observed wires is plotted against the diameter, extrapolation giving the diameter necessary for thirty-one wires. On the subject of the standardization of magnetic crack testing, Dr. Vaupel said that the importance of this method can be judged from the fact that in 1944 there were in Germany as many magnetic crack detectors in use as X-ray equipments. The methods by which magnetism is induced in the specimen had been standardized as well as the direction of the resultant magnetism. There is also a standard test for magnetic inks. Dr. Vaupel also described the Berthold magnetic penetrameter which indicates the efficiency of a magnetic test.

The first paper at the morning session of July 4 was read by Mr. J. F. Hinsley, of Edgar Allen and Co., Ltd., and had the title "The Radiography of Castings". Starting with a review of the casting processes, the subsequent chain of events in the foundry was described. To talk with the foundryman the radiographer needs to understand his terms, and these were explained. The design of castings was next discussed, in particular the formation of defects during the solidification process, and it was shown how the radiologist can help in this connexion, as also in the feeding process.

The last lecture, on July 4, was given by Mr. G. T Harris, of William Jessop and Sons, Ltd., who spoke on "Non-Destructive Testing in a Steelworks", which for the purpose of his talk he divided into three sections, namely, identification, checking mechanical and physical properties, and the detection of surface and internal defects. In the first section can be placed the spectrograph and its simplification, the spark test with a grinding wheel; microhardness testers and thermo- and tribo-electric methods were also described. In the second section Mr. Harris spoke of automatic thickness gauges and then described the core loss comparator, in which, by placing a coil round the bar under test and measuring the core loss, quality differences are at once obvious. In discussing magnetic crack detection, the effect of the direction of the field was shown. Inspection by penetrating oil has been improved by using fluorescent oils, and an American method called 'Dy-chek' was referred to. Another method has the advantage of using a water-soluble oil which is easily removed. Electrolytic etching is widely used, said Mr. Harris, as it is a very sensitive method of detecting surface cracks. He discussed the correlation of the results of ultrasonic flaw detection and radiology, and stated that it is difficult to estimate the size of a defect by the ultrasonic method, though he thought that automatic scanning would be an advantage. Speaking of radiology, Mr. Harris said that developments needed are X-ray equipments able to penetrate ten inches of steel, scanning of large specimens by counters, Xero-radiography and the amplification of fluorescent images by image converters.

B. N. CLACK

# MECHANISM OF PHOTOGRAPHIC SENSITIVITY IN SILVER BROMIDE

IT has been shown recently by Loening[1] that pure silver bromide in the form of an aqueous sol has only a very slight sensitivity to light as judged after development. Sensitization can be achieved by adding silver ions or gelatine or substances such as sodium nitrite to the sol. Ordinary photographic emulsions have already the sensitivity conferred by gelatine, and there are three well-established methods[2] of obtaining further gains of sensitivity, depending on the addition of one of three substances: reducing agents, gold salts and sulphur compounds. These substances probably react with the silver bromide to form minute quantities of silver, gold and silver sulphide respectively at the grain surfaces: at any rate, that is the simplest supposition. All this refers to 'chemical' sensitization, as distinct from extension of spectral sensitivity by dyes.

According to the theory of the photolysis of silver bromide put forward in 1938 by Gurney and Mott[3], the absorption of a light quantum by silver bromide removes an electron from a bromide ion, leaving a 'positive hole'. The electron and the hole should both be highly mobile. If silver particles are present, they become negatively charged by trapping electrons and grow by attracting the mobile interstitial silver ions that are naturally present in the crystal (Frenkel disorder). This theory still holds the field, more recent attempts based on the assumption of Schottky disorder having now been abandoned[4]. As applied

o the formation of latent images, however, the theory
incomplete: one has to explain how the positive
les are prevented from recombining with the
trons and how the first electrons are trapped if
ver is initially present. What is lacking is
y a theory of sensitization, and the question
o the sensitizers mentioned function as
es, or positive hole traps, or both?

e given on November 20 before the
and Technical Group of the Royal Photo-
ic Society, Dr. J. W. Mitchell described a
ies of elegant experiments on the point carried
out by himself and collaborators in the University of Bristol. The complications of photographic emulsion work were avoided by using pure dry monocrystalline plates of silver bromide and applying the sensitizer (silver, gold or a metallic sulphide) directly in a very thin uniform surface-layer by vacuum evaporation. The plates were about 1 cm. square and 0·01 cm. thick, with the crystallographic [100] axis approximately perpendicular to the square face. An ordinary metol-hydroquinone developer was used, with a little gelatine added to prevent excessive fog. Unexposed unsensitized specimens gave only a slight irreducible fog in the form of small oriented silver crystals scattered over the surface, as observed in previous single-crystal work by Dankov[5] and Boissonnas[6]. Exposure to light produced no further developable effect, even when sufficient to produce visible (internal) separation of silver. A developable latent image was produced, however, by exposure under a solution containing a bromine acceptor.

By means of slits and masks, the deposition of sensitizing substances and the exposure to light were restricted to well-defined circular or rectangular areas of the specimen. Areas bearing $10^{15}$ silver atoms per sq. cm. (about one monolayer) were blackened by development without exposure, the edges appearing well defined. Specimens bearing $10^{14}$ silver atoms per sq. cm. gave only the normal irreducible fog without exposure, but were blackened in certain areas by development after exposure—that is, they were sensitized but not fogged by the deposited silver. This blackening or latent-image formation was expected to occur only in the areas both silvered and exposed to light, but the result was quite different. The blackening appeared only in the unexposed areas, and spread beyond the silvered areas, the spreading being greater at a greater distance from the exposed area: with sufficient exposure the entire unexposed area became blackened. Essentially the same phenomena were observed with gold and with arsenious, antimony and thallous sulphides (silver sulphide, not being stable enough for evaporation, was not tried).

If the sensitizers in these experiments acted mainly as electron traps, the blackening would presumably have been confined to the sensitized areas. It seems that the phenomena can only be explained by supposing that they act as positive-hole traps, that is, they react with the bromine, which is quite reasonable from a chemical point of view. If some of the bromine is removed in this way, a surplus of electrons remains, and apparently no special electron traps are then needed to ensure the formation of latent-image silver specks, for the latent image appears mainly on the naked silver bromide surface. The mobility of the electron being about twice that of the positive hole explains why the image is produced far from the exposed area, in which a surplus of positive holes will be left. The space charge produced by the electrons
travelling faster than the holes would proc
urging interstitial silver ions into the el
regions. Dr. Mitchell did not, however,
give a complete theory of the phenomena.

It appears then that silver, gold an
sulphides all sensitize by the same mecha
the function of each is to react with ha
that no special electron traps are needed
tivity. In the case of silver sensitization, t
of positive holes by the silver permits the
of new silver elsewhere by the electrons
stitial ions, and one might say that in
latent image is formed by redistributing
initially present. These tentative conclusio
they may not be directly applicable to the
tion of ordinary emulsions, are of obvious
the photographic chemist and represent
revision of earlier thought on the subject

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tivity", 149, ed. J. W. Mitchell (London: Butterwo
Publications, 1951); *Phot. J.*, 92B, 126 (1952).

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Mechanisms", 112.

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[5] Dankov, P. D., and Kochetkov, A. A., *C.R. Acad. S*
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282 (1949), "Fundamental Mechanisms", 36

# THE FORESTRY COMMIS

## REPORT FOR THE YEAR 1950–

THE thirty-second annual report of th
Commission records the activities of
mission for the year ending September
During this time the passing of the Forestr
took place, and the year also marked the
first post-war quinquennium. The progress
forestry, and the dedication schemes and t
tion of land during the year are worthy o

The Forestry Act 1951 was passed duri
1951, and its main provisions, which rel
maintenance of reserves of growing trees
Britain, came into force two months lat
the beginning of the Second World Wa
had been controlled by statutory instrum
Defence Regulation 68. This was not inte
permanent; nevertheless, the timber re
Great Britain in both conifers and hardw
alarmingly small, and unchecked felling co
countenanced. The Forestry Commission i
charged by the Act with "the general du
moting the establishment and maintenanc
Britain of adequate reserves of growing t
carry this out the Commission is required
with the Home Grown Timber Advisory C
consisting among others of those appoint
advice of woodland owners and the tim
The Act also provides for the maintenan
conservancy of a regional advisory c
"certain members of which are appointed
sultation with the above organizations an
forestry societies, for the purpose of ad
Commissioners as to the performance of thei
under the provisions of the Act relating t
and compulsory felling". The Act prohibits

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[*] Forestry Commission: Thirty-second Annual R
Forestry Commissioners for the Year ending Septemb
Pp 82. (London: H.M.S.O., 1952.) 3s. net

of any growing tree (apart from certain exceptions such as trees less than a given diameter, garden and orchard trees and a licence-free allowance of 825 cu. ft. per quarter) unless a licence has been granted by the Commissioners.

Apart from the Forestry Commissioners and the staff of the Forest Department proper, there are no less than three National Committees (England, Scotland and Wales), eleven Regional Advisory Committees (five for England, four for Scotland and two for Wales) and a Home Grown Advisory Committee—a total of fifteen committees to assist in carrying out the forestry work of a comparatively small island.

One important provision of the Act is that the Commissioners have now the power to add replanting of the area to a felling licence. By establishing the principle that it is contrary to the public interest that forest land should be cleared and then allowed to lie derelict, the Act will check the further accumulation of unproductive woodland areas.

The area of forest planted during the year was 57,164 acres, of which 17,491 were in England, 26,960 in Scotland and 12,713 in Wales. The total area of land acquired during the year was 113,200 acres, of which 56,000 were classed as plantable. Of the latter, 16,000 were in England, 33,000 in Scotland and 7,000 in Wales.

It is estimated that private owners planted 12,300 acres, of which 6,300 acres were planted with the aid of grants. Under the dedication scheme deeds were completed with seventy-nine owners in respect of 37,010 acres of woodland. The planting and maintenance grants have been revised and increased. During the quinquennium a total area of 138,000 acres of the woods planted since 1921 has been thinned, and it is estimated that during the same period 38 million cu. ft. of poles and timber (roughly a million trees) have been extracted from these new public forests, and a small return on the capital outlay is being obtained.

An additional national forest park, named Loch Ard, was set up in the lovely Trossachs district of the Scottish Highlands. This must be one of the most beautiful of all the national forest parks so far established.

E. P. Stebbing

# COMMONWEALTH OBSERVATORY, CANBERRA

## REPORT FOR 1951

THE report of the Commonwealth Astronomer for the year 1951[*] covers the activity of the Commonwealth Observatory, Canberra, during the twelve months up to December 31, 1951. During this period sunspot sketches were obtained on 294 days, and solar radio-noise observations on a frequency of 200 Mc./s. were continued. Transit observations with the small reversible transit instrument gave 251 determinations of clock error obtained on 216 nights. Random errors from the sidereal pendulum clock have been eliminated by determining the error directly of one of the mean-time quartz-crystal clocks. Time services were originated four times each day, and some preliminary work has been carried out with the view of supplying a time service for South Australia.

Dr. G. E. Kron, of the Lick Observatory, assisted by Dr. S. C. B. Gascoigne, using the Reynolds 30-in. reflector, carried out a programme of red and infrared measurements, utilizing a refrigerated caesium oxide cell, and determined the magnitudes at effective wave-lengths 8250 A. and 6300 A. of stars in standard regions *D*2, *C*4, *C*6, *D*6, *C*8, *D*10, *C*12; of all nearer stars within about 12 parsecs (and this part of the programme included accurate photometric observations of Proxima Centauri); and of certain bright stars included in previous Mt. Stromlo programmes. In addition to this, they worked for eighteen nights on various objects in the Magellanic Cloud, using a refrigerated 1P21 multiplier. The magnitude limit was about 15·5, and all nine Cepheids examined were appreciably bluer than galactic Cepheids of similar period. Dr. O. J. Eggen, using an 1P21 multiplier on the Oddie telescope, measured colours and magnitudes of stars of known parallax brighter than photographic magnitude 11·0 and also of Cepheids brighter than magnitude 10·0. Objects of some interest were also observed, and *HD*223045 showed a light variation of 0·75 mag. with a period of only 80 min.

The contractors for the 74-in. reflector informed the director of the Commonwealth Observatory that the mounting was ready for dispatch from London, where it had been on exhibition during the Festival of Britain, and the mirror, which has been lightly polished, shows a good figure. Notable progress has been made with the building for the 50-in. (the old Melbourne 48-in.) reflector, and the mirror, by the firm of Cox, Hargreaves and Thomson, has arrived in Canberra. It is proposed that this instrument be initially set up in a Schmidt–Gregorian form prior to the completion of the Schmidt correcting plate and the construction of the plate-holder and tube for the Schmidt telescope. A 40-in. aluminizing tank is in use, and all the larger astronomical mirrors have been coated with aluminium.

The issue of regular monthly publications of the Ionospheric Prediction Service has been maintained. In addition to the analysis of data from Macquarie Island, some results have been obtained from the Townsville Station, which has been re-occupied. The new building for the Hobart Station has been completed, and power lines and aerials were in course of erection. Attempts are being made, in collaboration with the Overseas Telecommunications Commission, to re-introduce the system of storm warnings.

A supplement to the report for 1950[*], which marks the twenty-fifth anniversary of the commencement of the observational work of the Commonwealth Observatory, takes the form of a history of the Observatory to the end of 1950. Originally known as the Commonwealth Solar Observatory, which started on January 1, 1924, with the appointment of Dr. W. G. Duffield as first director, actual observations commenced at Canberra in the following year and at Mt. Stromlo in 1926. The history of the foundation extends back nearly twenty years from the latter date, and the details connected with this are very fully set out in the supplement in a review of about seven thousand words. At the end of this there are several illustrations and photographs, the former showing various details of the Observatory, and the latter giving general views of the Observatory, of the Reynolds 30-in. reflector arranged for photoelectric work, and of a corner of the machine shop. This supplement forms very interesting reading.

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[*] Commonwealth Observatory, Canberra. Report of the Commonwealth Astronomer for the Year 1951. Pp. 5. (Canberra: Commonwealth Government Printer, 1952.)

[*] Supplement to the Report of the Commonwealth Astronomer for the Year 1950. Pp. 11+7 plates. (Canberra: Commonwealth Government Printer, 1951.)

# FORMS OF INSECTICIDE-RESISTANCE IN HOUSEFLIES AND BODY LICE

By Dr. J. R. BUSVINE

London School of Hygiene and Tropical Medicine

## Investigations with Houseflies (*Musca domestica*)

In 1951, I described the distinctive characters of two laboratory strains of insecticide-resistant houseflies, originally obtained from Italy and Sardinia[1]. These have provided the material for some attempts to segregate, by selective breeding, different kinds of resistance which may occur in houseflies. Batches of flies in successive generations were exposed to various insecticides (by the methods described in 1951) and the lines maintained from survivors. The numbers exposed in each generation were about twenty-five unmated of each sex or forty to fifty fertilized females; and the aim was to adjust the dose to obtain a kill of 80–90 per cent. Owing to the rather small numbers available, failure to increase the resistance of a sub-colony may sometimes have been due to the chance absence of particular genes from the population sample chosen. Therefore, while a positive result was of interest, a negative one was of dubious significance.

The results of check tests, done at intervals of weeks, and sometimes months, showed that, in the absence of selection, the various strains and sub-colonies maintained their particular characteristics over many generations with little change.

The original strains were: an Italian colony (*I*), a Sardinian one (*S*) and a non-resistant colony (*N*). The lines selected from them were as follows:

(1) *Sub-colony* (*N* × *S*). Susceptible flies were crossed with those of the *S* strain and the progeny selected for resistance to γBHC. The surviving males were back-crossed with susceptible females and the progeny again selected for resistance to γBHC. This was repeated twice more with the following results. Selection with γBHC had maintained γBHC-resistance in the strain, together with some tolerance of chlordane and dieldrin; while the repeated back-crossing with susceptibles had lowered DDT-resistance practically to normal.

(2) *Sub-colony* (*Ch*). A line derived from the *I*-strain was selected for resistance to chlordane on six occasions over a period of eleven generations. There was an enormous rise in resistance to chlordane (× 500), to dieldrin (× 300) and to γBHC (× 60) with only a small increase in resistance to DDT (× 2·2).

(3) *Sub-colony* (*P*). An attempt was made to increase resistance to pyrethrins in a sub-colony of the *I*-strain. Batches were exposed to partially lethal concentrations on seven occasions over a period of twelve generations, with only a slight increase in resistance (× 1·3). Afterwards, flies of this sub-colony were twice selected for resistance to paralysis by DDT; this had the incidental effect of somewhat augmenting resistance to pyrethrins.

(4) *Sub-colony* (*SS*). Some flies derived from the *S* strain were selected for resistance to kill by DDT in two successive generations. This was in order to raise the average lethal dose to a level comparable with that of the *Ch* sub-colony.

(5) *Sub-colony* (*S.k-d*). My colleague, Dr. C. M. Harrison, kindly allowed me to use some flies of a sub-colony which she has been selecting for resistance to DDT-paralysis. This colony was derived from the *S* strain and selected over eleven successive generations by breeding from flies not readily knocked-down by DDT. The result of this selection (which will be reported more fully elsewhere) was highly successful.

*Investigation of selected strains.* After the selection procedures described, the various sub-colonies were maintained in isolation without further treatment. Their levels of resistance to a variety of insecticides were measured, and the results are set out in the accompanying table from which the following conclusions may be drawn:

(1) Resistance to BHC and chlordane in the housefly seems to be quite independent of DDT-tolerance; changes in resistance to the first two do not affect the level of the latter, and vice versa. On the other hand, the factors for resistance to BHC, chlordane and dieldrin are linked together, so that selection for one of them raises the resistance to the others. Possibly a single defence mechanism copes with a range of these chlorinated compounds.

(2) Resistance to the paralysis caused by DDT is not rigidly linked with resistance to its lethal effect. These factors are experimentally difficult to separate, because one cannot select for knock-down without killing some of the flies. However, it will be seen that strains *I* and *S* have about the same levels of resistance to the lethal action of DDT and so have strains *Ch* and *SS*; but the members of each pair differ considerably in resistance to paralysis.

(3) Something must now be said about the compound described as 'DANP' in the table, which is 1,1-dianisyl-neopentane. The preparation and properties of this compound have been described by Brown and Rogers[2], of the Merck Company, U.S.A., to whom I am indebted for supplying a sample. This compound is similar to DDT, but contains no chlorine; it has the *p*-chlorine atoms replaced by methoxy groups and the —CCl$_3$ group changed to —C(CH$_3$)$_3$. Therefore it cannot be degraded by dehydrochlorination to the non-insecticidal ethylenic body; which process appears to be one type of protective mechanism in DDT-resistant houseflies.

On inspection of the results in the table, it will be seen that resistance to paralysis by DDT is correlated with resistance to dianisyl-neopentane and to

Resistance characteristics of certain strains of houseflies ('DANP' is dianisyl-n entane; see text)

| Strain | Derived from | Med. leth. conc. (%) DDT | Knock-down by DDT (%) | | Medium lethal concentrations (%) | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | ½ hr. | 1 hr. | 'DANP' | Pyrethrin | γBHC | Dieldrin | Chlordane |
| *N* | Rome | 0·07 | 95 | 100 | 0·90 | 0·07 | 0·006 | 0·006 | 0·04 |
| *N.S* | *N* × *S* | 0·08 | 96 | 100 | 0·75 | 0·08 | 0·06 | 0·1 | 0·6 |
| *S* | Sardinia | 1·8 | 88 | 100 | 0·65 | 0·06 | 0·05 | 0·3 | 2·8 |
| *I* | Italy | 1·7 | 30 | 50 | — | 0·35 | 0·005 | 0·007 | 0·038 |
| *SS* | *S* | 3·7 | 66 | 93 | 1·1 | 0·10 | — | — | — |
| *Ch* | *I* | 3·8 | 50 | 50 | 6 | 0·22 | 0·3 | >1·8 | 20 |
| *P* | *I* | 5 | 17 | 20 | 7 | 0·6 | 0·006 | 0·004 | 0·05 |
| *S.k-d* | *S* | >5 | 0 | 0 | >10 | 0·8 | 0·03 | 0·22 | 1 |

pyrethrins. This is an extension of my 1951 observations that the paralysis-resistant strain *I*, which was also resistant to pyrethrins, was indifferent to the ease of dehydrochlorination of DDT analogues; thus contrasting with strain *S*. It seems clear that there is a DDT-resistance factor not concerned with dehydrochlorination, and it appears that this factor is associated with resistance to DDT-paralysis and kill by pyrethrins.

## DDT-resistant Body Lice

The report of DDT-resistance in Korean body lice[3] re-awakened our interest in alternative insecticides for control measures. Body lice are unpleasant to rear continuously, and we had allowed our culture at the London School of Hygiene and Tropical Medicine to lapse. Some difficulty was experienced in obtaining a new colony, until Dr. S. Madwar kindly sent some eggs by air from a strain kept at the laboratory of the Insect Control Section of the Ministry of Public Health, Cairo. This strain was maintained and expanded here and was used for testing new synthetic insecticides.

Results of comparative tests, however, suggested that these lice possessed undue resistance to DDT. Thus, spray tests indicated a median lethal concentration nine times as high as that obtained with the same technique in 1946[4] using susceptible British lice, whereas the dose for γ-benzene hexachloride was only 1·3 times as great. To confirm the earlier observations, another susceptible colony was started, from an infested man in London, and tested side by side with the Egyptian lice.

A range of new insecticides was then tested against the new DDT-resistant strain. Batches of the lice were exposed for a standard period (18-hr.) at 30° C. on filter papers impregnated with 3 mgm. per sq. cm. of oil solutions of different concentrations. From the resulting mortalities, median lethal concentrations were determined as follows: DDT $>$ 3 per cent (susceptible lice 0·6 per cent); γBHC 0·025 per cent; chlordane 0·12 per cent; dieldrin 0·018 per cent; aldrin 0·04 per cent; toxaphene 0·6 per cent; allethrin 0·74 per cent; pyrethrins 0·14 per cent.

From these figures, it appears that lice of this colony are normally susceptible to insecticides other than DDT. Tests with dianisyl-neopentane gave a median lethal concentration of 2·5 per cent for the susceptible colony, whereas none of the Egyptian colony was killed by 10 per cent. Therefore, the resistance cannot be accounted for by a dehydrochlorination mechanism.

*Origin of the resistant strain.* Insecticide-resistant strains of pests are usually 'developed' by widespread use of a particular insecticide, which kills off the susceptible individuals and allows the resistant ones to proliferate. A possible reason for the DDT-resistance of the strain from Cairo is that the Egyptian Ministry of Public Health had undertaken vigorous campaigns of DDT-dusting of villagers in all districts for four years (1946–50) before the colony was started in the Cairo laboratory. Afterwards the lice were reared for two years in the absence of insecticide before the sub-colony was sent to me.

It is not possible to compare with precision the DDT-resistance of these lice with those in Korea without a detailed knowledge of the technique used by the American workers. However, it appears that the Korean lice were more resistant, because they were stated to pass their complete life-cycle on cloth impregnated with 0·1 per cent DDT in acetone. Fifty first-stage nymphs of the Cairo strain were placed on tape impregnated with this solution, and most of them died within five days, all being dead within twelve days.

*Acknowledgements.* I am grateful to Dr. C. M. Harrison for allowing me to experiment with flies from one of her cultures; and also to Dr. A. A. Shwarby for helping me to obtain and rear the lice from Cairo.

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# PERMEABILITY OF INSECT CUTICLE TO AQUEOUS STAINS AND VULNERABILITY TO INSECTICIDES

By S. MUKERJI and S. N. CHATTERJEE

Indian Agricultural Research Institute, New Delhi

WIGGLESWORTH[1] showed that abrasion of the surface of the cuticle of an insect by inert dusts not only increases the permeability to water but also facilitates the entry of insecticides. Later[2], he showed, by the use of ammoniacal silver hydroxide, that the abrasion of the protective wax layer in beetles takes place chiefly at the points of articulation of the limbs but also, to some extent, at other points where the soft cuticle of the moving insect is rubbed against the dust or where the dusts get into the mobile joints. More recently, Slifer[3] used aqueous solutions of dyes (methylene blue, neutral red, fast green and crystal violet) to find out worn and abraded areas of the cuticle on the ventral walking surface of the legs, namely, the tarsus and pretarsus with their appendages. Slifer's studies in this direction indicated that the under-surface of the arolia of *Melanoplus differentialis* (Thomas) lacked the protective cement layer which elsewhere on the leg protects the waterproof waxy film present in the outermost layers of the cuticle. She thus concludes that, because of the absence of the cement layer, the wax on the ventral surface of the arolium is easily dissolved by wax solvents and the inner layers which remain then offer little resistance to the penetration of dyes and other substances. Slifer's observations thus lend support to the experimental results with insecticides made by Kennedy, Ainsworth and Toms[4]. By staining, with iodine, various parts of the body of *Locusta migratoria migratorioides* R. & F., Slifer[5] afterwards obtained results which indicated a similar absence of the cement layer from other cuticular areas besides the arolia. So far, nothing is known about work on similar lines on other insects.

Using the cuticle as a whole of insects of different orders collected from Nature as well as bred in the laboratory, and following Slifer's technique, the reaction of aqueous solutions of various dyes was observed with the view of locating the areas permeable to stain which would, at the same time, react positively to an aqueous solution or wettable powder of some well-known insecticides. Thus, the use of a carrier oil was altogether avoided, so as to ascertain the degree of permeability of the aqueous solution or

| Name and stage of insects tested | Vulnerable areas: Areas with stain reaction positive with 0·1% aqueous solution of crystal violet | Vulnerable areas: Areas with stain reaction positive treated with insecticides: Nicotine sulphate 0·3% solution: Mortality (%) | Time of action (hr.) | 'Gammexane' 2·0% colloidal susp. in water: Mortality (%) | Time of action (hr.) | Non-vulnerable areas: Areas with stain reaction negative or doubtful | Non-vulnerable areas: Areas with stain reaction negative treated with insecticide: Nicotine sulphate 0·3% solution: Mortality (%) | Time of action (hr.) | 'Gammexane' 2·0% colloidal susp. in water: Mortality (%) | Time of action (hr.) |
|---|---|---|---|---|---|---|---|---|---|---|
| *Athalia proxima* Klug<br>Larva (Hymenoptera Tenthredinidae) Collected from Nature | (a) Ventral cervical shield | 20·0 | 24 | 98·0 | 24 | (a) Thoracic tergum (prothorax) | nil | | 16·6 | 24 |
| | (b) Dorsum of last abdominal segment | 10·0 | 24 | 100·0 | 24 | | | | | |
| *Pyrilla perpusilla* Walker. Adult (Hemiptera: Fulgoridae) Collected from Nature | Ventral part of first tarsus of hind leg | 74·24 | 24 | 69·6 | 24 | (a) Mesothoracic tergum | 88·7 | 24 | 12·6 | 24 |
| | | Toxaphene 0·5% colloidal susp. in water | | | | | Toxaphene 0·5% colloidal susp. in water | | | |
| | | Mortality (%) | Time of action | | | | Mortality (%) | Time of action | | |
| *Schistocerca gregaria* Forskal (Orthoptera: Acrididae)<br>V stage nymphs (gregaria) bred in laboratory | (a) Membrane below metanotum | nil | | 90·0 | 24–76 | (a) Dorsum of metanotum | nil | | 16·6 | 24 |
| | (b) Above dorso-pleural line distal to spiracular openings (abdomen) | | | 100·0* | 20–48 | (b) Sternal inter-segments of abdomen | nil | | 16·6 | 24 |
| | (c) Tarsi and pretarsi | | | 100·0 | 22–48 | (c) Ventro-pleural line (membrane) | | | 10·1 | 24 |
| Adults bred in laboratory | (a) Above dorso-pleural line distal to spiracular openings (abdomen) | | | 100·0* | 24–96 | (a) Thoracic sternite | | | nil | |
| | (b) Tarsi and pretarsi | | | 100·0 | 24–48 | | | | | |

* The fluid was absorbed in this region rapidly

suspension, as the case may be, of the toxic materials in a localized zone and their subsequent transference to the vital epidermal cells. Although different stain reactions were obtained with various types of insects, only the results of those which were tested with insecticides have been incorporated in the accompanying table. Of the four stains used, crystal violet was found to be the most penetrating reagent as it is most fat-soluble; a 0·1 per cent aqueous solution of this stain was therefore used as final indicator. In the case of *Schistocerca gregaria* Forsk., both freshly emerged (moulted forms) or older nymphs and adults were used, and there was but little difference in the reaction to stain or insecticide in the same stage of the insects tested. Older adults were, however, found to be comparatively more resistant to BHC. The wettable powder was applied to the parts with a positive stain reaction with a very fine brush and allowed to dry on the spot.

The results so far obtained indicate that for each type of insect the vulnerable areas react differently to different types of toxic materials used, that is to say, they are selective for positive reactions for different insecticides. The reaction is therefore dependent on the various physical properties of the insecticides involved, as well as on the morphological and chemical character of the cuticular components. The results further establish the fact that besides the areas of natural abrasion, which one of us (S. M.) is tempted to name 'ecoabrasion', other selective vulnerable areas are also present on the insect cuticle through which the absorption of a fatal dosage of the toxic materials in aqueous media may occur. Preliminary experiments indicate that in the case of the tarsi (with appendages) of freshly moulted adults, kept under conditions where there was least chance of abrasion, a high percentage of mortality was noticed after the superficial application of wettable BHC, whereas no death was observed when the compound was applied to the pretarsi.

Further work on this subject is in progress.

We are indebted to Prof. V. B. Wigglesworth (Cambridge) and Dr. E. H. Slifer (Iowa), respectively, for valuable advice. [April 18.

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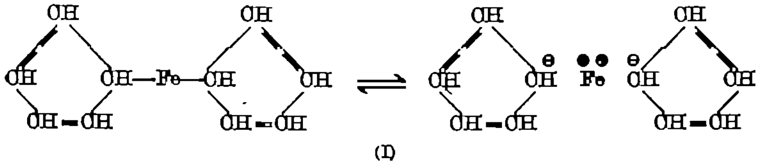
# LETTERS TO THE EDITORS

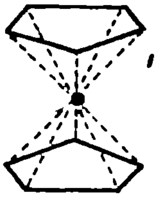
*The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications*

## *Bis*-cyclopentadienyl Iron: a Molecular Sandwich

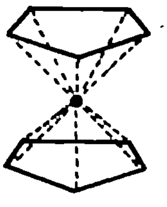
Kealy and Pauson[1] have described the preparation of *bis-cyclo*pentadienyl iron, $(C_5H_5)_2Fe$, which they formulated as (I). More recently, Wilkinson, Rosenblum, Whiting and Woodward[2] have observed that the compound is diamagnetic, that it has zero dipole moment, and that only one C—H stretching frequency occurs (at $3{\cdot}25\,\mu$) in the infra-red absorption spectrum; on the basis of these observations they have proposed the very unorthodox structures (II) or (III). In the present communication we wish to present X-ray evidence for the correctness of (II) and also to interpret this unusual structure in terms of electronic structural principles.



(I)



(II)



(III)

*Bis-cyclo*pentadienyl iron crystallizes from common organic solvents in a variety of forms, needles elongated along [110] and diamond-shaped plates bounded by {110} and {001} occurring the most frequently. The unit cell is monoclinic with cell dimensions, $a = 10{\cdot}50$ A., $b = 7{\cdot}63$ A., $c = 5{\cdot}95$ A., $\beta = 121°$, space-group $P2_1/a$ ($C^5_{2h}$), and contains two formula units of $C_{10}H_{10}Fe$. Each molecule must therefore possess a centre of symmetry occupied by the iron atom, which contributes either $+\,2f_{Fe}$ or zero to the structure factors according as $h + k$ is even or odd, so that the preliminary structure analysis may be carried out in a direct fashion.

The main features of the structure are apparent from the initial projections of the electron density on the (010) and (001) crystal planes. The function $\rho(xz)$ computed with all signs positive is shown in Fig. 1. Four of the five atoms in each *cyclo*pentadienyl unit are resolved, the fifth being obscured by the heavy iron peak at the origin. For $\rho(xy)$, all terms with $h + k = 2n$ have been taken as positive; of the other terms, only two, $F(210)$ and $F(120)$, are of any considerable magnitude and, since $F(110)$ is strong and necessarily positive, it follows from the relationship[3], $s(h) = s(h')s(h + h')$, that these two terms must have the same sign, which may be taken arbitrarily as either positive or negative. The function $\rho(xy)$ is shown in Fig. 2. The plane of the *cyclo*pentadienyl ring is almost normal to the projection plane and the individual atoms are not resolved; but the general shape of the molecule is fairly obvious.

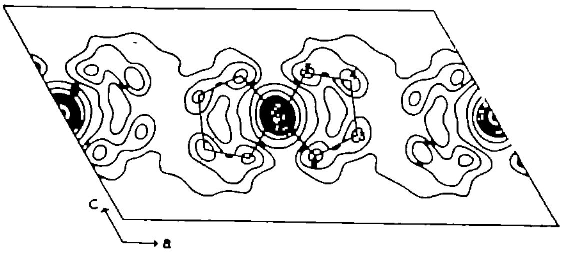


Fig. 1. Plot of function $\rho(xz)$. Contour lines are drawn at equal arbitrary intervals except for the iron atom, where the intervals have been increased by a factor of four for the sake of clarity

The two projections, considered together, leave no doubt that the 'sandwich' structure (II) proposed by Woodward *et al.* is correct. It is not yet possible to derive accurate details of the molecular dimensions and only a rough description can be provided at present. A molecular centre of symmetry is imposed by the space-group restrictions; but the appearance of the projections is reasonably consistent with a much higher molecular symmetry, $D_{5d}(\bar{5}m)$. Within rather wide limits of error, the C—C distance is about $1{\cdot}4$ A. and the C—Fe distance about $2{\cdot}0$ A.

A simple ten-bonded structure for $(C_5H_5)_2Fe$ is excluded, since only eighteen potentially bonding electrons are available and since, further, the set of iron orbitals of the correct symmetry cannot be formed using only *s*, *p* and *d* orbitals. A plausible formulation involving the resonance of a smaller number of bonds among the ten positions might be possible; but we have preferred to use molecular orbital theory.

The set of *d*-orbitals transforms in the group $D_{5d} = C_{5v} \times i$, according to the following scheme: $d_{z^2} \sim A_{1g}$, $d_{xz}, d_{yz} \sim E_{1g}$; $d_{x^2-y^2}, d_{xy} \sim E_{2g}$. The $\pi$-orbitals of the *cyclo*pentadienyl radical, according to simple molecular orbital theory, are $A_1$, $E_1$ and $E_2$ in order of decreasing stability. For two *cyclo*pentadienyl radicals oriented as in this molecule, each pair of orbitals can combine to give two orbitals transforming as even (gerade) or odd (ungerade) representations, for example, $2A_1 \rightarrow A_{1g} + A_{1u}$.

We assume that in the molecule the pair of *cyclo*pentadienyl radicals has the configuration

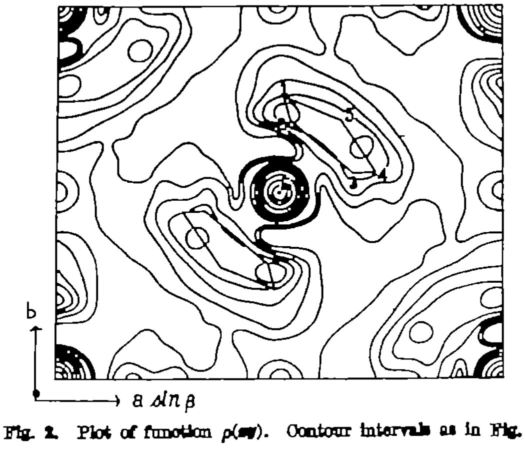


Fig. 2. Plot of function $\rho(xy)$. Contour intervals as in Fig. 1

$(A_{1g})^2(A_{1u})^2(E_{1g})^2(E_{1u})^4(E_{2g})^0(E_{2u})^0$ and the iron atom the configuration $(A_{1g})^2(E_{1g})^2(E_{2g})^4$. It will be seen that formally we may form two 'covalent-ionic' bonds using the $E_{1g}$ orbitals on the two parts of the molecule and also two 'donor' bonds in which the $E_{2g}$ electrons of the iron atom are able to spread into the empty $E_{2g}$ *cyclo*pentadienyl orbitals. (Although the σ-orbitals of the pair of *cyclo*pentadienyl radicals transform in the same way as the π-orbitals, they will not contribute to the bonding, since (1) the bonding orbitals are fully occupied and too strongly bound to lose electrons to the iron atom, and (2) the antibonding orbitals will be much less stable than the empty π-orbitals and hence will not behave as acceptors in the formation of 'donor' bonds.) The diamagnetism of the compound follows from the coupling of the four previously uncoupled $E_{1g}$ electrons.

The *cyclo*pentadienyl radicals will presumably acquire a negative charge as a net result of the two types of bond formation. The numerical value of the bond energy and the extent of the charge transferred cannot be calculated by methods at present available. We can, however, make some predictions as to the stability of *bis-cyclo*pentadienyl compounds of the other transition metals. Manganese and chromium, with sufficient donor and acceptor orbitals available, should form compounds of the same order of stability as that of iron. The cation $[(C_5H_5)_2Fe]^+$, which has been isolated as the tetrachlorogallate and picrate[2], is exactly analogous to the manganese compound. Nickel, with the configuration $(3d)^{10}$, has no orbital available for covalent bonding, while cobalt has only one orbital available. In both cases, therefore, we expect the compound to be much less stable than that of iron. Another possible stable compound, however, is the cation $[(C_5H_5)_2Co]^+$, in spite of the instability of the corresponding cobaltous complex.

Work is being continued with the view of obtaining a more precise description of this unusual molecule. We should like to thank Dr. H. M. E. Cardwell for preparing a sample of *bis-cyclo*pentadienyl iron for us.

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## Daily Variation of Meson Intensity and its Possible Solar Origin

THE variation of meson intensity with solar time has been studied at Ahmedabad (mag. lat. 13° N., altitude 50 m.) and at Kodaikanal (mag. lat. 1° N., altitude 2,343 m.) with vertical triple-coincidence Geiger counter telescopes of narrow aperture with 11 cm. of lead. Observations at Ahmedabad with two similar independent telescopes extend over a period of two years, while at Kodaikanal with four independent telescopes they extend over a period of five months. Elaborate precautions were taken to keep experimental conditions very constant, and the results of independent but simultaneously operated telescopes at each place were similar. The intensity at each place was determined from hourly photographs of the mechanical recorders. For the purpose of the solar daily variation, the bi-hourly values of intensity were considered.

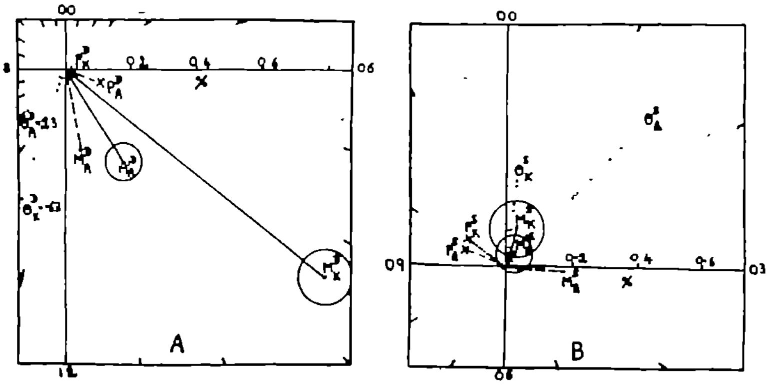
The solar daily variation of meson intensity is predominantly diurnal at Kodaikanal with an amplitude of 1·1 per cent. At Ahmedabad it has an amplitude of only 0·4 per cent with an important semidiurnal component as well. Figs. *A* and *B* show on 24-hr. and 12-hr. harmonic dials respectively the diurnal and semidiurnal harmonic components of the meson intensity $M_A$ and $M_K$, the atmospheric pressure $P_A$ and $P_K$ and the ground temperature $\theta_A$ and $\theta_K$ at Ahmedabad and Kodaikanal. The diurnal and semidiurnal components are indicated by the additional suffixes *D* and *S* respectively.

At low latitudes the periodic daily variations of *P* and θ are larger and more pronounced than the irregular day-to-day variations which are so marked at places in high latitudes. Also, at low latitudes the daily variation of atmospheric pressure is mainly semidiurnal and that of temperature is diurnal. As a result, the semidiurnal components $P_A{}^S$ and $P_K{}^S$ are predominant, whereas $\theta_A{}^S$ and $\theta_K{}^S$ are negligible. This fortunately provides a means of studying the effect of pressure on meson intensity independently of other meteorological factors. At Ahmedabad, $M_A{}^S$ and $P_A{}^S$ have a very high correlation of − 0·96, the pressure coefficient being − 1·7 per cent per cm. mercury, in agreement with the mass absorption coefficient for mesons observed by other workers from day-to-day variations of intensity. At Kodaikanal, on the other hand, this correlation is only + 0·29. As, however, $M_K{}^S$ itself is only 0·12 per cent in amplitude and is not significant, this positive value might be fortuitous. The absence of the usual mass absorption coefficient indicates that during the atmospheric oscillations at Kodaikanal opposing factors act on *M*, and mask this absorption effect. These could be changes in heights of levels of meson formation or perhaps a density effect near these levels. An interesting feature of the present results is that, even near the equator for a high-level station, there is no marked semidiurnal variation of meson intensity positively correlated with pressure.

The atmospheric pressure plays an important part in the solar daily variation of mesons at the low-level station at Ahmedabad, but produces a negligible effect at Kodaikanal. The correlations of $M_K$ with $\theta_K$ and of the pressure-corrected meson variation $M'_A$ with $\theta_A$ are negligible. Ground temperature has therefore negligible effect at both places.

The curve of the residual meson variation corrected for pressure at Ahmedabad and the meson variation curve at Kodaikanal are both significant and strikingly similar. Both are diurnal with amplitude $M'_A = 0{\cdot}33 \pm 0{\cdot}06$ per cent and $M_K = 1{\cdot}1 \pm 0{\cdot}08$ per cent with maxima at 0950 and 0840 hr. local time respectively. It is unlikely that these variations are caused by a positive temperature effect such as is found by Duperier from day-to-day variations of mesons. Apart from the maxima being much earlier than the time at which a maximum of temperature in the upper atmosphere would be expected to occur, the amplitude of the diurnal temperature variation at the 200-mb. level is, on existing meteorological evidence, totally insufficient to account for a variation of meson intensity of 1·1 per cent as found at Kodaikanal. Variations of geomagnetic field are also not capable of explaining this variation.

There are thus grounds for believing that the observed diurnal variation of *M* is caused by an anisotropy of the primaries and is therefore extra-terrestrial in origin. The greatly reduced amplitude as well as a shift of maximum towards later hours at Ahmedabad when compared with Kodaikanal appears to be connected with the change of altitude between the stations. This is also seen in the ionization chamber results obtained at Huancayo as compared to the lower-level stations operated by the Carnegie Institution[1]. The amplitude of variation observed with our narrow-aperture Geiger counter-telescopes is larger than the omnidirectional ionization chamber results, as is to be expected. The increase of the percentage amplitude with elevation suggests the contribution of a larger number of low-energy particles which can make their effect felt at a high-level station but not at a sea-level station.



Amplitudes and hours of maxima in local time of harmonic components of meson intensity, atmospheric pressure and ground temperature variations. (*A*) 24-hr. harmonic dial; (*B*) 12-hr. harmonic dial

Since the variation is believed to be extra-terrestrial in origin, and the hour of maximum occurs at about the same local time during daylight hours throughout the year, a solar origin of this variation is suspected. The possibility of a part of the cosmic radiation originating from the sun, as deduced here from the nature of the residual diurnal variation of mesons, is supported by the occasional large increases in cosmic-ray intensity associated with solar flares, by recent observations associating variations of cosmic-ray neutrons with solar prominences, and by the large diurnal variation of the star intensity in the upper atmosphere reported by Lord and Schein[2]. Riddiford and Butler[3] have recently described processes by which particles from the sun can be accelerated to cosmic-ray energies. A close study of the occurrence of the hour of maximum under different conditions of observation of cosmic-ray intensity would throw a great deal of additional light on this subject. We hope to present shortly more data concerning this.

We are indebted to the Atomic Energy Commission of India for supporting this project. We are grateful to Prof. K. R. Ramanathan for many valuable discussions, particularly concerning the meteorological aspects of the problem.

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## Improved α-Track Autoradiographs of Biological Specimens

THE use of Eastman Kodak nuclear track plates, type *NTA*, in the autoradiographic study of tissue containing thorotrast has been described previously[1]. Autoradiographs of this type are made as a matter of routine by floating a paraffined tissue section on to a photographic plate. However, during the floating and subsequent contact with wet emulsion, some of the radioactive material is leached out. Moreover, the large opaque clumps of thorium deposits in the tissue make counting of α-tracks in the underlying emulsion difficult.

The difficulties can be surmounted when liquid emulsion is poured over the section. This technique has been applied by Leblond and co-workers[2] and further improved by Bélanger[3], who described the 'inverted autograph' in which the tissue–emulsion complex is inverted and stained after processing. The 'inverted autograph' is of great advantage in the work with transparent sections, but observation of an autograph through tissue containing opaque substance is unsatisfactory. An attempt was therefore made to repeat the inversion process prior to final mounting for microscopic inspection.

The Ilford *G 5* emulsion which is available in the gel form was applied. The conditions adopted were as follows: the emulsion was liquefied at 42° C. and poured over the deparaffined section on a prepared glass slide at approximately 40° C. The emulsion was dried by means of an air stream and stored in a 5-cm. lead shield inside the refrigerator. The *G 5* emulsion was processed with an amidol developer and required an acetic acid stop-bath prior to fixing. When fixation was almost concluded, hardener was added. Inversion was done after washing, and the tissue–emulsion complex was allowed to dry on the new slide before staining. Since staining involves re-swelling and subsequent drying, an effort must be made to keep the emulsion from wrinkling. It was found advantageous to cut off excess emulsion at a distance of a few millimetres from the edge of the tissue section immediately before re-inversion. The difficulties in obtaining a plane tissue–emulsion complex which will adhere smoothly to a glass slide after re-inversion were minimized when the thickness of the processed emulsion was well below 100 microns. Since the maximum range in emulsion of the α-particles from thorium and its decay products is about 45 microns, the emulsion layer need not be thicker than that range.

The re-inverted autoradiographs give a clear picture of the distribution of the α-emitter in the tissue. Counting and topographic co-ordination of tracks with their points of origin in the tissue is extremely easy, even where large clumps of deposits are present in the tissue. Leaching of the radioactive material during the histological fixation of the tissue cannot be avoided completely; but, with proper precautions, contamination by dissolved and redistributed radioactive material becomes negligible. Therefore, in this case, the method of freeze-drying offers little advantage.

The diffusion of thoron out of the section and into the emulsion during exposure manifests itself more strikingly in the poured *G 5* emulsion than in the *NTA* plate. The emulsion over the tissue contains a multitude of thoron stars and, due to the favourable geometrical conditions, the probability for all four-prongs of the thoron stars being visible is very high. Also, the associated β-particles show in the *G 5* emulsion as tracks. Storage of the plates in a lead shield reduces the accumulation of electron background tracks considerably (about a factor of 50 after a 10-day exposure).

Experiments are in progress in which the same technique is being applied to tissue containing beta emitters.

This investigation was supported by the James Picker Foundation on the recommendation of the Committee on Radiology, National Research Council.

*Note added in proof :* Since this communication was submitted, a letter by Prof. L. F. Bélanger upon the subject and dated July 15 has been published in *Nature* of October 11, p. 625.

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## Abnormalities in the Ionosphere at High Latitudes

THE object of this communication is to direct attention to some interesting features of the incidence of the abnormal ionization in the *E*- and *D*-regions of the ionosphere at high latitudes during periods of magnetic disturbance[1,2].

For convenience, we select for study types of storm disturbance which are easily identified in the tables of data circulated by ionospheric observatories: (*a*) Storm *E*, the dense form of abnormal *E* which is totally reflecting on frequencies high compared with the *E* critical frequency (for example, present above 6 Mc./s. or preventing observation of the *F2* critical frequency); (*b*) storm *D*, the intense *D*-region ionization which attenuates high-frequency waves so that they cannot be received at vertical incidence on any frequency.

The variations of the frequency of occurrence of these phenomena with time and position are readily evaluated and are found to have very interesting properties. The polar region may be divided into three zones, in each of which the incidence of the phenomena varies in a fairly regular manner. The most important zone may be called the 'storm belt'. In this the disturbances are particularly frequent and intense and show very regular and coherent variations with longitude. This zone overlaps, but is probably not identical with, the zone of maximum auroral activity. The number and intensity of the *E*- and *D*-region disturbances decrease rapidly with distance outside the storm belt but are otherwise similar to those found in the nearest sections of the belt. In the 'polar zone', the diurnal variations of both phenomena are radically different from those found elsewhere, but are modified locally by the activity in the storm belt. It is interesting to note that the characteristics of the fluctuations in the *F2*-region are also anomalous in this zone.

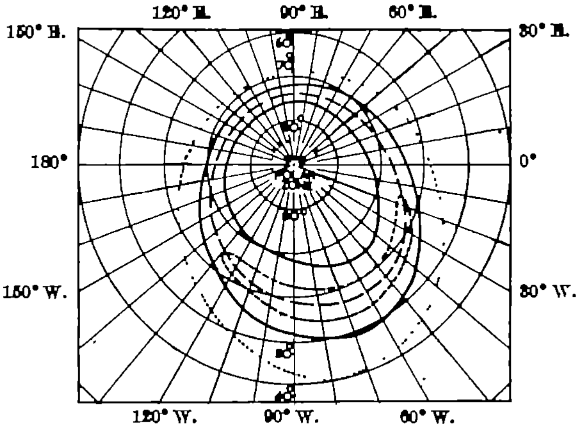

Fig. 1. Approximate position of main arctic zones: ———, boundaries of storm belt; - - - -, boundaries of abnormally intensely disturbed part of storm belt; — —, approximate position of maximum activity; ......, outer boundary of polar quiet zone

The diurnal variation of the storm *E* at all stations in the storm belt is very large. Thus, for example, over Canada about 80 per cent of the occurrences are found between 2000 and 0200 L.M.T., and less than 5 per cent between 0800 and 1600 L.M.T. The local time at which the diurnal maximum probability of occurrence is found is almost independent of longitude, changing from about 2100 L.M.T. in Sweden to 2300 L.M.T. in Canada. Thus the ionization behaves, approximately, as if it were generated in the classical manner by a stream of charged particles entering the ionosphere at a fairly constant angle relative to the direction of the sun. The diurnal maximum probability of occurrence of storm *E*, however, varies very greatly with longitude, reaching a large maximum near and over Canada. This change is particularly great for the most dense forms of storm *E* ionization which are practically confined to a sub-zone centred near Canada (Fig. 1).

The storm *D* ionization in the storm belt has quite different characteristics. The diurnal variation is less than that for storm *E* owing to the presence of occasional periods during which the ionization is present continuously for more than 24 hr. If these periods are omitted, the diurnal range becomes comparable to that found for the storm *E*, and most of the disturbances occur within ± 3 hr. of the maximum.

The time of maximum rate of occurrence near the centre of the storm belt varies in a most remarkable manner with longitude. The form of this varia-

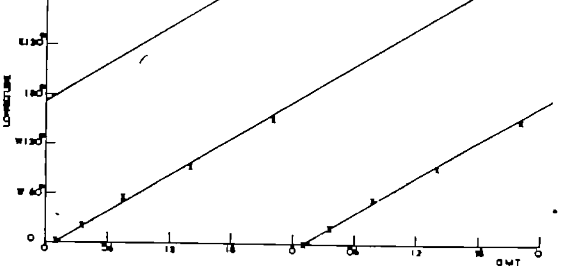

Fig. 2. Positions of storm *D*-zone maximum activity with time

tion may be clarified by plotting the longitudes at which it is found at different universal times (Fig. 2). As may be seen, the observed points, which are based on three years results in most cases, lie on a pair of straight lines separated by 180° (or 24 hr.), each of which repeats every 48 hr. Thus we can demonstrate the existence, at any instant, of two centres of activity on the *D*-region spaced 180° apart which rotate once around the earth every 48 hr. In contrast to the storm *E*, the probability of occurrence of storm *D* near the centre of the storm belt is almost constant throughout the western hemisphere between Sweden and Alaska.

The less intense forms of storm *D* perturbation, which do not completely attenuate all signals, have more complicated variations which combine the characteristics of the storm *E* and storm *D* perturbations discussed above.

An examination of individual disturbances shows that there is a close connexion between the areas affected by active *D* centres, *F*2-region perturbations and abnormally intense local magnetic activity.

The work described above was carried out as part of the programme of the Radio Research Board, and this note is published by permission of the Director of Radio Research of the Department of Scientific and Industrial Research.

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## Insulin and the Permeability of Cell Membranes to Glucose

THE effect of insulin in accelerating the peripheral utilization of glucose is generally ascribed to an action on the enzymic carrier system responsible for the intracellular oxidation of glucose, in which the first step is the hexokinase reaction.

More recently, evidence has accumulated suggesting that the locus of action of insulin may be, not on intracellular enzymes, but upon the transport mechanism whereby glucose is transferred across the cell membrane from the extracellular to the intracellular fluids. Such evidence is to be found in the work of Levine and his colleagues[1] on the effect of insulin on the distribution of galactose between the blood and the tissues, and in the effect of insulin in accelerating the rate of transfer of glucose across the blood-aqueous barrier[2].

This concept is further strengthened by studies on the uptake of glucose and other sugars by the isolated rabbit lens. Pairs of lenses immediately on removal from the eyes of anaesthetized rabbits were decapsulated and quickly weighed. They were then placed in tubes containing 3 ml. of Krebs–Henseleit–Ringer phosphate solution, *p*H 7·4, at 37° C. A sample of aqueous humour from one of these eyes had previously been removed by paracentesis and its glucose concentration estimated. Glucose was added to the medium so that its glucose concentration was identical with that of this aqueous humour. One unit of soluble insulin was added to one of the tubes, and both were incubated at 37° C. for 3 hr.; samples were removed from both tubes after 10, 60 and 180 min.

The mean uptake of glucose by the normal lens was 0·202 mgm./gm. lens substance/hr.; in the presence of insulin the uptake was 0·71 mgm./gm./hr. Insulin had thus accelerated the rate of uptake by 350 per cent. When homogenates of lens tissue were used, the rate of uptake of glucose was accelerated by only 33 per cent. When galactose was added to the medium and one hour allowed for equilibration, there was no uptake of galactose by the normal lens; but in the presence of insulin the uptake was 0·11 mgm./gm./hr. When sucrose was similarly employed, there was no uptake either in the presence or absence of insulin.

Insulin greatly accelerates the rate of glucose assimilation by the intact lens, but does so to a much less extent in homogenates in which the cell membranes have been broken down. Although the normal lens did not utilize galactose, nevertheless galactose is transferred into the cell in the presence of insulin; it is of interest to note that such lenses became opaque much more quickly than did lenses in the absence of galactose, suggesting that galactose blocks the glucose utilization mechanism. There is no specialized system for the transport of sucrose across the cell membrane, and hence insulin cannot promote the uptake of sucrose.

This work affords added support for the concept that an important action of insulin is to increase the permeability of cell membranes to biologically important sugars by accelerating an enzymic transport mechanism, and that in its absence such substances must enter the cell by solution in the cell membrane or by passage through 'pores'. The low lipoid solubility and high molecular weight of the sugars mean that their rate of entry by these routes would be slow, so that the organism, in the course of evolution, has developed these specific accelerator mechanisms to facilitate the entry of an adequate amount of glucose into the cell. The hyperglycaemia of diabetes mellitus is the result of the inability of glucose to enter the cells, rather than of a failure of intracellular enzymic oxidations. The intracellular oxidations essential for the life of the cell are maintained in diabetes mellitus largely by the utilization of 2-carbon-atom fragments obtained from the breakdown of fats, which are able to enter the cell because of their high lipoid solubility.

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## Histochemical Detection with Ditetrazolium Chloride of some Enzymatic Activities in Isolated Mitochondria

IN an earlier paper[1], I have reported that ditetrazolium chloride, a substance introduced by Seligman and Ruthenburg[2] for the histochemical detection of succinoxidase in tissue sections, can also be used for the detection of the same enzyme in mitochondria isolated from kidney and liver. This has been recently confirmed by Schiebler[3] on the granula isolated from the neurohypophysis by differential sedimentation.

OXIDATION OF SOME SUBSTRATES BY RAT LIVER AND KIDNEY MITOCHONDRIA AS SHOWN BY THE REACTION OF DITETRAZOLIUM CHLORIDE (—, negative reaction; +−, very weak positive reaction; +, weak positive reaction; ++, positive reaction; +++, strong positive reaction; ++++, very strong positive reaction)

| Substrate added | Liver |  |  |  |  |  | Kidney |  |  |  |  |  |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  | Reading after |  |  |  |  |  | Reading after |  |  |  |  |  |
|  | 30 min. | 1 hr. | 2 hr. | 6 hr. | 12 hr. | 24 hr. | 30 min. | 1 hr. | 2 hr. | 6 hr. | 12 hr. | 24 hr. |
| Sodium lactate | ++ | +++ | ++++ | ++++ | ++++ | ++++ | ++ | +++ | ++++ | ++++ | ++++ | ++++ |
| Sodium *dl*-malate | +− | + | ++ | ++ | ++ | +++ | +− | ++ | ++ | ++ | ++ | +++ |
| Sodium α-glycerophosphate | +− | + | + | ++ | ++ | +++ | + | ++ | +++ | +++ | +++ | +++ |
| *dl*-Alanine | +− | +− | + | + | + | ++ | + | ++ | ++ | ++ | +++ | +++ |
| *l*(+)-Alanine | − | − | − | − | − | − | − | − | − | − | − | − |
| Sodium glutamate | − | − | − | − | − | − | − | − | − | − | − | − |
| Tyramine | − | +− | +− | + | + | + | − | +− | +− | + | + | + |
| Hypoxanthine | − | − | − | − | − | − | − | − | +− | + | + | ++ |
| Sodium butyrate | − | − | − | − | − | − | − | − | − | − | − | − |
| Ethanol | − | − | − | − | − | +− | − | − | − | − | − | − |
| Glucose | − | − | − | − | − | − | − | − | − | − | − | − |

Since ditetrazolium chloride is an indicator for oxidation-reduction processes, an investigation was begun to determine if this substance could also be used for the histochemical detection of other enzymatic activities in isolated mitochondria.

Mitochondria were isolated from rat liver and kidney by Schneider's method. A small amount of the mitochondrial sediment was stratified on the interior surface of small tubes, and a mixture containing one part of ditetrazolium chloride (1 mgm. per ml. of distilled water), one part of physiological saline, one part of 0·01 *M* phosphate buffer solution (*p*H 7·4) and one part of the substrate solution was added until the final volume of 1 ml. was obtained. Control was made by omitting either the substrate or the colour solution. The tubes were then kept in a thermostat at 38° C. Readings were made after 30 min., 1 hr., 2 hr., 6 hr., 12 hr. and 24 hr.; when a blue colour was given, it indicated a positive reaction.

The following substrates were used, at the concentration indicated: sodium lactate 1 *M*, sodium α-glycerophosphate 0·2 *M*, sodium *dl*-malate 0·2 *M*, *dl*-alanine 0·2 *M*, *l*(+)-alanine 0·2 *M*, *dl*-glutamate 0·2 *M*, tyramine hydrochloride 0·25 *M*, sodium butyrate 0·2 *M*, glucose 0·2 *M*, ethanol 1 mgm., hypoxanthine 1 mgm. The results obtained are shown in the table. It was observed that the ditetrazolium chloride permits the histochemical detection in isolated mitochondria of lactodehydrogenase, of α-glycerophosphate dehydrogenase and of malic oxidase, which gave very strong positive reactions.

The reaction was also positive for *d*-amino-acid oxidase, oxidation of *dl*-alanine being more intense in kidney than in liver mitochondria. Very weak reactions were obtained for tyraminoxidase in both liver and kidney and for xanthinoxidase only in kidney mitochondria. The reaction was negative for alcoholdehydrogenase, glucosedehydrogenase, *l*-amino-acid oxidase and for the oxidases of glutamic and butyric acids.

The results obtained by this histochemical method agree with those previously obtained by manometric techniques on the localization in mitochondria of lactic dehydrogenase[5], α-glycerophosphate dehydrogenase[6], malic dehydrogenase[7] and *d*-amino-acid oxidase[8,9].

The negative reaction given by other enzymes, such as *l*-amino-acid oxidase and alcoholdehydrogenase, which were found to be present in mitochondria by other techniques, can be attributed to the low intensity of these enzymatic activities.

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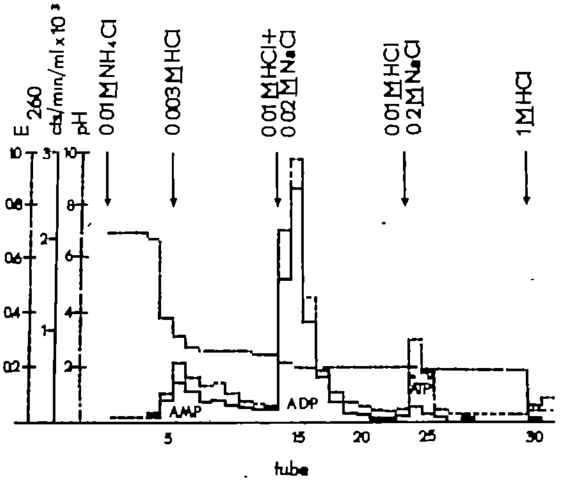
## Formation of Adenine Nucleotides from Adenine by Pigeon Liver Homogenates

ALTHOUGH the mechanism of the formation of inosinic acid from hypoxanthine[1] or glycine and formic acid[2], and the phosphorylation of adenosine to form 5-adenylic acid[3,4], have been studied in cell-free systems, the participation of adenine in nucleotide synthesis has received little attention. During an investigation of the pathway of incorporation of radioactive adenine into ribonucleic acid by *in vitro* systems in this laboratory, it was found that homogenates of pigeon liver were very active in the formation of acid-soluble adenine nucleotides within a short time.

In a typical experiment, 2·5 µ*M* of adenine-8-$^{14}$C hydrochloride[5] (containing 3·4 × $10^5$ counts/min. corresponding to 2·2 µC. carbon-14) were incubated at 37° for 20 min. with 15 ml. of a pigeon liver homogenate containing 2 gm. of tissue in the following medium: 0·13 *M* potassium chloride, 0·015 *M* potassium dihydrogen phosphate, 0·0046 *M* sodium bicarbonate, 0·0001 *M* sodium fluoride, 0·002 *M* magnesium sulphate brought to *p*H 7·1 with ammonia. The barium salts of the nucleotides were precipitated from the acid-soluble fraction at *p*H 8·2 in 80 per cent alcohol by the method of LePage[6]. A diluted solution of the regenerated barium-free nucleotides was brought to *p*H 5·6 and passed through a 'Dowex-1-chloride' column (3·5 cm. × 0·8 cm.$^2$). The effluent contained an, as yet, unidentified substance which seems not to be identical with adenine, adenosine, 5-adenylic acid, adenosine di- or tri-phosphate. Further work is



Ion-exchange separation of adenine nucleotides from acid-soluble fraction after 20 min. incubation of pigeon liver homogenate with adenine-8-$^{14}C$

being done to determine the composition of this material, since in some experiments it contains a fairly large proportion of the original radiocarbon.

The column was then eluted according to the method of Cohn[7], as shown in the accompanying diagram, and 10-ml. fractions were collected. The pH extinctions at 260 mμ and carbon-14 were determined for each fraction and the results are summarized in the diagram.

It can be seen that the relatively small amount of adenine incubated with the tissue was mainly converted to the adenosine-5′-phosphoric acids. The identity of the adenosine monophosphate was confirmed by the differential enzymatic spectrophotometric method of Kalckar[8] with 5-adenylic acid deaminase prepared from rabbit muscle. All the absorption at 260 mμ was due to material which could be deaminated by the enzyme. The fractions marked ADP and ATP (adenosine di- and tri-phosphate) were similarly analysed by using a preparation of potato apyrase along with the 5-adenylic acid deaminase. While the adenosine diphosphate fraction reacted quantitatively with the enzymes, the content of adenosine triphosphate determined enzymatically was about one-half that indicated by the 260-mμ absorption. This may account for the lower relative count observed. It can be calculated that the activities of the adenosine mono- and di-phosphate correspond to a fourfold dilution of the original adenine.

The proportions and activities of adenosine mono-, di- and tri-phosphate vary considerably from one experiment to another, but the total counts found in the three nucleotides were usually 40–70 per cent of the initial carbon-14 added.

In another experiment the material which was not precipitable by barium and alcohol was analysed by paper chromatography; it was found to consist solely of labelled hypoxanthine with a specific activity corresponding to a sixfold dilution of the original adenine. A study of the formation of hypoxanthine as a function of time indicated that it is probably not derived directly from adenine, as has been suggested[9] for rabbit marrow slices.

The possibility that adenosine is the intermediate between adenine and adenosine monophosphate is now being investigated, as is the isolation of the enzymes responsible for the formation of 5-adenylic acid.

I wish to thank Dr. H. M. Kalckar for supplying me with the labelled adenine, and to acknowledge his stimulating criticisms and guidance. This work was performed under a fellowship of the American Cancer Society, Inc., recommended by the Committee on Growth, U.S. National Research Council.

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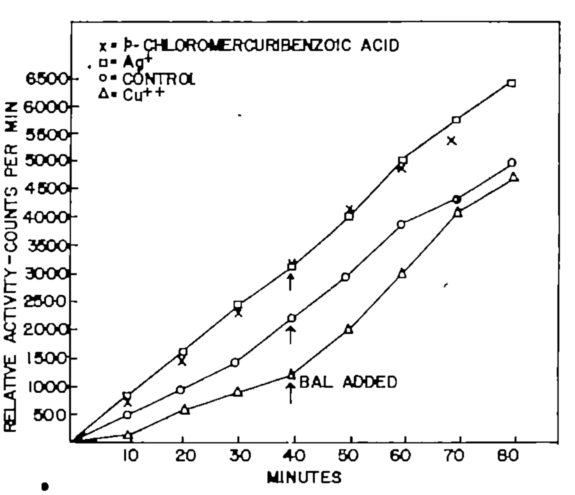
## Effect of Sulphydryl Reactants on Liver Ribonuclease

WHILE investigating the characteristics of rat liver ribonuclease it was noted that several reagents which react with sulphydryl groups increased the activity of this enzyme in homogenates. $4 \times 10^{-4}$ *M* silver or lead ions increased the activity approximately 25 per cent, while saturation of the test system with *p*-chloromercuribenzoic acid or phenyl mercuric chloride caused a similar increase. Cupric ion of $4 \times 10^{-4}$ *M* concentration was, however, inhibitory to the extent of 50 per cent. The inhibitory action of cupric ions could be reversed by the addition of 2,3-dimercaptopropanol (BAL); but this compound had no effect on systems containing the other sulphydryl reacting agents, or on the enzyme alone. The accompanying graph shows the results of a typical experiment.

The method of Roth and Milstein[1] was employed for the assay, and the control contained 10·0 ml. of veronal-acetate buffer of *p*H 7·75 and 0·17 *M* with respect to sodium ion; 2·0 ml. of 1 : 50 rat liver



Effect of sulphydryl-reacting agents on the activity of rat liver ribonuclease homogenate and 3·0 ml. of distilled water. 1·0 ml. of 0·01 *M* lead chloride, silver nitrate or cupric chloride was substituted for 1·0 ml. of distilled water in separate flasks, while 10·0 mgm. of *p*-chloromercuribenzoic acid or phenyl mercuric chloride was added to other flasks containing the same components as the control. At zero time, 10·0 ml. of 1 per cent labelled yeast ribonucleic acid was added to each of the flasks, and after 40 min. 50 mgm. of 2,3-dimercaptopropanol was added to each. At 10-min. intervals, 3·0-ml. samples were withdrawn from the mixtures and to them was added 3·0 ml. of 1·0 *M* hydrochloric acid in 76 per cent ethanol. Blanks in which 2·0 ml. of water were substituted for the liver homogenate were run for each of the test systems. After addition of the acid-alcohol, the solutions were filtered and the radioactivity determined on an aliquot of the clear filtrate. The radioactivity of the blank filtrates was subtracted from the respective experimental filtrates to give the values shown in the graph. In general, the sulphydryl reactants had negligible effect on the substrate, although methyl glyoxal caused an increase in the acid solubility of the ribonucleic acid. This increase in acid solubility did not occur below *p*H 6, however.

Although other explanations are possible from the results obtained, it appeared likely that a sulphydryl-containing substance in liver homogenates was acting as a ribonuclease inhibitor, and that sulphydryl reactants could counteract this inhibition, at least in part. The anomalous action of cupric ions may be due to direct combination of this ion with the enzyme or substrate in preference to the inhibitor. As further evidence for the presence of a ribonuclease inhibitor in liver homogenates, it has been found that the sum of the activities of separate liver and kidney homogenates is greater than the activity of the same homogenates when mixed. Recently, Pirotte and Desreux have described an inhibitor for ribonuclease in guinea pig liver[4].

The presence of an inhibitor in liver which is absent from kidney might explain the considerably smaller ribonuclease activity of liver. The liver inhibitor may be heparin or a heparin–lipoprotein complex[5] which has been shown to contain cysteine, and it has been demonstrated that heparin is a potent inhibitor of ribonucleases[6]. Further work is in progress to determine the nature of these phenomena and their relation to cell division and growth.

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## Sudden-Death Disease of the Clove Tree, *Eugenia aromatica*

THE clove crop of the Zanzibar Protectorate, on which the economy of the islands is largely based, and which provides nine-tenths of the world's supplies, is seriously threatened by the sudden-death disease. In 1950, it was estimated that at least half of the clove trees in Zanzibar Island had already been killed by this disease, and that in the island of Pemba there were more than two thousand separate outbreaks[1]. The disease has made rapid progress since that date.

An organization for research into clove diseases was set up by the Colonial Office in 1947. Preliminary field studies showed that sudden-death was almost certainly caused by a pathogen, and a virus was considered the most probable[2]. For three years, however, every known technique for revealing the presence of a virus was used with consistently negative results.

This led us, late in 1950, seriously to re-examine the possibility of a fungal cause, a hypothesis which had been considered unlikely, as it was generally believed that this had been disproved by previous workers. We then found that sudden-death is invariably associated with a hitherto undescribed species of *Valsa*. The absorbing roots die at a comparatively early stage of the disease, and the fungus can then be isolated from the distal parts of the root system. It can be found at the collar a week or more after death and afterwards spreads rapidly throughout the tree, producing an intense yellow colour in the invaded tissues. Extensive surveys have shown no instance of sudden-death where this *Valsa* was absent, and we have never found it in trees which have been killed by other agencies, such as fire, drought or severe dieback. Furthermore, we have failed to find any other fungus consistently associated with the disease.

Experiments have shown that *Valsa* can readily invade the tissues of mature clove trees, that young trees are comparatively resistant, and that seedlings are immune. Field experiments in which massive spore suspensions have been applied over a period of some months to uninjured roots of mature trees have demonstrated that the absorbing roots are attacked by the fungus, which later invades the fibrous root system, advancing in the cambial region, whence it spreads to other tissues.

Young clove saplings, between the ages of about eight and eighteen years, frequently suffer from a progressive decline over some years, accompanied by a root rot; this occurs in plantings in areas previously devastated by sudden-death and in which the old stumps are almost invariably left standing. We have found *Valsa* associated with this root rot, and consider the disease to be the symptom-expression of attack on young trees which are not yet fully susceptible to this fungus, and thus to be a form of the sudden-death disease.

It is not known how new outbreaks of sudden-death arise in previously disease-free areas, of which only a few still remain. We think it significant that in trees in these areas, as in the infected parts of the islands, *Valsa* can often be found acting as a wound parasite and causing a branch dieback.

Details of this work will be reported elsewhere.

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## A Freshwater Eel on Zanzibar Island

Playfair and Gunther's "Fishes of Zanzibar", 1866, bears a somewhat misleading title, for some of the species included come from places other than Zanzibar, some quite distant.

"Zanzibar" to-day means Zanzibar Island itself, whereas in earlier times the dominion and name extended over a wide area, including the coastal regions of East Africa. In consequence, creatures unknown from the Island itself have been recorded as occurring in "Zanzibar". One such is the freshwater eel, *Muræna mossambica* Peters, 1844.

Owing partly to the porous nature of the Island, there are few and restricted bodies of fresh water on Zanzibar, and there is only one run of water which merits naming as a river, and that disappears before it reaches the sea. The wide fluctuations in ocean-level during the Pleistocene would, in periods, have reduced the present Zanzibar Island to at most a group of islets, with almost certain extinction of most of the purely freshwater fauna of the more extensive lower drowned levels. During the recessions of the glacial periods some of this may have been restored; but there is no evidence that the larger rivers of the adjacent mainland flowed near Zanzibar. It is therefore not surprising that there is only a severely restricted freshwater ichthyfauna on the Island, only three or four species having been found there. In passing, it may be indicated that some of the recent wide fluctuations in ocean-level may well provide a clue to the explanation of at least some of the puzzling features in the land fauna of Mafia, Zanzibar and Pemba.

In current ichthyological literature, the freshwater eel is listed as occurring in Zanzibar. No less than three species, namely, *mossambica* Peters, 1844, *bengalensis* Gray, 1830, and *australis* Richards, 1841, are stated to be present in Zanzibar by Boulenger ("Freshwater Fishes of Africa", 3; 1915). These are apparently based on specimens recorded in Playfair and Gunther's "Fishes of Zanzibar" of 1866. A record of *mauritiana* Bennett, 1831, from Zanzibar by Weber and de Beaufort ("Fishes of the Indo-Australian Archipelago", 3, 247; 1916) is presumably based on the record of *A. johannæ* in Playfair and Gunther's "Fishes of Zanzibar".

Investigation reveals that none of the records is from Zanzibar Island itself, and so far as may be ascertained there is no authentic record of any species of freshwater eel having been found there. If the marine origin of the eels of this region be accepted, as they are found in the Ruvu and Pangani Rivers of the adjacent mainland, but for the accident that only comparative trickles of fresh water reach the sea from Zanzibar Island, it is surprising that no eels have ever been found there.

During a recent visit to investigate the fish life of the Zanzibar area, I inquired into the matter of the freshwater fishes, which have been investigated by several people during the past hundred years; but no further discoveries have been made in that period. Towards the close of my stay I learned that a large 'water snake' had been seen in a disused reservoir in which the lower "Chem-Chem" spring is completely enclosed; this structure is an unfortunate experiment by an engineer of earlier times, it is said, for he had failed to determine in advance the hydrostatic level of the source of the water. At my request the authorities kindly agreed to assist, and by means of a portable pump the water in this enclosed and roofed structure was reduced to a level where it kept pace with the restored flow through the porous coral rock. No life was visible in the considerable body of water remaining; but by means of an irritant chemical and nets, we soon captured the 'water snake', which proved to be a 30-in. well-nourished specimen of *Muræna mossambica* Peters, 1844, apparently the first to be known from Zanzibar Island.

This spring lies less than half a mile from the sea; but how the fish got into it is a mystery, as no water has ever flowed out of it, and the manholes in the roof of the enclosing structure have iron covers, supposed to have been kept closed for many years. It is just possible that a minute elver might have come through the eye of the spring, but not very likely in view of the absence of flow. The aliments in this specimen have not yet been examined, but its food can have consisted of little else than insects, and most likely of the smallest only.

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## Encapsulation in Rumen Bacterial Fractions

METHODS of fractionating the rumen contents of sheep previously described in the literature (see, for example, footnote 1) involve centrifugation of uncooled, strained, rumen liquids at varying speeds on centrifuges running at room temperature. These procedures were found by us to be unsatisfactory for two reasons. First, during the time between collection and centrifugation of the liquids, the composition of the sample might alter as a result of bacterial fermentation and autolysis; and secondly, during the centrifugation, especially at high speeds, the liquids warm up to as much as 40° C., thus setting up convection currents in the centrifugate and causing fermentation with the liberation of gases which break up the sediments. We have found that these difficulties are overcome by the following procedure, which allows of fractionation on a small scale.

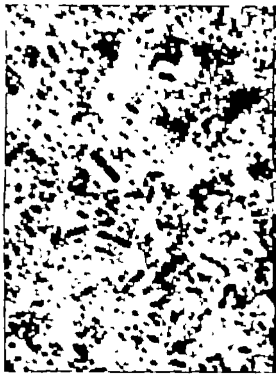
Rumen contents were collected through a permanent rumen fistula[2] by means of a wide-bore glass tube fitted with a rubber suction bulb, and immediately pipetted into a conical flask cooled in a freezing mixture of ice and salt, which reduced the temperature of the rumen contents to *c.* + 1° C. in 10–15 min. Further operations were then carried out in a cold room at + 1° C. The rumen contents were strained through a 60-gauge copper gauze to remove plant particles. (It is well to note that, if the fractions are required for cultural studies, the copper gauze should be replaced by bolting silk, as small traces of copper have a bactericidal effect.) The resulting liquid was centrifuged for 20 min. at 22,500 *g* in a 'Superspeed' head on a refrigerated centrifuge (M. S. E., London), conditions being adjusted so that the rumen liquid remained at + 1° to + 3° during centrifugation. If the temperature was further lowered, ice began to separate from the liquid.

Two sheep were used in the experiments. One was fed mixed concentrates (250 gm.) and potato starch (100 gm.), twice daily, with one feed of hay (250 gm.) in between, and the other was fed on hay (*ad lib.*). The rumen contents were sampled three hours after the morning feed. The samples from the starch-fed sheep were thick and formed four distinct

| Fraction No. | Appearance | Constituents |
|---|---|---|
| 1 | Brown opalescent liquid | Almost bacteria-free; few Gram-positive cocci and Gram-negative bacilli |
| 2 | White semi-solid layer | Almost entirely Gram-negative bacilli, cocci and vibrios; few Gram-positive cocci and bacilli |
| 3 | Fine green compact sediment | Protozoa, selenomonas and bacteria, as in fraction 2, plant particles and starch granules |
| 4 | Coarse material | Mostly plant particles, with some bacteria and protozoa |

fractions on centrifuging. These are described in the accompanying table.

Fractions 1 and 2 from the rumen liquids of the hay-fed sheep were similar to those from the starch-fed animal, but fractions 3 and 4 formed a single layer. The sediments were easily separated by repeated washing with a small volume of phosphate buffer (0·1 *M*; *p*H 7·0). A photomicrograph of a typical bacterial fraction (2) from the rumen liquids of a starch-fed sheep is shown in Fig. 1.



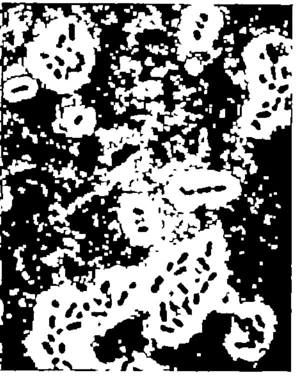


Fig. 1. Bacterial fraction 2 from a sheep on a starch-containing diet. Stained by Gram's method. × 1,500

Fig. 2. Bacterial fraction 2 from a sheep on a starch-containing diet. Wet indian ink preparation, more dilute than Fig. 1, showing extensive encapsulation. Phase contrast. × 1,650

Examination of fraction 2 by Duguid's indian ink technique[3] showed that large numbers of the bacteria were heavily encapsulated, a fact which has not been noted in fractions prepared by the usual methods. The largest capsules, up to 9 µ in transverse diameter, were found on the bacteria from the hay-fed sheep. In the fraction from the starch-fed sheep large clumps of agglutinated bacteria surrounded by capsular material were seen. Moir and Masson[4] have recently described a survey of whole rumen contents, either fresh or incubated *in vitro* for one hour with glucose, in which they noted some encapsulated organisms. The present work suggests that encapsulated organisms constitute a large part of the bacterial fractions. This capsular material appears, from preliminary experiments on a strain of rumen streptococcus isolated in pure culture[5], to contain polysaccharide which, like the majority of the bacterial capsular materials so far investigated, does not stain with iodine. However, whether this capsular material can be utilized by the host animal at a later stage in the digestion cycle, as can starch-type intracellular polysaccharides[6], or can be converted by other bacteria into products of value to the host cannot yet be stated.

We wish to thank Dr. A. E. Oxford for interest shown in this work and for placing the hay-fed sheep at our disposal.

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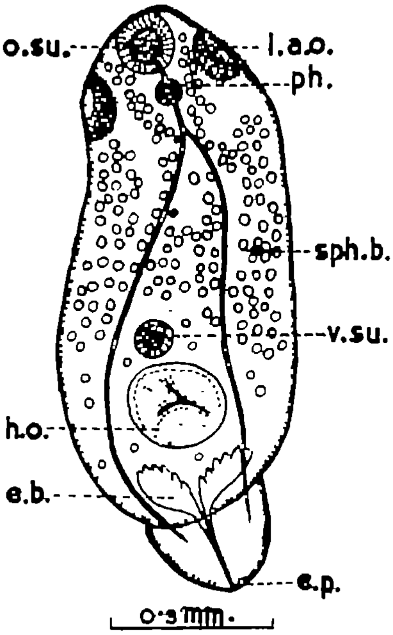
## A New Trematode Metacercaria from the Eyes of Trout

Several workers[1-4] have reported the occurrence of eye metacercariæ from various British freshwater fishes, and all have regarded their specimens as *Diplostomum volvens*. This, as described originally by Nordmann (1832) and reported later by various workers, has an oral sucker much smaller than the ventral, and its lateral adhesive organs are never in the form of cup-shaped structures. Moreover, its ventral sucker is also shown to be pre-equatorial in position. During an investigation on the trematodes of the brown trout, *Salmo trutta* L., at Edinburgh, I obtained, mostly from the vitreous humour of the eye, a metacercaria in which the oral sucker was much larger than the ventral, the lateral adhesive organs formed cup-shaped sucker-like structures and the ventral sucker was post-equatorial in position. It is, therefore, distinct from *Diplostomum volvens*. Furthermore, the present metacercaria on comparison comes nearer to some of the American and Australian species of *Diplostomulum* but differs from all these in several important features. It is, therefore, regarded as a new species and designated *Diplostomulum truttæ* n.sp. (*Diplostomulum* being the name given to eye metacercaria of which the adult has not yet been identified).

Its abbreviated specific description is as follows. The fore-body is large and the hind-body very small; at the lateral sides of the anterior end are deep cup-shaped sucker-like structures which can be protruded as ear-like lateral adhesive organs (*l.a.o.*). In a specimen of about 1·1 mm. length, the oral sucker (*o.su.*) measures 0·11 mm. in diameter and the ventral sucker (*v.su.*), which is post-equatorial and much smaller than the oral, measures 0·075 mm. in diameter. A short prepharynx leads into a globular pharynx (*ph.*), followed by a short œsophagus and two intestinal cæca extending into the hindbody. A well-developed holdfast organ (*h.o.*) lies posterior to the ventral sucker. Minute papillæ cover the body cuticle and a large number of spheroidal bodies (*sph.b.*) occur internally, especially concentrated in the middle third of the forebody. A well-developed bilobed excretory bladder (*e.b.*) opens postero-dorsally at the excretory pore (*e.p.*). In some living examples a number of longitudinal and transverse excretory vessels with about twenty-four flame cells could be made out.



*Diplostomulum truttae* n.sp., showing body structures

This metacercaria is widely distributed in Scotland. It is with great pleasure that I thank Prof. James Ritchie for providing me with facilities to carry out this investigation in the University of Edinburgh.

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## Growth and Axon Formation in the Midbrain of the Chicken Embryo

IN the development of anterior horn cells, Hydén[1] recognizes three successive phases. The first is one of intensive growth without axon formation. In the second, growth is diminished, but axon formation occurs. In the third phase, growth is again intensive and associated with continued axon formation. The resulting peripheral axon can, in the adult, be regenerated by a 'revival' of this stage.

It is thus of interest to inquire whether equivalent phases occur in the development of nerve cells the axons of which remain within the central nervous system and which cannot regenerate. In the chicken embryo, such cells are found in the dorsal region of the midbrain vesicle which contributes to the corpora bigemina, and observations have been made on this region.

As in other parts of the central nervous system, axon formation cannot be demonstrated in the cells of the ependymal layer; but, in the earlier stages of development, these cells grow and divide rapidly and correspond to the first phase. However, when cells pass from the ependymal to the mantle layer, axon formation occurs. The developing axons accumulate in the more peripheral marginal layer, the width of which is, for a time, an indication of the amount of axon material formed by the mantle cells immediately underlying any particular region. Although this relationship becomes modified by the ingrowth and outgrowth of axons, the modification is not important before the eighth day of incubation. Hoadley[2] transplanted the three-day midbrain on to the chorio-allantoic membrane and, five days later, found that, although smaller than the controls, the transplanted midbrains had a normal architecture, achieved in the absence of ingrowing or outgrowing axons.

Since cell division does not occur in mantle cells, these would conform to the second phase if, while a significant amount of axon formation took place, there was little or no increase in cell size. The average volume of the cells was determined by counting the nuclei in measured areas of histological sections of known thickness. It was found that the volume of the mantle cells did not vary by more than ± 10 per cent in the period 3–8 days of incubation, although measurements of the diameters of the midbrain indicated an increase in its volume of more than a hundred times. In the same period the non-nucleated axon-containing layers increased from 2 to 40 per cent of the total width of the midbrain wall. Hence, in the period 3–8 days of incubation, mantle cells form axon material equivalent to about 40 per cent of their bulk without increasing in size, and thus conform to the second phase described in the development of anterior horn cells.

During the 3–8 day period, growth of the midbrain as a whole must be due to growth and division of cells in the ependymal layer. However, dividing cells disappear from this layer after the eighth day of incubation, so that subsequent growth of the midbrain can be assumed to require increase in size of individual cells. Further, these cells must continue to form axon material in order to make and maintain connexions with other parts of the central nervous system—a combination of growth and axon formation similar to that described above in the third developmental phase. Thus, the three phases occurring in the development of the anterior horn cells have their equivalent in the development of the cells of the midbrain, which, in contrast to the anterior horn cells, produce axons that do not leave the central nervous system and which are incapable of regeneration.

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June 30.

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## Neurosecretory Pathways in the Prawn, *Leander serratus*

LAST year, I reported the presence of neurosecretory cells within the tritocerebral commissure of *Penaeus brasiliensis*, and the distribution of fuchsinophil droplets along the course of two post-commissure nerves[1]. Two flat extensions of these nerves, adjoining blood sinuses and therefore described as sinus-plates, were full of these droplets. Injection experiments showed that those regions with the most droplets yielded the most potent extracts when these were tested by their effects on the white chromatophores. The sinus-plates resemble the sinus-glands of the Mysidacea[2], and this parallel has been made

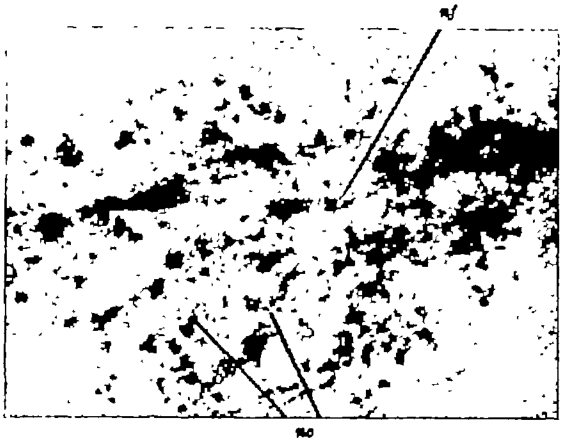

Fig. 1. The wide proximal portion of a post-commissure nerve

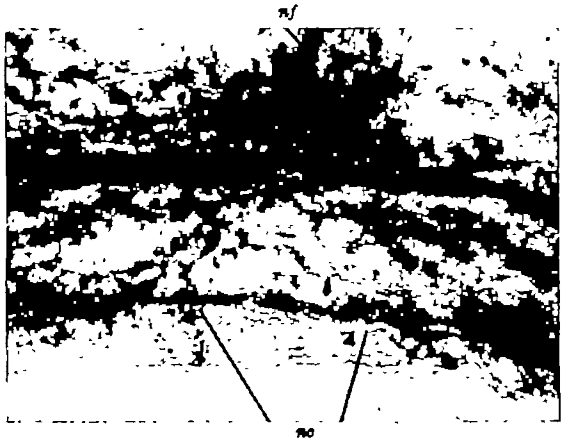

Fig. 2. The commissure at the base of a post-commissure nerve. *nf*, Position of nerve fibres in centre of post-commissure nerve; *nc*, lines of droplets marking the position of possible neurosecretory channels

more striking by the recent evidence of Enami[3], Passano[4] and others that the sinus-glands of some decapods are supplied by neurosecretory cells in the medulla terminalis; the secretory products pass along nerves and are released via secretory canals in the sinus-glands[2]. In the present experiments a search was made for secretory canals in the tritocerebral commissure and the post-commissure nerves of the prawn, *Leander serratus*. The nervous system was stained by a modification of the methylene blue method used by Alexandrowicz[5]; specimens were immersed in a solution of methylene blue for nine hours in a refrigerator.

Each post-commissure nerve of *Leander serratus* is broad and flat for the first half of its length. Nerve fibres lie along its centre and the remainder is filled by droplets which stain with methylene blue. These droplets are not dispersed at random but lie in lines, apparently along branched channels which radiate from the central fibres (Fig. 1). There is insufficient evidence at present to show whether these 'channels' are, in fact, axon fibres, though they seem to lie more superficially than the fibres, apparently within the tissue of the epineurium. Similar channels, marked by the position of droplets, radiate from the bases of the post-commissure nerves for some distance over the upper and the lower surfaces of the commissure (Fig. 2). Two slightly deeper channels extend from the bases of the post-commissure nerves to two large cells which lie in a median position within the hinder margin of the commissure.

One cannot ignore the possibility that the droplets which stain so readily with methylene blue are, in fact, artefacts, but I am inclined to consider them as secretory droplets for the following reasons: (1) they correspond in position to fuchsinophil droplets observed in serial sections of the commissure region of *Leander affinis*; (2) they are very numerous in the post-commissure nerves and in the commissure near by, but are sparse or absent in the rest of the commissure and in the connectives, and there is some degree of correlation between the concentration of droplets and the potency of extracts obtained from the different areas. The injection of extracts of the post-commissure nerves and of the adjacent region of the commissure was followed by a prolonged concentration of the white chromatophores and a brief concentration of the red chromatophores in normal and eyeless animals. Extracts of the nearby connectives, on the other hand, promoted only a slight and a brief concentration of the red and the white chromatophores.

Serial sections of the commissure have revealed evidence of secretory activity in the two large cells within the hinder margin of the commissure. It seems probable that a chromatophorotropin is produced by these cells, conveyed to the bases of the post-commissure nerves, and thence distributed, stored, possibly elaborated and released along channels in the epineurium of the commissure and that of the post-commissure nerves, the latter being especially important. This interpretation of the post-commissure nerves as reservoirs and distributors of material produced by secretory cells within the nervous system agrees with current concepts of the X-organ–sinus-gland relationship in crustaceans[1], the pars intercerebralis–corpora cardiaca system in insects[6], and the hypothalamo–hypophyseal system in vertebrates[7].

The work was done at the Stazione Zoologica, Naples, Italy.

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## A Growth-Inhibitor for Streptomycin-resistant Mutants in Dense Suspensions of *Brucella abortus* (Strain 19)

It was observed that when bacterial suspensions in broth were exposed to streptomycin in a concentration of 100 μgm. per ml. the survivors multiplied slowly after a prolonged lag phase[1]. It was also observed that, when bacterial suspensions containing 320–1,600 millions of *Brucellae* per 10 ml. were exposed to streptomycin, then the resistant mutants appeared in them more frequently than in those containing 1,600–8,000 millions of *Brucellae* in the same volume[1].

In order to determine whether the lower rate of appearance of resistant mutants in bacterial suspensions of high density exposed to streptomycin was due to an inhibiting action of the dead bacteria on the survivors, the following experiment was carried out.

2-ml. portions of suspension of *B. abortus* (Strain 19) containing 6 × $10^9$ micro-organisms and streptomycin were distributed into seven series of test-tubes and Erlenmeyer flasks containing varying quantities of trypticase-soy-broth with streptomycin (100 μgm. per ml.). The varying quantities of broth were 0, 2, 4, 6, 10, 18 and 38 ml.; the densities of the bacterial suspension varied, therefore, and were 3 × $10^9$, 1·5 × $10^9$, 1 × $10^9$, 7·5 × $10^8$, 5 × $10^8$, 3 × $10^8$ and 1·5 × $10^8$, while the bacterial population was the same in each sample (6 × $10^9$). Ten replicas were prepared from every sample of bacterial density. By plating and incubating the bacterial suspension with streptomycin-agar, it was determined that seven resistant mutants were present in 2 ml. among 6 × $10^9$ micro-organisms, or one resistant mutant in a bacterial population of 8·6 × $10^8$. After 11, 14, 20 and 27 days, 0·05-ml. samples were removed from each test-tube and inoculated on to agar plates in order to determine whether resistant mutants had survived and multiplied. The frequency of their appearance from samples of different bacterial density is given in Table 1.

Table 1

| Bacterial density per ml. | Appearance of resistant mutants after an incubation of: 11 days | 14 days. | 20 days | 27 days |
|---|---|---|---|---|
| 3·0 × $10^9$ | 0/10 | 2/10 | 2/10 | 8/10 |
| 1·5 × $10^9$ | 4/10 | 4/10 | 4/10 | 8/10 |
| 1·0 × $10^9$ | 8/10 | 8/10 | 10/10 | 10/10 |
| 7·5 × $10^8$ | 10/10 | 10/10 | 10/10 | 10/10 |
| 5·0 × $10^8$ | 10/10 | 10/10 | 10/10 | 10/10 |
| 3·0 × $10^8$ | 10/10 | 10/10 | 10/10 | 10/10 |
| 1·5 × $10^8$ | 10/10 | 10/10 | 10/10 | 10/10 |

Filtrates of recently prepared bacterial suspensions in streptomycin broth containing 3 × $10^9$ *Brucellae* per ml. did not delay the appearance of resistant mutants. But when these suspensions were kept four months at room temperature, filtered through Seitz filters, diluted and inoculated with 1·5 × $10^9$ *Brucellae* per ml., the delay observed in the appearance of resistant mutants in replicas of five culture-tubes is shown in Table 2.

Table 2

| Concentration of the filtrate | | Appearance of resistant mutants after an incubation of: 6 days | 10 days | 15 days |
|---|---|---|---|---|
| Undiluted | | 0/5 | 2/5 | 2/5 |
| Diluted | 1 . 2 | 1/5 | 1/5 | 1/5 |
| | 1 : 5 | 2/5 | 3/5 | 3/5 |
| | 1 . 10 | 2/5 | 2/5 | 2/5 |
| | 1 : 20 | 3/5 | 4/5 | 4/5 |
| | 1 . 50 | 3/5 | 4/5 | 4/5 |
| | 1 : 100 | 3/5 | 4/5 | 5/5 |
| Control | | 4/5 | 5/5 | 5/5 |

This experiment shows that the inhibiting factor was liberated by autolysis from the bacteria which were killed by the action of streptomycin.

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## Additional Photoperiodic Response in Sheep

HITHERTO most work on the photoperiodic behaviour of mammals has been related to their reproductive cycles[1,2]. Hammond, jun.[3], working with mink, was able to demonstrate an effect on the onset of moulting (correlated with new and more rapid growth of hair), when the animals were responding to photoperiodic stimulation by coming into œstrus.

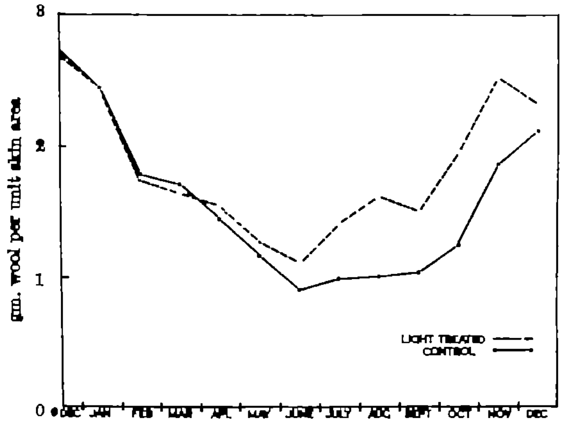
The general opinion among workers that the initial stimulus is received in the eye region and thence proceeds to activate the pituitary body in a gonadotrophic manner remains unaltered, although the exact sequence of events is not yet defined. In an attempt to elucidate further this exteroceptive stimulation of the pituitary body by light–dark sequence, experiments designed to test the nature of the response in sheep were commenced in January 1951. One important aspect of the question is, whether the stimulation is specifically a gonadotrophic one, or whether other hormones known to be elaborated by the pituitary are also involved.

Fourteen mature Corriedale ewes were randomized into two groups, and housed in individual pens in two adjacent rooms. The control group received solar light-rhythm by means of glass skylights in the roof and walls. The experimental group was housed in a blacked-out room and subjected to an artificial light-rhythm consisting of 8 hr. light–16 hr. darkness.

Exactly the same daily ration of concentrates and chaffed lucerne hay was allowed both groups during the experiment. Mean temperatures in the two rooms were approximately the same. All the ewes were mated, and at lambing in September were made to suckle twins if this did not occur naturally.

Monthly clippings from similar tattooed areas of skin were taken from both groups throughout the period. The accompanying graph shows the mean weight of clean scoured wool produced per month from these areas in the two groups.

In addition to wool growth, a study is being made of the photoperiodic effect on (*a*) the lactation curve of the ewes, (*b*) the composition of the milk, and (*c*) the growth-rate of the lambs. It is not possible at this stage to deal with all these aspects of the investigation, which is still in progress, but there is obviously a significant increase in wool-growth amounting to more than 15 per cent throughout the twelve months.



Mean weight of scoured wool

It is suggested that this may be due to the increased activity of the pituitary bodies of the light-treated animals, resulting in an increased output of either growth hormone or thyrotrophic hormone.

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## Transfer of Labelled Nitrogen from Glutamic Acid to Pine Seedlings through the Mycelium of *Boletus variegatus* (Sw.) Fr.

IN a previous paper from this Institute[1] it was shown, by using the isotope technique, that hyphæ of *Boletus variegatus* (Sw.) Fr. in mycorrhizal connexion with pine seedlings transfer nitrogen from a solution of an ammonium salt to the roots. The labelled nitrogen was added as ammonium nitrate containing the stable isotope nitrogen-15 in the ammonium group. By a special arrangement, only the mycelium was exposed to the isotope, and then the amounts of nitrogen-15 were measured in different parts of the seedlings.

We have now studied in the same way the transfer of labelled nitrogen from an organic source to pine seedlings by means of mycorrhizal mycelium.

The nitrogen source chosen was glutamic acid. It has been recently demonstrated in this Institute[2] that the growth-rate of many mycorrhizal fungi is increased by certain amino-acids in a nutrient solution containing also ammonium-nitrogen. The growth-rate of *Boletus variegatus* is much increased, particularly by glutamic acid, under these experimental conditions. As a sole source of nitrogen, however, glutamic acid—in contrast to aspartic acid—yielded only a very poor mycelial growth. This seems to indicate that glutamic acid was not deaminated in any high degree by the fungus mycelium. Therefore, labelled glutamic acid seemed suitable for use as a tracer compound.

The experimental method used was as previously described[3]. In wide-necked 500-ml. Erlenmeyer flasks were placed cups near the wall. Both vessels were supplied with purified sand to which was added a nutrient solution containing ammonium phosphate as source of nitrogen. Into each of the Erlenmeyer flasks one aseptic seedling of *Pinus sylvestris* was introduced, and after some time mycelium of *Boletus variegatus* was inoculated in the cups. The cultures were grown during the spring and summer of 1951.

Glutamic acid labelled with nitrogen-15 was kindly synthesized by Dr. S. Wideqvist, Chemical Institute, University of Uppsala. It contained 6·3 atomic per cent of nitrogen-15.

When mycorrhizæ had become well developed, the labelled amino-acid was added to the glass cups in amounts of 50 mgm., that is, about 4·5 mgm. nitrogen. To the sand outside the cups were supplied corresponding quantities of unlabelled acid, to prevent, if possible, diffusion from the hyphæ. Half the cultures were harvested after one and a half days, the others after three days, of exposure.

The seedlings were divided into two sections, namely, (1) stem and needles, (2) the roots. The sections were then treated as previously described[4].

The measurements of nitrogen-15 were made by Dr. G. Ryhage, at the Institute of Chemistry, Stockholm. The mass spectrometer used was of the Nier type and gave a maximal error of 0·002 atomic per cent nitrogen-15 excess when the quantity of total nitrogen was 10 μgm.

In the accompanying table are given the values of the dry weights of the different sections, their total nitrogen content and the atomic per cent nitrogen-15 excess. It is clearly shown that nitrogen has been transported through the *Boletus* mycelium to the pine roots. From the mycorrhizal roots the isotope has further been translocated to the different parts of the seedlings. It may be difficult to prove that the nitrogen really has been delivered to the host tissues as glutamic acid. It may have been transaminated, at least in part, to other amino-acids already in the hyphal cells, and also have entered directly into the metabolic pathways leading to the synthesis of protein.

ATOMIC PER CENT NITROGEN-15 EXCESS IN PINE SEEDLINGS GROWN IN MYCORRHIZAL CONNEXION WITH *Boletus variegatus* EXPOSED TO LABELLED GLUTAMIC ACID

| Plant No. | Portion of seedling | Dry weight (mgm.) | Total nitrogen (mgm.) | Atomic per cent nitrogen-15 excess |
|---|---|---|---|---|
| | | 1½ days of exposure with the isotope | | |
| I | Stem | 97 | 2·98 | 0·010 |
| | Root | 39 | 1·16 | 0·034 |
| II | Stem | 103 | 3·11 | 0·010 |
| | Root | 49 | 1·43 | 0·036 |
| | | 3 days of exposure with the isotope | | |
| III | Stem | 109 | 3·30 | 0·013 |
| | Root | 52 | 1·62 | 0·069 |
| IV | Stem | 99 | 3·02 | 0·012 |
| | Root | 44 | 1·31 | 0·052 |

The experimental evidence leads to the assumption that nitrogen may be transferred to the root tissues through the *Boletus* mycelium from other amino-acids as well as glutamic acid. It may also be assumed that other mycorrhizal fungi of trees have the same ability as the fungus used in this experiment.

This investigation has been supported by a grant from Fonden for Skoglig Forskning, Stockholm.

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## Effect of Boron and Molybdenum Fertilizers on Berseem (*Trifolium alexandrinum*)

THE cultivation of berseem, a leguminous forage crop, is gaining in importance in India on account of its high yields of succulent fodder of excellent nutritive value. Phosphatic fertilization of this legume has been found to be very beneficial[1].

Brenchley and Thornton[2], Midgley[3], Naftel[4] and others have shown that boron is essential for proper

IN ANY VERTICAL COLUMN STRIP READING DOWNWARDS, THE FIRST FIGURE STANDS FOR TOTAL FODDER YIELDS OF ALL THE CUTTINGS IN MAUNDS PER ACRE, THE SECOND FOR SEED YIELD IN LB. PER ACRE, AND THE THIRD FOR *Bhusa* (DRY HAULMS OF SEED CROP) YIELD IN MAUNDS PER ACRE (1 MAUND = 82·3 LB.)

| Treatment | Superphos. | | Rock phos. | | Ammophos. | | Ammon sulph. | | Control | | Average | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 49–50 | 50–51 | 49–50 | 50–51 | 49–50 | 50–51 | 49–50 | 50–51 | 49–50 | 50–51 | 49–50 | 50–51 |
| Boron | 668<br>176<br>37 | 1,016<br>204<br>49 | 680<br>148<br>34 | 937<br>232<br>48 | 893<br>203<br>40 | 1,091<br>297<br>50 | 787<br>171<br>46 | 938<br>210<br>42 | 635<br>180<br>38 | 899<br>141<br>35 | 773<br>175<br>39 | 976<br>229<br>45 |
| Molybdenum | 669<br>169<br>37 | 1,048<br>241<br>60 | 737<br>163<br>35 | 1,013<br>228<br>50 | 902<br>242<br>39 | 1,118<br>263<br>62 | 770<br>153<br>34 | 962<br>193<br>42 | 660<br>167<br>42 | 915<br>127<br>34 | 748<br>179<br>37 | 1,011<br>210<br>50 |
| Boron + molybdenum | 639<br>145<br>35 | 945<br>214<br>45 | 691<br>128<br>33 | 914<br>207<br>43 | 881<br>172<br>37 | 1,030<br>215<br>44 | 754<br>163<br>40 | 878<br>167<br>37 | 638<br>165<br>33 | 853<br>117<br>29 | 721<br>155<br>36 | 924<br>184<br>40 |
| Control | 571<br>124<br>29 | 908<br>192<br>41 | 676<br>118<br>25 | 848<br>166<br>41 | 854<br>161<br>36 | 1,007<br>176<br>41 | 758<br>171<br>32 | 857<br>136<br>32 | 606<br>124<br>33 | 834<br>100<br>30 | 693<br>140<br>31 | 891<br>154<br>37 |
| Average | 637<br>154<br>35 | 979<br>228<br>49 | 696<br>138<br>32 | 928<br>208<br>46 | 883<br>195<br>38 | 1,062<br>238<br>49 | 767<br>165<br>38 | 909<br>176<br>38 | 635<br>159<br>37 | 873<br>121<br>32 | 724<br>162<br>36 | 951<br>194<br>43 |

| | Fodder yield in maunds/acre | | | | Seed yield in lb./acre | | | | *Bhusa* yield in maunds/acre | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Major element | | Micronutrient | | Major element | | Micronutrient | | Major element | | Micronutrient | |
| | 49–50 | 50–51 | 49–50 | 50–51 | 49–50 | 50–51 | 49–50 | 50–51 | 49–50 | 50–51 | 49–50 | 50–51 |
| 'F' test significant at | 1% | 1% | Nil | 1% | Nil | 1% | 1% | 1% | Nil | 5% | 1% | 1% |
| C.D. at 1× | 93 | 82 | — | 28 | — | 69 | 28 | 22 | — | — | 5 | 5 |
| C.D. at 5× | 66 | 58 | — | 25 | — | 47 | 21 | 17 | — | 11 | 3 | 3 |

growth and development of legumes. It is known that, in symbiotic nitrogen fixation, molybdenum plays an important part[5–7]. In proper doses boron and molybdenum have been reported also to have increased the yield of red clover and lucerne[8,9].

The results of a field experiment laid out on the Indian Agricultural Research Institute Farm at Delhi to study the effects of these two micronutrients in conjunction with certain major-element treatments on berseem are reported here. This experiment has been in progress on the same field for the past two seasons, namely, rabi (winter) 1949–50 and rabi 1950–51. The treatments are: main plot (1) superphosphate, (2) rock phosphate, finely ground to pass through a 100-mesh sieve, (3) 'Ammophos', all three to supply 80 lb. of phosphate ($P_2O_5$) each per acre, (4) ammonium sulphate to supply as much nitrogen as contained in treatment (3), and (5) control or no major element. Sub-plot: (1) boron to supply 5 lb. of borax per acre, (2) molybdenum as sodium molybdate to supply 1 lb. of molybdic oxide per acre, (3) boron and molybdenum (combined) as in (1) and (2), and (4) control or no micronutrient element. The design is 'split plot' with four replications. Net plot size is 1/60 acre.

The 0–9 in. depth sample of the soil, a loam, had the following characteristics: organic carbon 0·34 per cent, total nitrogen 0·04 per cent, available phosphate (Dyer) 0·034 per cent, base exchange capacity (milli-equiv./100 gm. soil) 16·60, pH 6·7.

Among the observations taken on several plant characters during the cropping seasons, nodulation was found to be significantly influenced by both boron and molybdenum. Before leaving the crop for seed, in 1949–50 four cuttings and in 1950–51 five cuttings of fodder were taken. The accompanying table gives the consolidated yield figures for the two seasons.

It is interesting to observe from these two years results that boron and molybdenum exercised a significant influence on the fodder, seed and 'bhusa' yields of berseem. Statistical analyses of the yields of individual cuttings have shown that in the first season the major element fertilizers were significant up to the third cutting; but in subsequent cuttings they failed to attain statistical significance, while the micronutrients started to become significant from the fourth cutting onwards. In the second season, however, while the major elements were found significant only up to the second cutting, the micronutrients proved significant in all the cuttings. A possible explanation for this would be that, since the requirements of micronutrients are small for normal healthy growth, the quantity present in the soil at the start was enough for the first few cuttings. But as more and more fodder was removed, they started to become a limiting factor, and thereafter the influence of fertilization with micronutrient elements became well pronounced.

The possibility of using boron and molybdenum as fertilizers in conjunction with phosphates to obtain increased yields of leguminous fodder and seed on soil types similar to those of Delhi is therefore indicated.

Further work is in progress.

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May 24.

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## FORTHCOMING EVENTS

(*Meetings marked with an asterisk * are open to the public*)

### Saturday, January 17

BRITISH MYCOLOGICAL SOCIETY (at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 11 a.m.—Scientific Papers.

### Monday, January 19

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 5.30 p.m.—Mr. Thomas Martin "The Faraday Manuscripts with a Word about Davy".

SOCIETY OF CHEMICAL INDUSTRY, CROP PROTECTION PANEL of the AGRICULTURE GROUP (at the Chemical Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Dr B. A. Kilby. "The Biochemistry of Schradan".

### Tuesday, January 20

SOCIETY OF CHEMICAL INDUSTRY, AGRICULTURE GROUP (in the Chemistry Lecture Theatre, Royal College of Science, Imperial Institute Road, London, S.W.7), at 2.15 p.m.—Mr. R. A. Hamilton, Dr. A. B. Stewart and Dr. W. F. Raymond Papers on "The Manuring of Grassland".

ROYAL PHOTOGRAPHIC SOCIETY (at the Royal Society of Arts, John Adam Street, Adelphi, London, W.C.2), at 3.30 p.m.—Mr. Bertram Sinkinson: "The Centenary of the Royal Photographic Society".

INSTITUTION OF ELECTRICAL ENGINEERS, MEASUREMENTS SECTION (at Savoy Place, Victoria Embankment, London, W.C.2), at 5.30 p.m.—Discussion on "Measurements of Magnetic Permeability" (to be opened by Dr. A. J. King)

UNIVERSITY OF LONDON (in the Senate House, Malet Street, London, W.C.1), at 6 p.m.—Sir Godfrey Thomson: "The Geometry of Mental Measurement".* (Further Lectures on January 21 and 22.)

SOCIETY OF CHEMICAL INDUSTRY, CORROSION GROUP (at the Chemical Society, Burlington House, Piccadilly, London, W.1), at 6.30 p.m.—Dr. M. Pourbaix "The Electrochemical Behaviour of Metals and Corrosion".

SHEFFIELD METALLURGICAL ASSOCIATION (in the Grand Hotel, Sheffield), at 7 p.m.—Annual General Meeting

SOCIETY FOR VISITING SCIENTISTS (at 5 Old Burlington Street, London, W.1), at 7.30 p.m.—Discussion on "The Physiology of Athletes" (Chairman Prof. A. V. Hill, F.R.S.; Speakers: Dr. C. G. Douglas, F.R.S., Mr Roger Bannister and Prof. A. Hemingway).

### Wednesday, January 21

ROYAL SOCIETY OF ARTS (at John Adam Street, Adelphi, London, W.C.2), at 2.30 p.m.—Prof. S. C. Harland, F.R.S.: "Plant Hormones" (Fernhurst Lecture)

ROYAL STATISTICAL SOCIETY, RESEARCH SECTION (at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 5.15 p.m.—Mr. D. V. Lindley: "Statistical Inference".

EUGENICS SOCIETY (at the Royal Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Dr. J. D. Nisbet: "Family Environment and Intelligence".*

ROYAL METEOROLOGICAL SOCIETY (joint meeting with the BRITISH GLIDING ASSOCIATION, in the Lecture Theatre, Science Museum, Exhibition Road, London, S.W.7), at 5.30 p.m.—Discussion on "Fair Weather Cumulus".

ROYAL MICROSCOPICAL SOCIETY (at Tavistock House South, Tavistock Square, London, W.C.1), at 5.30 p.m.—Annual General Meeting; Brigadier H. G. Smith: Presidential Address.

INSTITUTION OF ELECTRICAL ENGINEERS, EDUCATION DISCUSSION CIRCLE (at Savoy Place, Victoria Embankment, London, W.C.2), at 6 p.m.—Discussion on "Some Difficulties in the Teaching of Electrical and Mechanical Resonance" (to be opened by Mr. C. T. Baldwin and Mr. J. C. Oakden).

ROYAL INSTITUTE OF CHEMISTRY, LONDON SECTION (joint meeting with the LONDON SECTIONS of the SOCIETY OF CHEMICAL INDUSTRY and the INSTITUTE OF METALS, at University College, Gower Street, London, W.C.1), at 6.30 p.m.—Dr. A. C. Menzies: "Analysis of Metals by Spectroscopy".

WOOL EDUCATION SOCIETY (at the Royal Society of Arts, John Adam Street, Adelphi, London, W.C.2), at 7 p.m.—Prof. J. H. Nichols: "Improving the World's Wool Supply—The Role of the Biologist".

### Thursday, January 22

LONDON MATHEMATICAL SOCIETY (at the Royal Astronomical Society, Burlington House, Piccadilly, London, W.1), at 5 p.m.—Prof. H. Cartan: "On the Calculation of Homotopy Groups".

MINERALOGICAL SOCIETY (at the Geological Society of London, Burlington House, Piccadilly, London, W.1), at 5 p.m.—Scientific Papers

INSTITUTE OF RURAL LIFE AT HOME AND OVERSEAS (in Room H 301, Colonial Office, Church House, Great Smith Street, London, S.W.1), at 5.30 p.m.—Dr. F. N. Woodward: "The Uses of Seaweed".

UNIVERSITY OF LONDON (in the Physiology Theatre, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Prof. F. Bergel: "Some Chemical Aspects of Normal Growth".* (Further Lectures on January 30 and February 6.)

CHEMICAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 7.30 p.m.—Prof. R. P. Linstead, F.R.S.: "Discoveries Among Conjugated Macrocyclic Compounds" (Pedler Lecture)

INSTITUTE OF WELDING, NORTH LONDON BRANCH (in the Fyvie Hall, The Polytechnic, Regent Street, London, W.1), at 7.30 p.m.—Mr. W. V. Binstead: "The Joining of Aluminium and its Alloys".

UNIVERSITY OF LONDON (in the Swanley Hall, Wye College, Wye, Ashford, Kent), at 8.15 p.m.—Mrs. Jacquetta Hawkes: "Our Primitive Beginnings".*

### Friday, January 23

ROYAL ASTRONOMICAL SOCIETY (joint meeting with the GEOLOGICAL SOCIETY, at Burlington House, Piccadilly, London, W.1), at 4.15 p.m.—Geophysical Discussion on "The Magnetization of Rocks" (Chairman: Prof. C. E. Tilley, F.R.S.; Speakers: Dr J. M. Bruckshaw, Mr. A. F. Hallimond, Mr. J. Hospers and Mr. S. K. Runcorn).

## APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

PRINCIPAL OF THE MID-ESSEX TECHNICAL COLLEGE, Chelmsford—The Chief Education Officer, County Offices, Chelmsford (January 23).

ASSISTANT SECRETARY (graduate of a British university, preferably in science or engineering, with some experience of industry) to the University Appointments Board—The Registrar, The University, Liverpool (January 24).

PHYSICIST—a knowledge of statistics desirable (Ref A.335/52A), and a BIOLOGICAL CHEMIST—preferred, but chemist with analytical experience or biologist with interest in chemistry acceptable (Ref. F. 808/52A), at the Ministry of Supply Tropical Testing Establishment, Port Harcourt, Nigeria, to assist in study of effect of tropical conditions on Service materials and equipment—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting the appropriate Ref. No. (January 24)

PHYSICISTS at a Ministry of Supply Establishment, Aldermaston, for (*a*) research on methods of radiation measurements—knowledge of radiation physics desirable; (*b*) research on physical properties of radioactive materials—practical experience of electron diffraction work, or measurement of short time intervals using high speed oscilloscopes, desirable—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting A.336/52A. (January 24).

UNIVERSITY GRADUATE (preferably physiologist) as Research Student in the Birmingham and Midland Eye Hospital, Church Street, Birmingham, for work in connexion with hereditary ocular disease—The Secretary, Dudley Road Hospital, Birmingham 18 (January 24).

LECTURER IN INORGANIC AND PHYSICAL CHEMISTRY—The Principal, Heriot-Watt College, Edinburgh (January 20).

SENIOR LECTURER IN THE DEPARTMENT OF ELECTRICAL ENGINEERING, University of Natal, Durban—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (February 1).

ASSISTANT ENTOMOLOGIST at the Wattle Research Institute, University of Natal—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (February 14).

ASSISTANT LECTURER IN GEOGRAPHY—The Secretary, London School of Economics and Political Science, Houghton Street, Aldwych, London, W.C.2 (February 20).

LECTURER or ASSISTANT LECTURER IN ZOOLOGY at the University, of Malaya, Singapore—The Secretary, Inter-University Council for Higher Education in the Colonies, 1 Gordon Square, London, W.C.1 (February 23).

SIMON FELLOWSHIPS for advanced study or research in the Social Sciences—The Registrar, The University, Manchester 13 (March 1).

BIOCHEMIST (with a postgraduate degree in biochemistry and five years teaching experience) at the Lady Hardinge Medical College, New Delhi—The Secretary, Division 5A, Ministry of Health, Savile Row, London, W.1.

DIRECTOR AT THE NATIONAL COAL BOARD CENTRAL RESEARCH ESTABLISHMENT II, Isleworth, Middx, and a DIRECTOR OF EXTRA-MURAL RESEARCH, A (Physics, Chemistry and Engineering)—Sir Charles Ellis, National Coal Board, Hobart House, Grosvenor Place, London, S.W.1.

EXPERIMENTAL OFFICER at the Royal Aircraft Establishment, Farnborough, to co-ordinate technical data, development and approval of electronic valves for joint Services use—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting A.339/52A.

GRADUATES for positions in marine zoology and salmon research, in the fields of research on groundfish, salmon, marine mammals, herring and lobsters, and other commercial invertebrates—The Director, Newfoundland Fisheries Research Station, St. John's, Newfoundland, Canada.

HOSPITAL BIOCHEMIST (principal grade)—The Group Secretary, Southampton Group Hospital Management Committee, Bullar Street, Southampton.

LECTURER IN PHYSICS—The Secretary, Royal Technical College, Glasgow.

LECTURER IN SYSTEMATIC BOTANY AND ECOLOGY—The Secretary and Registrar, The University, Southampton.

METEOROLOGICAL ASSISTANTS by the Falkland Islands Dependencies Survey for service at Port Stanley—The Crown Agents for the Colonies, 4 Millbank, London, S.W.1, quoting M.28136.E.

PRINCIPAL SCIENTIFIC OFFICER at a Ministry of Supply Experimental Flying Establishment, near Salisbury, to lead a section responsible for the complete design and proving of aircraft test instruments—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting A.341/52A.

SCIENTIFIC OFFICERS at Ministry of Supply Research Establishments in South-East England: EXPERIMENTAL PHYSICISTS (near Southend) with interest in light engineering or metallurgy (Ref. A. 279/52A), and THEORETICAL PHYSICISTS or APPLIED MATHEMATICIANS (near Sevenoaks)—experience in astrophysics useful for one post (Ref. A.280/52A)—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting the appropriate Ref. No.

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# HUMAN RELATIONS IN INDUSTRY

IN order that the results of action taken concerning human relations in industry during the past few years might be assessed, and that consideration could be given to further steps that should be taken, the Ministry of Labour organized a conference held in London during March 18–20, 1952 (see *Nature*, 169, 872; 1952). The subjects on the agenda were grouped under four headings: (1) factors affecting the opportunity to work; (2) factors affecting the capacity of workers; (3) factors affecting wastage of man-power; (4) factors affecting the will to work. Matters concerning the physical environment, working methods and task organization were omitted.

Papers setting out the situation in each of these groups of subjects, as seen by the Ministry, were circulated in advance to the four hundred delegates who attended the conference. With them went a paper summarizing the findings of the various Anglo-American 'productivity teams' on human relations in American industry and one prepared by Sir George Schuster on conclusions from the projects sponsored by the Human Factors Panel of the Committee on Industrial Productivity, of which he was chairman.

The Ministry of Labour has now published a report on this conference*, which includes as appendixes the papers referred to. Sir George Schuster's paper is particularly welcome since, although condensed, it gives the first comprehensive report on the work of the Human Factors Panel, with a summary of the results of the group of researches which the panel sponsored.

The conference consisted of two kinds of meeting. There were general sessions, at the first of which the proceedings were opened by an address from the Minister; at these sessions speakers introduced the main groups of questions. In addition, Sir Cuthbert Clegg, president of the British Employers' Confederation, and Mr. T. Williamson, of the General Council of the Trades Union Congress, spoke on the paper on the reports of the Anglo-American 'productivity teams', and Sir George Schuster introduced his own paper. For the second type of meeting the conference broke up into groups, each group discussing one of the four main topics. These discussions were free and informal, and at their conclusion an outline of the report from the discussion group to the conference in general session was agreed upon and later prepared by a *rapporteur* for each group. The reports, which were considered in final sessions of the congress, are now published with a summary of the discussion on them.

At a fairly early stage in the conference, Mr. Lincoln Evans, general secretary of the Iron and Steel Trades Confederation, struck at the root of the problem of human relations in industry when he said: "We shall never get that relationship, each with the other, really right unless we can get the proper climate in industry; and we shall never get that unless industrial relations are based on something broader than the conception of two sides in industry".

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* Ministry of Labour and National Service. Report of the Human Relations in Industry Conference, held at the Institution of Civil Engineers, London, March 18–20, 1952. Pp. vi+128. (London: H.M.S.O., 1952.) 3s. 6d. net.

Sir Cuthbert Clegg, president of the British Employers' Confederation, referred to the same point when he spoke of the vital necessity in our present economic situation of building up a greater sense of common interest and the development of mutual confidence between employers and work people. Sir Richard Snedden, also of the British Employers' Confederation, further supported Mr. Lincoln Evans's contention that industry should not be regarded as being made up of two sides. But as the conference proceeded, despite the efforts made by speakers from the employers' associations and the trades unions to avoid the use of the language of negotiation, it became clear that a good many of those present were still thinking of industry in terms of the conflict of interest between two sides. Perhaps it was this which led one speaker in the general discussion to protest that in a conference of this size it was not possible usefully to discuss many of the fundamental problems of human relations in industry.

The scientific aspects of the questions were considered by Sir George Schuster in his speech. His particular concern was to deal with the question: "How far and on what points is more knowledge required as a guide to the right handling of human factors, and what steps should be taken to obtain such knowledge and ensure its utilization ?". His general approach was governed by his belief that there is a real need for more systematic studies, but that such studies should be directed to meet known needs, and that the methods and research workers must inspire the confidence of those concerned with the practical conduct of industry, whose active interest and collaboration are essential. Although distinguishing five main groups of human problems in industry, Sir George emphasized the close relation between them and directed attention to the fact that circumstances outside the factory should not be ignored. He advocated, in fact, an ecological approach. Sir George contended that if 'scientific' were used in the wide Baconian sense, in which it included any orderly empirical study of the natural world, then the methods used for the study of human behaviour could fairly be described as scientific.

It must be admitted that the proceedings at the conference provided a good deal of evidence that the answer to Sir George Schuster's question: "Have we enough factual knowledge of what is happening in industry as a whole or are we putting forward opinions based on a narrow range of our own experience, or on intuition or preconceived ideas ?", is in the negative. The reason lies to some extent, at least, in the difficulty in identifying the real problem presented by a situation. This is shown in the confident assumptions sometimes made in industry on matters of morale and motivation, and also by the bewilderment aroused by behaviour which cannot apparently be logically explained. Failure to diagnose the nature of a problem from the symptoms tends to lead, if not to its dismissal, to its explanation in terms satisfying to the observer. The formulation of problems of human relations by those in industry in a fashion which permits their attack by scientific study is not easy; if, as is commonly the case, this consequently falls to the lot of the researcher, he has to convince both management and worker that he is attacking what is really a need for knowledge.

It was also clear that there has been a failure in communications between those who undertake scientific studies of human problems and those who are in the positions to make use of the knowledge acquired. Although some responsibility must be placed on the failure of the scientific worker to record his results in a fashion easy for the industrial manager to understand, there is a suggestion that in this field, too, industry is suffering from a lack of technologists who can translate the results of basic research into effective action.

Sir George Schuster had certain practical proposals for tackling some of the problems he raised. After referring to the discussions which had been in progress between the Department of Scientific and Industrial Research and the Medical Research Council about arrangements for the conduct of research in the human factor field, he suggested that the Ministry of Labour should set up a departmental advisory committee to watch the whole field, to identify problems and to keep in touch with research and progress. He advocated also an expansion by the universities, and particularly their social science departments, of studies of human problems of industry. The universities are particularly well placed, he suggested, to establish contact with industry in their area and to provide continuity of research, which is an essential requirement in the training of the new research workers who are needed if any expansion of activity in the study of human relations in industry is to be undertaken.

# SCIENTIFIC ACHIEVEMENTS OF M. V. LOMONOSOV

Russia's Lomonosov

Chemist, Courtier, Physicist, Poet. By Boris N. Menshutkin. Translated from the Russian by Jeannette Eyre Thal and Edward J. Webster under the direction of W. Chapin Huntington. (Published for the Russian Translation Project of the American Council of Learned Societies.) Pp. ix+208+5 plates. (Princeton, N.J.: Princeton University Press; London: Oxford University Press, 1952.) 25s. net.

FROM time to time the scientific world has had its attention directed to the achievements of Mikhail Vasilyevich Lomonosov (1711–65), one of the many distinguished men of science of whom Russia is so justly proud. Born in a village on the coast of the White Sea, he studied science and metallurgy in Germany and returned to Russia in 1741, becoming a member of the Academy of Sciences in St. Petersburg, where he worked and taught until his death. Lomonosov was a grammarian, poet, historian and man of affairs as well as a scientist, and his collected works have been published by the Soviet Government. Although not mentioned by German historians of chemistry such as Kopp and E. von Meyer, he was quoted with appreciation by Demachy and by Hoefer (who thought the chemist and the poet were different persons). B. N. Menshutkin published an account of his work in 1904, and excerpts from his writings in Ostwald's "Klassiker" (No. 178) in 1910, and from these Lomonosov became better known outside Russia. Since then, B. N. Menshutkin has studied unpublished sources, but a comparison of the present book with an earlier study published in 1912 does not reveal much new material of importance. The book has been translated from Russian, and not very well; the names of Thomas Young and Fresnel, for example, appear as "Jong" and "Frenelle".

The main tendency of the book is the claim that Lomonosov anticipated many important discoveries, including those of Lavoisier, and that historians of science have denied him his true rights. Much of what is claimed for him (with an absence of reference to sources in many cases) is, however, not his property. A few examples may be given, and the editors have corrected more of the rather extravagant claims in the book itself. It is quite true that Lomonosov was in advance of his contemporaries in many respects, but a detailed examination of the claims made on his behalf does not substantiate some of them.

Although Lomonosov argued against the material nature of heat and regarded heat as a form of motion, this had been said long before by Francis Bacon, and the nature of the motion had been more correctly described by Bernoulli (who was in St. Petersburg) in 1738; he presented a kinetic theory of gases more correct than Lomonosov's. The latter assumed that the particles are rotating and that motion is transmitted from particle to particle by friction between their rough surfaces. Although Lomonosov, who had a good mathematical training, emphasized that chemistry should be developed on mathematical lines, this idea had been anticipated by Keill in 1708 and Freind in 1709, both of whom published a mathematical treatment of chemical changes in considerable detail, not to mention the book by Swedenborg of 1721 on the explanation of chemistry by geometry. The statement in the book that Lomonosov anticipated Lavoisier in stating the law of conservation of mass, together with the information that this law did not appear in books on chemistry until about 1860, will not bear investigation. Lomonosov had the idea that weight is not a true measure of mass and that weight could change in the same place if particles of an aggregate were separated so as to expose more surface to the action of gravity. He used this idea to explain the increase in weight of a metal on calcination in 1748, although a more correct explanation, that the increase is due to some material taken from the air, had been given by Mayow in 1674. It is true that Lomonosov says that "the air particles which always flow over the calcined body combine with it and increase its weight", but he explained the cause of the increase in weight in the way just given.

The claim that Lomonosov anticipated Lavoisier seems to be based on his criticism of Boyle's experiments on the increase in weight of tin on calcination, in which he said, in 1756, that Boyle should have weighed the sealed vessel before opening it and allowing the air to enter, and that Boyle's explanation that the increase in weight is due to the fixation of fire is invalid. But these statements had been made in 1679 by Cherubin d'Orléans. No details of Lomonosov's experiments on this subject survive, and in the few words of his conclusions from them he does not say that the increase in weight is due to the fixation of the air or part of the air, as Mayow had definitely said in 1674. Lomonosov had many good ideas, and if he had worked them out in detail he might well have made notable advances in science, but his duties as an academician and to some extent his irregular mode of life hampered his progress in scientific research. Yet others in even worse circumstances were not prevented from making discoveries.

It is clear from the book that Lomonosov, besides his theoretical ability, had also a keen interest in applied science; he set up a factory for making mosaics and in other ways was active in technology. He was undoubtedly a man of genius, but no service is done either to his memory or to the history of science by exaggerated claims that he anticipated important discoveries attributed to others. An impartial and objective study of his scientific work would be valuable and would receive sympathetic consideration; but it is to be feared that the exaggerated and, in many cases, unfounded claims made for him in the present book will create an unfavourable impression among those who have some knowledge of the facts of the history of science, and in this way will defeat the praiseworthy object of the author in making known the services of one of Russia's great men.

J. R. PARTINGTON

# THE ANATOMY OF CHROMOSOMES

**Allgemeine Pflanzenkaryologie**

Von Prof. Dr. Georg Tischler. Hälfte 2: Kernteilung und Kernverschmelzung. (Handbuch der Pflanzenanatomie, Allgemeiner Teil: Cytologie (Die Organe der Zelle), Band 2.) Zweite Auflage. Lieferung 1. Pp. 384. 58 D. marks. Lieferung 2. Pp. 385–720. 48 D. marks. (Berlin-Nikolassee: Naturwissenschaftlicher Verlag vorm. Gebrüder Borntraeger, 1951.)

IN 1922 Prof. G. Tischler, of the University of Kiel, published an account of the nucleus and the chromosomes in plants. This work was a section of the cytological part of an encyclopædic work on plant anatomy. The present two volumes are a new edition expanded to twice the original size and now illustrated with 466 text figures.

Prof. Tischler's first edition was fully in keeping with the standards of chromosome studies in plants at the time, standards which did not widely depart from those of plant anatomy. That is to say, it was descriptive and it gave weight to each author according to the mass of his publications. The new edition follows the same method. It never resists the temptation to be complete, and it is, in fact, most exhaustive. No controversy is so dead that it cannot here be revived and exhibited; no figure so doubtful or so hazy that it cannot here be accurately reproduced. Description, forgotten history and experimental data are set forth in what is no doubt a carefully considered order. But it is the order of plant anatomy translated to another level. Torn into the shreds of botanical subdivision, we find the dismembered unity of chromosome behaviour. The immediate interpretation we see described with utter impartiality as between the worst and the best. How wise the author is, in these circumstances, to leave the genetical and physiological interpretation out of the picture altogether.

Can such a book have any value? It is difficult to say. For, although there are perhaps twenty thousand references to names, with and without dates, in solid masses in the text, in the countless footnotes, and in the legends of figures, there is no list of references, no index and no contents. These will follow: but without them one can scarcely use the volume even as a work of reference.

Prof. Tischler's work will stand as a monument to his devotion, his industry, and his learning, the greatest which have ever come to fruition in this field of knowledge. Moreover, with the passage of time it will not diminish in value. A hundred years hence it will still show in the utmost detail how an attitude towards scientific research and a programme of scientific publication conceived in the nineteenth century could be faithfully continued in the middle of the twentieth century, thereby fulfilling the hopes of a generation which had passed away.

C. D. Darlington

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# ANGLO-SAXON MAGIC AND MEDICINE

## Anglo-Saxon Magic and Medicine

Illustrated specially from the Semi-Pagan Text "Lacnunga". By J. H. G. Grattan and Charles Singer. (Publications of the Wellcome Historical Medical Museum, New Series, No. 3.) Pp. xii+234+7 plates. (London: Oxford University Press, 1952.) 28*s*. net.

This welcome and noteworthy addition to the scanty literature of Anglo-Saxon medical history is the combined work of two authorities, each eminent in his own sphere. The three-volume treatise by T. O. Cockayne, dated 1864–66, entitled "Leechdoms, Wortcunning, and Starcraft of Early England", was an important contribution, as also were J. F. Payne's Fitzpatrick Lectures of 1903, which were printed in the following year under the title "English Medicine in the Anglo-Saxon Times".

The late Prof. J. H. G. Grattan, an unrivalled expert in Early English language and literature, has collaborated with the leading medical historian of the present day, Prof. Charles Singer, in this book which, although smaller, is a worthy successor to Cockayne's and Payne's works. The first part, roughly one-half, of the book consists of a general survey of magico-medical practice in Anglo-Saxon England, by Prof. Singer, while the remaining part is the text, with translation on the opposite page, besides notes and a glossary, of "a magico-medical commonplace book" known as "Lacnunga", from the sole surviving manuscript in the British Museum, where it is listed as MS Harley 585. It seems to have been written, about the year A.D. 1000, by a 'leech' who was not of the priestly class, and who, as Prof. Singer remarks, "still dwells in the barbarian world of magic and hardly emerges therefrom". He begins with remedies for the head and eyes, and works his way downward in the time-honoured fashion. More than a hundred medicaments are mentioned, of vegetable origin for the most part, and not all of them can be identified. Among the animal remedies are fox's grease, hind's milk and crab's gall. Apparently more important than the remedies themselves are the incantations and exorcisms which must accompany their administration. One of these is the "Lorica" of Gildas, written in Ireland in the seventh century; there is also a spell against flying venom and a lay against elfshot, besides a Christian prayer for sore eyes.

The lays were to be sung over the medicines three times, and also "into the man's mouth and both ears". Nor is veterinary medicine neglected, as exemplified by a "rite for lost cattle" and a "charm for a sprained horse". Anglo-Saxon medicine appears to have little rational basis. According to Singer, it cannot be regarded "as an early stage of what is to become a great intellectual movement". It is, rather, "a final pathological disintegration of the great system of Greek medical thought". As examples of the charms may be mentioned the formula against malaria: "Flee, ye fevers, eighty-thousand angels are after you", and, for what are called seizures, the patient is advised to "take a hazel stick. Cut thy name thereon: fill the name with blood, and throw it over the left shoulder into running water, all silently".

While all those recipes are of interest to the medical historian as evidence of a decadent epoch in the progress of the healing art, the "Lacnunga" will probably be of greater value to the student of Anglo-Saxon than to the medical man. The medium by which the information is conveyed is at least as interesting as the facts themselves. The brief survey of the grammar contained in the last fifteen pages of the book may be of much value to students of linguistics, while the section dealing with "Semantics of Anglo-Saxon Plant-Names", giving the Anglo-Saxon, English, and Latin or Linnæan versions, forms a useful contribution to botany. The well-chosen illustrations are in themselves most informative, although it is perhaps unfortunate that the plates are not described in more detail. As is to be expected, the book is clearly printed and well produced.

Douglas Guthrie

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# TEXT-BOOK ON RELATIVITY

## The Theory of Relativity

By Prof. C. Møller. (International Series of Monographs on Physics.) Pp. xii+386. (Oxford: Clarendon Press; London: Oxford University Press, 1952.) 35*s*. net.

This book is based on lectures given during the past twenty years by Prof. C. Møller, who is professor of mathematical physics in the University of Copenhagen. The preface describes it as a text-book for students in physics whose mathematical and physical training does not go beyond the methods of non-relativistic mechanics and electrodynamics. In arrangement the book follows a conventional pattern, slightly more than half being devoted to the special theory of relativity (including an introductory chapter with a historical survey) and the rest to the general theory, including a little on cosmological models (Einstein and de Sitter). It ends with some mathematical appendixes, an author index and a subject index which, like most subject indexes, might with advantage be fuller.

The style is clear and persuasive, and the author shows himself a skilful teacher in the way in which he dilutes the abstract with the particular. The mathematical machinery of tensor calculus is developed as the need arises, first for the special theory and then for the general theory. By the time the reader reaches the end of the book, he should have a good basic knowledge of the theory of relativity.

Ever since Minkowski published his famous paper on space and time in 1909 there have been two ways of looking at relativity—the old kinematical way, with constant reference to measuring-rods and clocks, and the Minkowskian way, in which the geometry of the four-dimensional continuum dominates. Prof. Møller definitely favours the former. He writes: "On the whole, the epistemological significance of the four-dimensional representation should not be exaggerated" and ". . . it must be emphasized that such a representation is quite formal". But of course he cannot get on without the space–time continuum, which is introduced in Chapter 4 with these cautionary remarks. There are even space–time diagrams on pp. 96, 152, 168; but they are queer diagrams—topologically incorrect representations of space–time, since the axes of ($x_1'$, $x_4'$) should be both inside (or both outside) the axes of ($x_1$, $x_4$) (cf. Fig. 1 in Minkowski's paper in "The Principle of Relativity", p. 78 (London: Methuen, 1923) ).

It seems to me that the book would have been better if Prof. Møller had been more sympathetic to the Minkowskian way of looking at things. When the head begins to swim with contracted rods and slowed clocks, the best antidote to confusion is a simple space–time diagram. Thus, in Chapter 8, which leads to the general theory of relativity through the "principle of equivalence", it would be good to recognize that the ends of a short rigid measuring-rod are simply adjacent world-lines with a constant normal separation between them. But having recognized this, and remembering how Herglotz's masterly treatment of rigid-body motions (*Ann. d. Physik*, 31, 393; 1910) restricts such motions, one cannot but be surprised at the simple dogmatism of Prof. Møller's treatment of that thorny problem—the rotating disk. If a second edition of the book gives him an opportunity to revise Chapter 8, I hope he will use it to give the reader a clearer idea of the concept of rigidity in relativity.

J. L. Synge

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# EXPERIMENTAL EMBRYOLOGY OF BIRDS

## The Epigenetics of Birds

By Prof. C. H. Waddington. (Cambridge Biological Studies.) Pp. xvi+272. (Cambridge: At the University Press, 1952.) 35*s*. net.

PROF. C. H. WADDINGTON'S choice of the title of his new book is eye-catching and stimulating if for no other reason than that the word 'epigenetics' connotes in the minds of many embryologists a variable and changing spectrum of meanings. The author's rather broad use of this word as a name for "The science concerned with the causal analysis of development" may be somewhat surprising and unfamiliar to most embryologists, particularly, because such usage would seem to leave little room for ideas about the alternative, 'preformistic' causal aspects of development. Nevertheless, as one reads through the book it becomes apparent that 'epigenetic' is being used in a sense sufficiently broad to include both the interactive (inductive) and segregative (localizational) mechanisms of the developmental system. However, since Prof. Waddington's major concern is not the presentation of a general thesis of avian development (although his title might suggest it), we have little concern with the inevitable semantic difficulties which result from the use of the word 'epigenetics'.

The central purpose of the book, as the author states in the preface, has been to review the literature of experimental embryology of birds from 1930 up to about 1950. The book is fortunately much more than a simple review, for the author has frequently interjected his own evaluation and interpretations along with his description of the results and interpretations of the various workers in the field. Moreover, he has done this in a commendably objective and undogmatic way. His warnings about the making of interpretations of data accumulated by experimental methods and procedures that do not specifically warrant them should be accepted as a healthful shaking-up in our thinking about the mechanisms of bird development, regardless of whether all of us agree with his interpretations in particular instances (for example, interpretation of the organization of the unincubated *chick* blastoderm as a "single entity" on the basis of the results of studies of the unincubated *duck* blastoderm). One of the major contributions of the book is the comparison and critical evaluation of the many and sometimes conflicting results of the German, French, English and American workers—an analysis which has not been made previously in anything like as thorough a fashion.

The plan and order of presentation of the subject-matter follow in the main those of developmental chronology, beginning with an introductory chapter on technical methods and proceeding through a discussion of our knowledge of endoderm, primitive streak and embryo formation on to problems of organ system formation in later stages. The main emphasis has been devoted to such general problems as germ-layer interaction and primitive streak organizer (induction) activities. Special chapters deal briefly with a comparison of bird development with that of other vertebrates, biochemical mechanisms, feather development and pigmentation and with certain genetic effects and their phenocopies.

In the final and one of the most thought-provoking chapters in the book, the author has summarized the status of our knowledge of the "development of the epigenetic organization of the chick". This amounts in large part to a presentation and evaluation of our information about the regulative capacities of the early embryo. Among a number of valuable suggestions for future lines of attack is a most interesting one concerning the physiological mechanisms which underlie the processes of localization (or "segregation"). It is true that most of our information concerns the inductive (cell or tissue interactive) mode of differentiation—perhaps because this is most easily demonstrated experimentally—whereas almost nothing is known about the localizational or "segregative" mechanisms. Prof. Waddington suggests that "they offer to the embryologists of the future a problem perhaps even more important than that of the mechanisms of induction". It is obvious to all, however, that we still know very little about the actual mode of cell–cell interaction; for example, whether this is mediated by cell–cell contact and/or by diffusible substances remains an important problem in developmental physiology.

Embryologists will find this little book quite readable and provocative. It is well illustrated and contains a rather extensive bibliography. Prof. Waddington is to be congratulated for his efforts, which have produced a book both timely and valuable.

Nelson T. Spratt, Jun.

## Colloidal Dispersions

By Earl K. Fischer. Pp. vii+387. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1950.) 60s. net.

THE dust-cover of this book says that "Dr. Fischer's book is the first to cover both the theoretical and practical aspects of colloidal dispersions". This extraordinary statement becomes comprehensible when it is seen that the book is not, in fact, about colloidal dispersions at all, but deals with coarser systems. It deals, in fact, with the same field as J. M. DellaValle's "Micromeritics" (New York: Pitman Publishing Corporation, 1943), although there are considerable differences of emphasis and allocation of space to topics. A name for these very finely divided systems would be valuable, except that further divisions would continually arise: we might go from micromeritics to microteromeritics and microtatomeritics! From the point of view of free surface energy, the particle size is rigorous for spherical particles: for fine dispersions, all properties are highly dependent upon shape. 'Fine powders' or 'fine dispersions' would seem to be entirely adequate, without straining after an exactitude which does not and cannot exist.

"Colloidal Dispersions" is of little interest to academic workers but should be valuable to applied chemists. After an orthodox introduction of four chapters, rheological properties are discussed fully in seventy-seven pages, followed by thirty-four on surface-active agents in which pp. 225–227 contain an astonishing crop of peculiar statements. The remainder of the book describes grinding. The work is well documented by references to a wide variety of work and systems and forms an interesting chemical companion volume to Delavalle's more physical and fundamental book.

A. S. C. Lawrence

## Bird Migrants

Some Aspects and Observations. By Eric Simms. Pp. 212+16 plates. (London: Cleaver-Hume Press, Ltd., 1952.) 15s. net.

THE author declares that the purpose of his book is to introduce more people to the fascination of bird-watching and worth-while observations. It is now sixteen years since Landsborough Thomson's "Bird Migration" was published and became the standard work, so that there is room for a fresh account in view of the considerable advance in the study of bird navigation and orientation.

Perhaps the best chapters in this book cover a discussion on the latest theories, including the work by Griffin, Kramer and Matthews, and an exposition of seen and unseen migration. The author's experience as an airman enabled him to confirm that migration is usually at a level below the contours of the higher hills, and rarely indeed above three thousand feet. He describes the well-known cross-country migration, chiefly autumnal, between the Wash and the Severn, which he observed along the northern escarpments of the Cotswolds. East-coast migrants pour into the Wash southwards from Lincolnshire and westwards along the Norfolk coast, and are canalized along the Fen rivers south-westwards and follow the Avon to the Severn Estuary.

This is a promising first book. Unfortunately, it shows signs of hasty construction: the map of bird observatories omits the Lundy and Saltee stations, and there are too many vague generalizations with no supporting evidence. Thus: "migration and dispersal may happen not only amongst birds of different species, but amongst individuals of different age in the same species"; "The spotted flycatcher . . . in the mainland is not really uncommon except in some of the more remote groups of islands"; "At sea auks battle in the breakers to reach low-swimming herring and get tossed exhausted on the beach"; "the lonely and treeless Fair Isle, originally discovered by Dr. Eagle Clarke"; and the error made by Coward is repeated in stating that gannet and shearwater migrate overland in autumn, for "records cannot be invariably associated with weather". W. E. Kenrick, on the contrary, found by careful research into the meteorological records that the days preceding each inland recovery of these essentially marine birds were stormy, as a rule with some notable gale from a westerly quarter. These inland records proved to be of dead, dying or exhausted birds overtaken by weather and driven inland.

R. M. Lockley

## An Introduction to Acoustics

By Prof. Robert H. Randall. (Principles of Physics Series.) Pp. xii+340. (Cambridge, Mass.: Addison-Wesley Press, Inc., 1951.) 6 dollars.

THIS useful book, of intermediate degree standard, has been written mainly for students of physics, but it deserves to have a much wider range of readers, to include engineering students and others who may wish to specialize in communications and electro-acoustics. Indeed, a good knowledge of the basic principles of acoustics is absolutely essential to all who are engaged in the many practical applications of the subject.

The treatment given in the book follows a logical course, beginning with a study of vibrations as a preliminary introduction to the wave equations, and the importance of these topics to all branches of physics and engineering is stressed.

The mathematics used in the text should, in the main, be well within the compass of the students for whom the book is intended, except perhaps the complex notation used in Chapter 5, but even here the author gives only the essential material sufficient for the understanding of the text. The value of electrical analogies is fully recognized, and good use is made of such analogies in the solution of acoustical problems.

While giving a thorough account of the fundamentals of the subject, the author has not neglected the more popular and applied features, and has devoted considerable space to such topics as speech and hearing, loud-speakers, electronic devices, etc. In general, the book is quite a valuable contribution to the literature on acoustics.

## The Basuto

By Hugh Ashton. (Published for the International African Institute.) Pp. xi+355+17 plates. (London, New York and Toronto: Oxford University Press, 1952.) 35s. net.

THIS book gives a general, but accurate and comprehensive, account of the people of the wealthiest, and the largest in population, of the South African High Commission Territories. Basutoland came into being during the nineteenth century through the political genius of its chief, Moshesh; and through good fortune, and the warlike qualities of its people, managed to survive Zulu and Afrikaner attacks to emerge into the twentieth century as the largest native African State or tribe in southern

Africa. It takes its name from the Sotho or Suto, a group of southern Bantu people that extends from the Bechuanaland Protectorate southward to Basutoland. Thanks to the research of Prof. Schapera, anthropological attention has been mainly focused on the northern or Bechuana section; the publication of H. Ashton's book on the southern, and numerically far larger, section will help to redress the balance and, in addition, provide valuable comparative material and lead to a much fuller understanding of this southern Bantu people.

Some sections of the book, in particular the chapter on medicine, magic and sorcery, and the appendix on kinship marriage, will be of particular interest to social anthropologists; the greater part of it, however, is more general in character and will appeal to a far wider public. It is written by a man who is a competent administrator as well as an anthropologist, and who is thus able to give a direct and straightforward account of an African people in the twentieth century and to avoid the obscurity and abstraction which characterize the language and content of so many current anthropological monographs. In Chapter 15 on law, for example, Ashton describes the kind of law administered in the courts of Basuto ward chiefs immediately prior to the changes introduced by the British Government after the Second World War, quoting extensively from the court records of Chiefs Mosue and Bereng and giving us a study of what was actually happening in these particular courts. Such a chapter is much less likely to be coloured by the preconceptions of the field observer and his particular informants.

"The Basuto" is a book that has been worth waiting for and which should appeal to a wide range of readers. Its only regrettable feature is its price; it is a pity that the publicity section of the Commonwealth Relations or High Commissioner's Offices could not have subsidized its publication.

G. I. Jones

### Papers on the Basic Principles of Statistical Physics

By N. S. Krylov. Pp. 204. (Moscow: Academy of Science of the U.S.S.R., 1950.) 18 roubles.

PROBLEMS and arguments associated with the 'ergodic theorem' (or principle of continuity of path) have, from the times of Maxwell and Boltzmann to the present day, played an important part in establishing the kinetic theory. Decisive progress in the mathematics of these problems was made approximately twenty years ago, but scanty use has, so far, been made of this work for interpreting physical facts.

This book under review, which is written in Russian, was planned as a comprehensive treatise in which the recent mathematical results were applied to the statistical theories of physics. Owing to the premature death of the author, only some preparatory papers and single sections have been completed; but even the incomplete work is worth studying on account of the author's great knowledge of the mathematical aspects of every problem and its bearing on physics. The author's approach is to a remarkable extent independent of the traditional presentations of the subject; an example of his attitude may be found in the only paper he published in English (*Nature*, 153, 709; 1944).

Time series of observations of mechanical systems as compared with time series of random observations; specification of mechanical processes in terms of Markov chains; the calculation of relaxation times; the quantum mechanics of measurement with less than the greatest admissible accuracy: these and similar topics, which are relevant to the foundations of statistical thermodynamics and the stochastic theory of irreversible processes, are surveyed and utilized in original contributions. The author's work should—if translated—appeal to an appreciable number of English-speaking readers.

R. Eisenschitz

### Wild Flowers, Grasses, Ferns, Fungi, Trees

(Nature Field Series, 1.) Pp. vii+83.

### Birds and Wild Animals, including Marine Mammals

(Nature Field Series, 2.) Pp. vii+83.

### Insects and Spiders

(Nature Field Series, 3.) Pp. vii+72.

### Shore Life, Fish, Clouds and Weather

(Nature Field Series, 4.) Pp. vii+71.

By H. Trevor Jones. (London and New York: Frederick Warne and Co., Ltd., 1952.) 6*s*. 6*d*. net each.

THE succession of new books of natural history is almost as regular as the seasons of Nature herself. Some are primarily evocative and seek to attract the reader by appealing to the imagination and the emotions. Others are purely descriptive and attempt to win the intellectual interest of the reader. In this new series of Nature books for younger readers, H. Trevor Jones has set out both to stimulate enthusiasm and satisfy curiosity, and because of the attractive way in which the text and colour- and line-drawings are combined, can reasonably claim to have succeeded. The first book describes 145 species of wild flowers, six ferns, sixteen fungi and fifty-two trees. In the second book are descriptions of 163 species of birds and seventy-six species of other animals, including a few invertebrates. In the third, 152 species of insects and spiders are illustrated, while, in the fourth, Jones includes most of the common examples of fish and other forms of fresh-water and marine life in and around Britain; at the end of this book there is a useful section on clouds and weather, with additional information on tides and currents, stars and planets. In nearly every case the illustrations are conveniently set alongside the species to which they refer.

T. H. H.

### A Flower Book for the Pocket

By Prof. Macgregor Skene. Second edition. Pp. 378. (London, New York and Toronto: Oxford University Press, 1952.) 12*s*. 6*d*. net.

THIS little manual, a revised edition of a popular handbook, will provide a pleasant and instructive introduction to the study of British wild flowers. A simple system of classification is adopted in which eight groups are recognized; artificial keys are given to these groups and the natural families which comprise them. Further keys are provided to the genera in each family, and with the adequate and non-technical description of each species the beginner should have little difficulty in naming common wild flowers. More than five hundred plants are illustrated in colour, but the detail tends to be rather obscure. The author is to be commended for using, to a large extent, the nomenclature of the most recent British Flora.

# RAW MATERIALS OF LIFE*

By Dr. D. P. RILEY and Dr. U. W. ARNDT
Royal Institution

An egg contains within itself all that is necessary to make a live chick. Some air goes in through the shell and some carbon dioxide comes out; water vapour passes in and out; but apart from that, nothing is added or taken away. All the raw materials needed are already there and, given time and warmth, they are transformed into an organism capable of independent existence. These raw materials of life cannot but repay study, and, in fact, rapid progress has been made in the past few years in reaching an understanding of their complicated chemical structure.

One of the reasons why it is difficult to measure with certainty and precision the weight, size and shape of protein molecules is because many of them associate or dissociate to varying degrees in solution. A knowledge of molecular interaction in protein solutions would be of great importance to our understanding of processes occurring in the living cell and we are as yet only at the beginning of such knowledge. We have recently come to know, rather surprisingly, somewhat more about the intricate internal structure of protein molecules than we know about their grosser properties of shape and size. It is not too much to hope that a synthesis will soon be effected between the detailed chemistry of these molecules and their physico-chemical characteristics.

## X-ray Analysis

X-ray diffraction analysis has been used for many years in the study of proteins. It is not our present purpose to survey all that has been done in this field so much as to assess the relative value of various possible procedures in relation to the type of information it is desired to obtain.

The molecular weight of a 'globular' protein can be determined with considerable accuracy from a knowledge of the volume of the crystal unit-cell, its density and content of water or electrolyte solution. As is well known, the value derived in this way may be a multiple of the true molecular weight, but, apart from this factor, the degree of attainable precision is very great. The method is limited to those proteins which form large and sufficiently perfect single crystals. This elementary single-crystal procedure has been disappointing as a means of obtaining rapidly and unequivocally the actual molecular dimensions, although it is, in principle, capable of giving them with great precision. An alternative, and more generally applicable, method of studying molecular size and shape is afforded by the scattering of X-rays at low angles by solutions of proteins. In sufficiently dilute solutions, if no aggregation occurs, the observed scattering is a simple multiple of the scattering by a single molecule, averaged over all orientations. The derived quantity is a length, the 'radius of gyration', related to the moment of inertia, and does not uniquely define a volume or shape. However, by working under absolute conditions or by careful comparison with a standard protein of known molecular weight, the low-angle method provides molecular weights (or volumes) directly. Again, by the examination of concentrated solutions it is sometimes possible to estimate one or more molecular dimensions, if various simple assumptions are made. The combination of the three approaches should allow a fairly confident and rapid assessment of the shape and size of the molecule in favourable cases.

The forces acting between neighbouring protein molecules in concentrated solutions can, in principle, be measured by a process of Fourier inversion of the scattered X-ray intensity at low angles. The effect of changes in *p*H and ionic strength can be studied.

Many analogies exist between light-scattering methods and low-angle X-ray techniques, and the two procedures are, to some extent, complementary.

The most that one can hope to derive directly, concerning the molecular structure of proteins, from a diffraction experiment is the scattering function for a single molecule. This function, which is always real and positive or zero, is the conjugate complex of the 'Fourier transform' or 'diffraction picture' of the distribution of scattering matter within the molecule. The most direct way of observing the molecular scattering function would be to examine a partly-ordered assembly in which all molecules possessed exactly the same orientation, but random and relatively large intermolecular distances. This is achieved in part in some fibres and it may prove possible, although difficult, to produce suitable specimens artificially. The disadvantage of working with true crystals is that the regular arrangement gives rise to intermolecular interferences which obscure the pattern due to a single isolated molecule. Much ingenuity has been used in partially overcoming this difficulty, notably by the Cavendish Laboratory school, as described by Sir Lawrence Bragg in his Guthrie Lecture (*Proc. Phys. Soc.*, B, 65, 833; 1952). But it still remains the case that details of the intramolecular chemistry have yet to be deduced with certainty from work on single crystals.

## Molecular Models

If the strictly deductive procedure be abandoned, and the intellectually less satisfying (to the experimenter) procedure be adopted of working from hypothetical structural schemes, the problem becomes one of devising experimental approaches which can put such hypotheses to the test. A convenient method is to measure accurately the angular variation of intensity of monochromatic X-radiation scattered by an amorphous sample, with subsequent comparison with the intensity curve calculated from a given structural model. Alternatively, curves depicting the radial distribution of scattering matter may be the basis of comparison.

By the use of a proportional-counter spectrometer, intensity curves of this type can now be quickly obtained with an accuracy of about ± 2 per cent, and a survey of a number of proteins has been made*. All proteins, whether fibrous or corpuscular, seem to fall into three main structural types. For terminological convenience, these types will be called $\alpha$, $\beta$ and $\gamma$. $\alpha$-Proteins include the keratin–myosin–

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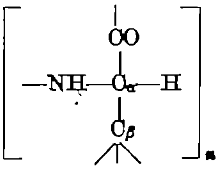
* Based on a Friday Evening Discourse entitled "The Chemistry of an Egg" delivered by Dr. D. P. Riley at the Royal Institution on November 7.

* The researches on protein structure in progress in the Davy Faraday Laboratory are being carried out with the assistance of Mr. W. A. Coates; publications describing the methods and results in detail are in course of preparation. Work has been greatly helped by grants from the British Empire Cancer Campaign.

epidermin–fibrinogen proteins of Astbury, also all the corpuscular proteins so far examined; silk fibroin is an example of the rarer β-proteins; and the γ-proteins constitute the collagen and gelatin group. Astbury's tripartite classification is thus of general applicability. It has further been shown that the only structural hypothesis so far studied which agrees with the scattering curves for α-proteins is Pauling, Corey and Branson's α-helix with about 3·7 amino-acid residues per turn in one coiled polypeptide chain. Here, the agreement is very close and the structure may be considered to be established beyond reasonable doubt. β-Proteins probably have fully extended polypeptide chains, while the configuration in the γ-proteins is not yet known.

A protein molecule consists of one or more main polypeptide chains:

$$(\text{—NH—CH}R\text{—CO—})_n \text{ or}$$



$$\left[\begin{array}{c} | \\ \text{CO} \\ | \\ \text{—NH—C}_\alpha\text{—H} \\ | \\ \text{C}_\beta \\ \diagup | \diagdown \end{array}\right]_n$$

to which are attached the side-groups, $R$, of relatively simple, and known, structure. The $C_\alpha$ carbon atoms at which these attachments occur are, in general, asymmetric and give rise to optical activity. The absolute configuration around the $C_\alpha$ atoms is now known and is described as *lævo* or L-. The above formula depicts it according to the usual convention: $C_\alpha$ is in the plane of the paper, the bonds to CO and $C_\beta$ are below, and those to NH and H above, this plane. The configuration being identical for all $C_\alpha$ atoms in proteins, there are only two ways of building an α-helix: a left-handed helix with the $R$ groups attached in one specific way, or a right-handed helix with the $R$-groups fixed in the alternative way. For brevity, these two structural types may be called $\alpha_1$ and $\alpha_2$, and their full descriptions are:

$$\alpha_1 = LH\ C_\beta 2\ \text{L-}C_\alpha\,;\quad \alpha_2 = RH\ C_\beta 1\ \text{L-}C_\alpha,$$

where $C_\beta 1$ and $C_\beta 2$ refer to the two alternative positions of the first carbon atoms ($C_\beta$) of the side-chains. The equivalent enantiomorphs, $\alpha_1'$ and $\alpha_2'$, can exist in synthetic polypeptides but not in natural proteins:

$$\alpha_1' = RH\ C_\beta 2\ \text{D-}C_\alpha\,;\quad \alpha_2' = LH\ C_\beta 1\ \text{D-}C_\alpha.$$

The α-type of protein structure can thus be divided, in principle, into two sub-types, $\alpha_1$ and $\alpha_2$, and there is no *a priori* reason why they should not both exist in Nature or even co-exist in one and the same protein molecule. By calculation, it can be shown that the amorphous scattering curves from $\alpha_1$ and $\alpha_2$ present recognizable differences, and the possibility therefore exists of distinguishing between them by experiment. Work along these lines is at an early stage, but it can provisionally be said that, while $\alpha_1$ seems to be the favoured structure in serum albumin, a mixture of $\alpha_1$ and $\alpha_2$ may exist in insulin. It is tempting to identify these with the $A$ and $B$ fractions of Sanger, and, indeed, the presence of a proline amino-acid residue (as in $B$) can be shown to impose the $\alpha_2$-configuration on the polypeptide chain in which it occurs. Examination of the separated fractions should settle the point.

Two methods are open to us for the examination of the side-chains by these X-ray scattering methods. One is to place the amino-acid residues along the main chain in the order found by Sanger by chemical means, and to calculate their effect on the intensity curve; the other is to perform a 'difference-Fourier' inversion of observed-minus-calculated intensity functions. The latter procedure gives a radial distribution curve corresponding to those parts of the structure which had been omitted from the first calculations, that is, principally, the side-chains. It has been shown in these ways that the effect of the side-chains on the scattering is not sufficiently specific to mask the dominating features imposed by the basic folding of the polypeptide chain.

In the case of insulin, the molecular structure would be almost completely determined if it were known how the $A$ and $B$ fractions are linked by cystine, —S—S—, bonds. The 'Courtauld' space-filling atomic models designed by G. S. Hartley and Conmar Robinson are of great help here; but a final unique solution still escapes us. One feature, however, which emerges from this sort of study is that neighbouring helices may well be skew to each other. If this is generally true, it would greatly complicate the detailed interpretation of Patterson series derived from single-crystal data.

Whether or not a given protein molecule has a unique structure is a matter for some doubt. Several workers have directed attention to the similarities between proteins and the silicate minerals. The possibility in proteins of 'isomorphous' replacement of 'non-specific' side-chains cannot be excluded and may even be probable. Such possibilities only lend weight to the argument that a detailed solution of the structure of a protein molecule is a matter for an integrated chemical and physical approach. On one hand, controlled degradation of the molecule with separation of the breakdown products, and, on the other, the use of an electronic computing machine in connexion with highly accurate intensity curves, would, in rational combination, lead to considerable advances in our understanding of the 'raw materials of life'.

## Survey of Structural Types

We should like to appeal for help from other centres in providing specimens for a survey of structural types in polypeptide molecules which we wish to undertake by the X-ray scattering method. It is not necessary in this sort of examination for the material to be crystalline; but adequate purity is important, particularly as regards freedom from inorganic salts. Purification could, of course, be done by us where necessary. Salt-free freeze-dried material is very suitable, as is any fine powder or amorphous mass. Fibrous material is less convenient. At present, the technique requires the use of about 100 mgm. of material to obtain the best results, but smaller quantities could be examined if need be.

We should be most grateful to any colleagues who might feel that they would like to contribute specimens to this survey. Perhaps they would, in the first place, write to us (at the Royal Institution, 21 Albemarle Street, London, W.1), giving details so that unnecessary trouble on their part could be avoided. If desired, the samples could be returned after examination, which should not normally affect them. It is desired to include in the survey natural proteins of all kinds (common and uncommon), denatured proteins or proteins which have been submitted to various chemical or physical treatments, synthetic polypeptides and natural polypeptides.

# PHYSICS OF THE HIGH ATMOSPHERE

A SESSION on the physics of the high atmosphere, under the chairmanship of Prof. A. M. Tyndall, was held on September 5 at Belfast by Section A (Physics and Mathematics) of the British Association. The meeting brought together four speakers who discussed this topic from different points of view, using what might be called the passive, the active and the direct observational, and the theoretical approach.

Historically, the scientific study of the earth's upper atmosphere evolved from ground observation of phenomena such as the auroræ and trails of meteors. It is remarkable, as became apparent from the paper by Dr. F. E. Roach (Naval Ordnance Test Station, Inyokern, Calif.), that this passive observational approach, when performed with modern, highly sensitive instruments, can still yield most valuable information about the properties of the upper atmosphere. An example of this type of approach has been the researches by Dr. Roach and his colleagues on the faint light emission from the night sky, known as the night air glow. They have been concerned mainly with the oxygen lines 5577 A. and 6300 A. which already formed the basis of Lord Rayleigh's classical work. It is interesting to note that the modern mean value for the intensity of $2 \cdot 8 \times 10^8$ quanta/sq. cm. column/sec. agrees rather closely with the value of $1 \cdot 8 \times 10^8$ obtained by Lord Rayleigh with his primitive equipment. Roach's measurements, conducted with photoelectric equipment under unusually good atmospheric conditions in the California desert, have led to the conclusion that the night air glow shows a maximum which occurs, on the average, near local midnight. On the basis of a detailed study of one night, Roach and Pettit[1] proposed that the isophot pattern of λ 5577 of the night air glow remains stationary with respect to the sun, while the earth rotates underneath.

Dr. Roach and his colleagues have tried to test this idea further by comparing the records of two stations—Cactus Peak, Calif., and Haute Provence, France—which are eight hours apart in terms of longitude. They have found that there appears to be some resemblance of the isophot patterns and sometimes of the maxima; but on the whole, the isophot patterns do not remain well preserved, indicating the influence of variable factors. When they attempt to measure the height of the emitting layer by means of triangulation methods, they find its altitude to be about 180 km. By other techniques, they have found altitudes in the neighbourhood of 250 km. All these values are in definite disagreement with photochemical theories which, in considering a purely static atmosphere, place the altitude of the emitting layer at approximately half that observed.

Another experimental approach of great interest was intended to establish the correlation between the intensities of the emission lines λ 5577 and λ 6300, a correlation which is to be anticipated since λ 5577 is a transition from the $^1S$-state of O I (which has a lifetime $\sim \frac{1}{2}$ sec.) to the $^1D$-state, and since λ 6300 is a transition from the $^1D$-state (which has a lifetime of $\sim 100$ sec.) to the $^3P$-state of O I. The comparison between the intensities of these two lines is most interesting: although generally about the same at the beginning of the evening, they show no relationship and even inverse correlations during the night. The correlation between λ 6300 and the total number of electrons in the $F$-layer, however, is very good. This again may be taken as an indication of the variability and instability of the very high atmosphere which becomes apparent because of the long lifetime of the $^1D$-state.

A more active approach to the study of the atmosphere has been reserved to this century. The probing of the upper layers by man-made radio signals commenced with the now famous experiments of Appleton and of Breit and Tuve. The values of the critical radio frequencies give immediately the concentration of electrons as a function of altitude. Mr. W. R. Piggott (Radio Research Station, Slough) discussed the vast amount of information which can be extracted from ionospheric reflexion data provided one looks at them in very special ways. Of particular interest is the influence on the upper atmosphere of tidal forces and their identification from the variations of electron density. There exists, for example, a definite twelve-hourly oscillation of the $F$-layer with a maximum height at local noon and midnight.

Expressing the variation of electron densities $N$ by the equation

$$\frac{dN}{dt} = q - f(N,X),$$

one can look separately at the agents which produce electrons ($q$), and other effects ($X$) which lead to the disappearance of electrons. It is found that this expression holds quite well in the lower ionosphere where the mean free paths are small and the layers are essentially in static equilibrium with respect to winds and oscillations. At the greater heights, however, the lifetime of the electrons increases as the collision frequency decreases, so that the atmosphere is no longer stable to large density changes.

These influences, which cause variations in the electron density, can be looked at in different ways. Mr. Piggott discussed, as an example, the dependence of $q$ on the sun. It is observed that the absorption in the $E$-region shows a maximum at noon and that during an eclipse the electron density in the $E$-region decreases very sharply. The upper layer, however, exhibits a completely different behaviour: for example, the formation of a new $F$-layer has been observed during a recent eclipse.

One of the most valuable features of ionospheric research is the possibility of geographical studies from data which come from fifty to sixty international stations distributed over the face of the earth. Such studies have shown the important influence of the earth's magnetic field on phenomena in the upper atmosphere: for example, the electron densities in the $F_2$-layer show a sharp dip ('cusp') in the immediate vicinity of the equator where the magnetic field is horizontal.

The high-altitude sounding rocket, the newest experimental technique for studying the upper atmosphere, was described by Dr. S. F. Singer (Office of Naval Research, United States Embassy, London). Rockets make possible measurements *in situ* by bringing instruments into direct contact with the upper regions of the atmosphere. They are unique, since they allow measurements of extra-terrestrial radiation, electromagnetic as well as corpuscular (for example, cosmic rays), before these radiations are modified or absorbed by the air. Of particular importance for the theory of upper atmosphere phenomena are measurements of the solar ultraviolet emission.

The results of rocket experiments of the past five or six years have, in many cases, confirmed conclusions already arrived at from sea-level observations. In many other cases they have provided more accurate and reliable data than can be obtained from the extrapolation of low-altitude measurements—for example, in determining the altitude distribution of ozone; and in a few cases they have given information which is completely new and sometimes unexpected—for example, the existence of gravitational separation of atmospheric constituents near the 70-km. level and the existence of a high-intensity electric-current stream above the magnetic equator.

Perhaps the greatest disadvantages of the rocket as a vehicle for high-altitude experiments are the high velocities and the short times spent in the upper atmosphere ($\sim 5$ min.). Rocket experiments involve other limitations which preclude their use for certain measurements and usually make them extremely difficult to perform from a technical point of view. The limited size and weight which are possible, the high accelerations and unpredictable motions, and the difficulty of recovering data, all enter into the design of an experiment. The rocket vehicles in present use in the United States are the small 'Aerobee', the altitude range of which is being extended to about 180 km., and the very large 'Viking' rocket, which has already achieved an altitude record of 220 km. and may be expected to go to much greater heights eventually. Both these research rockets were developed under the auspices of the United States Navy to take the place of captured German *V*-2 rockets with which high-altitude research in the United States was started in 1946.

The trend for the future of sounding rockets will be towards higher altitudes; but for certain experiments the present altitudes are already sufficient, and the greatest handicap consists of the fact that rocket experiments, allowing for but a few minutes of observations, can only be made infrequently and, in general, only at a particular location. In this connexion Dr. Singer reflected on the probable state of ionospheric research or of geomagnetism, were those sciences similarly confined. In his opinion, the development of a rocket capable of long-time observations over a wide geographical range would overcome these fundamental limitations of sounding rockets. Such a rocket might even represent an economical solution of the problem when one considers the expense at present involved in the instrumentation and launching of some dozens of 'Aerobee' rockets. In order to set up an observing station to last at least for a few days, it would be necessary, of course, to place it into an orbit where it could exist for some time as an artificial satellite of the earth. Such a satellite rocket should be viewed mainly as an observatory for studying variations in the emission of solar radiation, both ultra-violet and X-ray; of solar corpuscles; and of the solar component of cosmic rays. Such studies may well constitute the important link necessary for a more complete understanding of the physics of the sun and of the sun's influence on the earth's atmosphere.

The theorist of the upper atmosphere is constantly faced with the necessity of effecting a reconciliation between the physical theories and vast amounts of sometimes uncertain experimental data, together with inferences about the solar spectrum. As Prof. D. R. Bates (Queen's University, Belfast) put it: "It has been said that it is comparatively easy to write a paper about any single aspect of the upper atmosphere, but practically impossible to write consistently about several". As an example he mentioned the problem of the temperature of the exosphere. This temperature can be computed from the known rate of escape of helium gas; one may also ask how this high temperature is maintained in the face of cooling by conduction and also by infra-red radiation from the $^3P$-state of O I. If one invokes for this purpose an increase in the assumed ultra-violet emission of the sun, this in turn requires a re-interpretation of ionospheric observations.

One of the most fruitful lines has been the photochemical theory of the upper atmosphere, which seeks to account for chemical changes through the action of solar ultra-violet radiation. It has been particularly successful in explaining the formation and distribution of ozone. It has been used by Prof. S. Chapman and others to calculate the dissociation of the oxygen molecule; they have shown that, in the region above the 100-km. level, molecular oxygen must be completely broken down into atoms. The position concerning nitrogen is still the subject of controversy: on one hand, auroral spectra suggest that the molecular form is still abundant, even at altitudes of 500 miles; but, on the other hand, there is some observational evidence that dissociation into atoms is significant even at an altitude of about 100 km. Attempts have been made to calculate the relative abundances of the two forms of nitrogen at various levels from the rates of the various photochemical processes likely to be of importance, but these are so complicated that success has not yet been achieved. The time for equilibrium dissociation is found to be of the order of a few years, so that the local equilibrium depends very much on the dynamics of the atmospheric region. Hence any predictions based on static atmospheric models are likely to be incorrect. Similarly, the problem of chemical reactions of nitrogen is extremely difficult. For oxygen all the other gases present are inert, so that only four or five chemical reactions need be considered, whereas in the case of nitrogen molecules the oxygen enters into combination, thus leading to about thirty different chemical reactions.

Already the first measurements on the upper atmosphere have destroyed the old theory which pictured it in a state of hydrostatic equilibrium with hydrogen and helium predominant at the higher levels. Certainly new experimental findings will stimulate the theorist to try out new ideas, but Prof. Bates also reminded those present at the meeting that, in the case of the atmosphere, Eddington's famous advice, "never believe any observational results until they are confirmed by theory", is not without relevance.

The overall impression gained from these talks is that many of the fundamental features which affect the atmosphere are at present either unknown or roughly inferred. A particular point at issue is the ultra-violet and X-ray spectrum of the sun. Some rocket experiments have been made which have succeeded in measuring the spectrum down to about 2000 A. and have also obtained semi-quantitative information in some regions of the far ultra-violet and even X-radiation[2]. However, the technical difficulties of doing this work are very great. Besides this, it is known from the examination of ionosphere records that there exists a great variability in the ultra-violet emission from the sun, so that isolated rocket measurements may not give a representative picture of average conditions of the sun and of the range of these conditions. It seems more likely that once one can relate certain features of the ionosphere with solar ultra-violet emission, one may be able to observe the sun by following changes of the ionospheric layers.

The position is more satisfactory with respect to the structure of the atmosphere. Recent rocket measurements[3] have given values of the temperature, density and pressure up to altitudes of about 220 km. The values up to 150 km. can be considered to be well established and are in rather good agreement with values deduced from meteor observations. In regard to the chemical composition of the atmosphere, first definite evidence that gravitational separation takes place near an altitude of 70 km. has been obtained from stratospheric air samples recovered with rocket-borne sampling-bottles and analysed in Prof. F. A. Paneth's laboratory[4]. It now seems important to confirm these results up to higher altitudes; there is every hope that present techniques can be extended to obtain measurements up to about 120 km. In this connexion Prof. Bates emphasized the great importance of human activity in affecting the abundance of certain minor gases in the atmosphere. He even suggested a new technique, namely, that of deliberately introducing certain rare components, like sodium, into the upper atmosphere in order to observe their photochemical reactions. One might expect rather large luminosities to arise from the conversion of stored-up photochemical energy by only small quantities of sodium.

In the discussions following the papers, Prof. K. G. Emeléus (Queen's University, Belfast) mentioned very briefly the relation of laboratory experiments on gas discharges to actual phenomena in the upper atmosphere. The great stumbling-block in laboratory experiments are the walls of the discharge tube and their effects on the phenomena to be studied. Dr. Singer brought out the point that in many cases the upper atmosphere itself provides a laboratory in which one can study certain physical phenomena. For example, the region of very high electrical conductivity found in the *E*-layer at the magnetic equator[5] strongly suggests the existence of 'boundaries', which could effectively be established by the horizontal magnetic field.

Some important conclusions on the state of the atmosphere above about 150 km. emerged from these stimulating discussions on the physics of the upper atmosphere. Below this level the atmosphere can be thought of as being in a static state; but above this altitude a dynamic picture seems to be necessary, since the static model no longer describes the actual phenomena. This transition was brought out especially clearly by the ionospheric results presented by Mr. Piggott; the differences between the lower and upper regions of the ionosphere are immediately apparent if one draws 'isophots' over the earth's surface: the *E*-layer shows a normal distribution, while the *F*-layer does not. This was emphasized further by the disagreement between photochemical theory and the observations of Dr. Roach, particularly the striking discrepancy in the height of the emitting layers. This non-equilibrium, dynamic condition above the *E*-layer in certain respects resembles tropospheric weather. It is a consequence, it was thought, of the long mean-free-paths, low collision probabilities and consequent long lifetimes of certain states, the low thermal capacity of the upper layers, and also the variability of the ultra-violet emission of the sun. In this connexion the value of isolated observations by rockets above altitudes of 200 km. appears doubtful. It would seem much more necessary to adopt the synoptic approach, as is used for ionospheric studies, particularly with regard to the study of ultra-violet radiation from the sun.

S. F. SINGER

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# DIFFERENTIATION OF VITAMIN $B_{12}$ ACTIVE COMPOUNDS BY IONOPHORESIS AND MICROBIOLOGICAL ASSAY

FROM THE NATIONAL INSTITUTE FOR RESEARCH IN DAIRYING, UNIVERSITY OF READING

## Ionophoresis

By Dr. E. S. HOLDSWORTH

SINCE the isolation of vitamin $B_{12}$ and other members of this group, several other compounds have been detected, related to but not in the cobalamin series. Wijmenga[1] isolated from pig fæces a crystalline substance he called vitamin $B_{12m}$; Ford and Porter[2] found vitamin $B_{12}$-like factors *A*, *B* and *C* in calf fæces, and isolated factor *A* in crystalline form; workers at Glaxo Laboratories (Lester Smith, private communication) have isolated in a fermentation process a factor, to our knowledge, identical with factor *B*; Pfiffner *et al.*[3] obtained pseudo-vitamin $B_{12}$ and pseudo-vitamin $B_{12b}$ from a rumen anaerobe; Lewis *et al.*[4] reported the presence of vitamin $B_{12f}$ in rat fæces; Hausmann[5] has described further compounds, and other vitamin $B_{12}$-like compounds are being discovered. Dr. Pfiffner and Dr. Wijmenga kindly put at our disposal specimens of their compounds for comparison with those isolated by us.

In a study of these factors by paper chromatography with a number of different solvents, we noted that several had almost identical $R_F$ values. Thus factor *A*, vitamin $B_{12m}$ and the pseudo-vitamins $B_{12}$ and $B_{12b}$ could not be separated with the solvents usually employed. The ionophoresis of these substances on paper was then examined. In veronal/acetate buffers between pH 3·0 and 9·0, there was little advantage in the use of ionophoresis, since only factors *B* and *C* have appreciable mobility under these conditions, and these are easily distinguished chromatographically. However, the interesting observation was made that several of the factors when subjected to ionophoresis on paper using 2*N* acetic acid (pH 2·1) gave rise to multiple zones. Fig. 1 shows the findings after ionophoresis for 16 hr. at a potential gradient of 8 volts per cm. The atmosphere in the apparatus contained hydrogen cyanide in an attempt to retain the substances in the cyano-form, and the vitamins were revealed by the bioautographic technique described elsewhere[6]. Factor *A* and vitamin $B_{12m}$ were alike in giving one main zone of the same mobility, accompanied by four

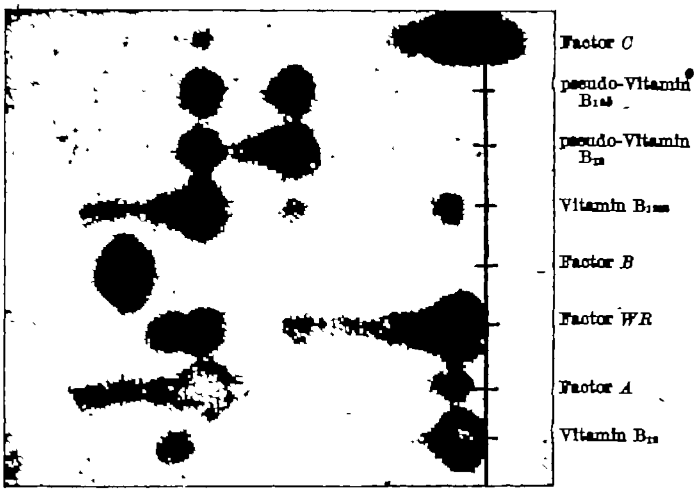

Fig. 1. Bioautograph using *Bact. coli*. Ionophoresis in 2*N* acetic acid for 16 hr. at 270 V.

others. Pseudo-vitamins $B_{12}$ and $B_{12b}$ each gave rise to two zones. A disadvantage of the bioautographic method for detecting activity is that the size of the bacterial growth-zone is proportional to the logarithm of the concentration of active substance, so that substances present only in traces are revealed; this explains why two spots were obtained from vitamin $B_{12}$, the more mobile spot probably representing vitamin $B_{12b}$ formed by loss of the cyano-group. To avoid this complication, the substances were used in larger quantities (50–500 µgm.) to give visible pink spots, the concentration of acetic acid was reduced to 0·5 *N*, with 0·01 per cent potassium cyanide, and finally, the apparatus was protected from strong light. Under these conditions, vitamin $B_{12}$ gave only one pink zone of zero mobility.

Factor *A* contained as major component a substance of mobility $3 \cdot 9 \times 10^{-5}$ cm.$^2$ V.$^{-1}$ sec.$^{-1}$ as calculated by the method described by Kunkel and Tiselius[7], together with three minor components the positions of which suggested that they could be due to the presence in factor *A* of vitamin $B_{12}$, pseudo-vitamin $B_{12}$ and factor *B* (Fig. 2, p. 151). With pseudo-vitamin $B_{12}$ and pseudo-vitamin $B_{12b}$ the major zone, of mobility $1 \cdot 5 \times 10^{-5}$ cm.$^2$ V.$^{-1}$ sec.$^{-1}$, was preceded by a pink spot of the same mobility as factor *A* (Fig. 2). Pseudo-vitamin $B_{12b}$ gave a third zone, brown in colour, of zero mobility and microbiologically almost inactive. By eluting each of the zones obtained from factor *A* and from the pseudo-vitamins $B_{12}$ and $B_{12b}$, and subjecting each to repeated ionophoresis, the materials were obtained as single spots of the presumably pure substances. Vitamin $B_{12III}$ was not available in sufficient amount to allow the separation of a visibly pink substance, but since it gave the same pattern of spots as factor *A* on the bioautograph (Fig. 1), there is reason to believe that vitamin $B_{12III}$ contains the same major component as factor *A*, with pseudo-vitamin $B_{12}$, vitamin $B_{12}$ and factor *B* as impurities. The same considerations suggest that factor *WR* obtained by Wijmenga[1] from ox liver is a mixture (Fig. 1). In cyanide extracts of the natural materials examined, we have so far been able to distinguish five substances having the following mobilities in 0·5 *N* acetic acid expressed as cm.$^2$ V.$^{-1}$ sec.$^{-1}$: factor *A* (vitamin $B_{12III}$), $3 \cdot 9 \times 10^{-5}$; factor *B*, $5 \cdot 0 \times 10^{-5}$; factor *C*, $- 1 \cdot 4 \times 10^{-5}$, that is, moving towards the anode; pseudo-vitamin $B_{12}$, $1 \cdot 5 \times 10^{-5}$; and vitamin $B_{12}$, with zero mobility.

An observation of practical importance made during the ionophoresis of the vitamin $B_{12}$-like substances is that ionophoresis may be applicable to other substances carrying very small electric charge. When the mobilities of the factors were compared in 0·5 *N* acetic acid and 0·1 *M* sodium acetate/hydrochloric acid buffer of the same *p*H, it was found that the mobilities in the buffer mixture were only about a third of those in acetic acid. If the acetic acid was made 0·2 *M* with respect to sodium chloride, sulphate or phosphate, without changing the *p*H of the solution, mobilities decreased. The polyvalent phosphate had the most effect, reducing mobilities almost to zero. Thus it is probable that the ionic strength of the conducting medium is the important factor, since it is known that a charged particle in solution acquires an atmosphere of oppositely charged ions, which have a retarding effect on the particle, the retarding effect increasing with increase in ionic strength[8]. Weak acids other than acetic (for example, phenylacetic and boric acids) can be used, and with a 0·5 *M* solution of boric acid, separations of the vitamin $B_{12}$-like substances can be obtained at a *p*H of 4·5 that cannot be obtained in the presence of strong electrolyte. Conducting solutions of low ionic strength must be used with caution, since they have very little buffering capacity and therefore the substances examined should be free from salts. Moreover, with increasing *p*H values, electro-osmosis becomes more marked and is a complicating factor in obtaining adequate separation.

## Microbiological Tests

By J. E. FORD

We have shown that certain of the vitamin $B_{12}$-like compounds are differently active for different test organisms (cf. Ford[9]). In addition, each substance has different activities, relative to that of vitamin $B_{12}$, for the individual test organisms used in different assay techniques. The ratios of these different vitamin $B_{12}$ activities are characteristic for each of the substances examined, and it was therefore possible to design differential assay procedures to provide evidence for their identity or otherwise.

*Tests with Bacterium coli.* A mutant of *Bacterium coli* requiring vitamin $B_{12}$ was used in the tube-assay technique described by Burkholder[10]. The basal medium was modified by substituting thiomalic for thioglycollic acid.

Tests were also carried out using this organism in the cup-plate technique perfected by workers at the Glaxo Laboratories[11–13] using the same basal medium as in the tube assays.

*Tests with Lactobacillus leichmannii* ATCC 4797. With this organism we have used the method and medium described by Skeggs *et al.*[14], modified only in that the *p*H of the medium was adjusted to 5·5. Nucleotides were omitted from the medium; tubes were steamed for 30 min. before inoculating, and incubated for 60 hr. at 35° C.

*Results.* In Table 1 are set out results of differential assays of a number of vitamin $B_{12}$-active compounds. It is evident that factor *A* and vitamin $B_{12\text{III}}$ have very similar microbiological activities, as have also the pseudo-vitamins $B_{12}$ and $B_{12b}$. The two groups of compounds, however, are clearly different in their microbiological properties. Factors *B* and *WR* are different from each other and from the other two groups of substances. The results presented for factor *C* are only tentative, since this compound has not yet been prepared in pure form in significant amounts, and tests were carried out on a relatively crude concentrate. Optical densities at 361 mμ are included as an indication of the concentrations of the various substances.

Table 1. RELATIVE VITAMIN $B_{12}$ ACTIVITIES OF DIFFERENT COMPOUNDS, MEASURED BY DIFFERENT ASSAY TECHNIQUES
Results are expressed in terms of the activities measured by the *Bacterium coli* tube-assay, given as 100 in each instance

| Substance | Relative optical densities* at 361 mμ | *Bact. coli* tube-assay | *Bact. coli* plate-assay | *Lacto. leichmannii* tube-assay |
|---|---|---|---|---|
| Vitamin $B_{12}$ | 100 | 100 | 100 | 100 |
| Factor *A* | 204 | 100 | 267 | 83 |
| Vitamin $B_{12\text{III}}$ | 238 | 100 | 282 | 91 |
| Pseudo-vitamin $B_{12}$ | 560 | 100 | 700† | 293 |
| Pseudo-vitamin $B_{12b}$ | 525 | 100 | 525† | 280 |
| Factor *WR* | 310,000‡ | 100 | large 'fuzzy' zones | 40,000‡ |
| Factor *B* | 1,350§ | 100 | 770 | 0·38 |
| Factor *C* | not known | 100 | 8,500 | 13·9 |

* Values are only very approximate. In some instances the amounts available for measurement were very small.
† Responses were markedly non-linear.
‡ This high figure reflects the low activity of factor *WR* in the *Bacterium coli* tube-assay.
§ The absorption maximum of this compound is, in fact, at 355 mμ.

In Table 2 are shown results obtained in the differential assay of certain components of these 'parent' compounds, obtained by ionophoresis in 0·5 *N* acetic acid as described in the first part of the paper.

Table 2. RELATIVE MICROBIOLOGICAL ACTIVITIES OF COMPONENTS OF VARIOUS VITAMIN $B_{12}$-LIKE COMPOUNDS OBTAINED BY IONOPHORESIS

| 'Parent' substance | Component | Ionophoretic mobility in 0·5 *N* acetic acid ($\mu \times 10^5$) | *Bact. coli* tube-assay | *Bact. coli* plate-assay | *Lacto. leichmannii* tube-assay |
|---|---|---|---|---|---|
| Factor *A* | Spot 3 | 3·9 | 100 | 274 | 64·4 |
| Pseudo-vitamin $B_{12}$ | Spot 2 | 3·9 | 100 | 264 | 68·0 |
| Pseudo-vitamin $B_{12}$ | Spot 1 | 1·5 | 100 | 1,400* | 425 |
| Factor *A* | Spot 2 | 1·5 | 100 | 1,000* | 375 |
| Factor *B* | Factor *B* | 5·0 | 100 | 580 | <0 3 |

* Responses were markedly non-linear

It is clear that the major component of factor *A*, its 'spot 3', is not distinguishable by these tests from the minor component of pseudo-vitamin $B_{12}$, its 'spot 2'. In the same way, the major component of pseudo-vitamin $B_{12}$, its 'spot 1', is not distinguishable from a minor component of factor *A*, its 'spot 2'.

There is evidence from bioautographs that factor *WR* contains, in addition to its several vitamin $B_{12}$-active components (see Fig. 1), a further substance inhibiting the growth of *Bacterium coli*. The presence of this inhibitor no doubt explains the low activity of the compound for this test organism.

# Occurrence of the Various Vitamin $B_{12}$ Active Compounds

## By J. E. FORD, DR. E. S. HOLDSWORTH, DR. S. K. KON and DR. J. W. G. PORTER

THE ionophoretic and microbiological findings just described show that compounds formerly accepted as pure were not, in fact, pure. We interpret our findings as proof that factor *A* and vitamin $B_{12\text{III}}$ are not pure substances, but that they contain the same major component. Similarly, pseudo-vitamins $B_{12}$ and $B_{12b}$ owe their activity to a common major component, different from that of factor *A* (or vitamin $B_{12\text{III}}$), and to factor *A*. The lower microbiological potencies of pseudo-vitamin $B_{12b}$ are probably due to the presence in it of a third component detected by ionophoresis (Fig. 2) that has little activity for micro-organisms.

Vitamin $B_{12f}$[4], from our experience with vitamin $B_{12}$-active compounds from rat fæces (see below), may possibly be a mixture of factor *A* and pseudo-vitamin $B_{12}$. Factor *WR*[1] from beef liver contains factor *A*, pseudo-vitamin $B_{12}$ and vitamin $B_{12}$, and is interesting in that it indicates that factors other than vitamin $B_{12}$ can appear in small amounts in the liver of ruminants (cf. Ford *et al.*[13]). Further, we have found that the vitamin $B_{12}$ activity of cow urine is largely contributed by substances other than vitamin $B_{12}$ (unpublished).

We have estimated the relative amounts of the different vitamin $B_{12}$-active compounds in the fæces of calves, rats and rabbits. Chromatography of extracts of all these materials showed a broadly similar distribution of activity: the main component being fraction *A* with small contributions from factors *B*, *C* and vitamin $B_{12}$. The fraction *A* component from each extract was repeatedly chromatographed until it appeared homogeneous: subsequent ionophoresis in 0·5 *N* acetic acid separated the apparently homogeneous fraction *A* component from calf fæces into factor *A* with some pseudo-vitamin $B_{12}$ and a trace of vitamin $B_{12}$; the fraction *A* component from rat fæces yielded approximately equal amounts of factor *A* and pseudo-vitamin $B_{12}$; and that from rabbit fæces yielded factor *A* and only a trace of pseudo-vitamin $B_{12}$.

In the light of these findings we now consider that the vitamin $B_{12}$-activity for micro-organisms of extracts of gut contents and fæces, prepared in the presence of cyanide, is contributed in varying proportions by the following five substances: factors *A* (vitamin $B_{12\text{III}}$), *B* and *C*, pseudo-vitamin $B_{12}$ and vitamin $B_{12}$ itself. In natural materials these compounds may exist in both free and combined forms (see also ref. 5).

The facts that these compounds act as alternative growth-factors for several micro-organisms, and that in extracts of *Bacterium coli* cells grown in a peptone medium all five compounds are present, suggest their close structural similarity.

The difficulty of separating these vitamin $B_{12}$-like compounds in a pure state by chromatography, and the relative ease with which chromatographically homogeneous though impure compounds crystallize (for example, factor *A*, vitamin $B_{12\text{III}}$ and pseudo-vitamin $B_{12}$), may give rise to a number of spurious new 'substances' with similar though not identical properties. Such new 'substances' are likely to be isolated during the fractionation of the vitamin $B_{12}$ activity of natural materials unless ionophoretic

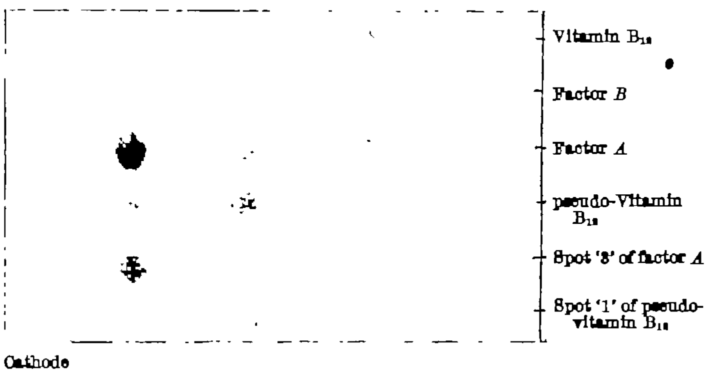

Fig. 2 Visibly pink amounts of the factors after ionophoresis in 0·5*N* acetic acid for 16 hr. at 270 V. Movement of vitamin $B_{12}$ was due to electro-osmosis

techniques, which are more selective than those of chromatography, are used for their resolution.

As these vitamin $B_{12}$-active compounds are formed by microbial synthesis in the rumen or in the large intestine or in both, it is probable that the relative amounts of each that appear in gut contents depend on the composition of the microbial flora. This is known to be, to some extent, governed by the composition of the diet, so that even within one species it is likely that the relative amounts of each of these factors will vary with the nature of the diet.

We should again like to thank Dr. Pfiffner and Dr. Wijmenga for their generosity in allowing us to examine their compounds, and to publish our findings. The interpretation of the results is solely ours ; the conclusions may not represent the views of Dr. Pfiffner or Dr. Wijmenga and do not bind them in any way. [Dec. 3.

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# OBITUARIES

## Prof. M. G. Evans, F.R.S.

PHYSICAL chemists all over the world will have learned with sorrow of the untimely death of Prof. M. G. Evans. A graduate of the University of Manchester, Evans was appointed to the staff of the University in 1926, and after spending a year with a Rockefeller fellowship at Princeton, he was appointed to the chair of inorganic and physical chemistry in the University of Leeds in 1939. While at Leeds he established an international reputation for his work on the fundamental processes occurring in chemical reactions, and was elected a Fellow of the Royal Society in 1947. In 1948 he returned to Manchester to the chair of physical chemistry, and had already established a flourishing research school there when his scientific work was so tragically brought to its close.

Evans occupied a unique position in English physical chemistry. His versatile and flexible mind endowed him with a remarkable capacity for grasping the essentials of any scientific problem which was presented to him. All those who had the opportunity of working with him were astonished at his ability to state their problems for them in clear, exact and illuminating language, and there was no better cure for the all too common complaint of 'getting stuck' than to go and have a chat with 'M. G.', as he was known to all his friends. Evans's inspired common sense was the secret of his scientific success, both in his own work and in guiding the research of others.

Evans was one of the early pioneers of the transition state theory, applying it to quite complicated chemical reactions ; and it was largely his inspiration which led to the modern theory of unimolecular reactions. His work on the initiation of polymerization led to important technical advances, and in more recent years he clarified in an elegant way the nature of the electronic processes occurring in oxidation and reduction. The papers of Evans and his school on the so-called electron-transfer reactions are classics in that field. Possibly less well known but no less penetrating were his contributions to applied wave mechanics and the statistical mechanics of surfaces, and one of his most important contributions to the theory of bond dissociation energies was made only just before his death. The 1953 Jubilee Discussion of the Faraday Society on "Solutions of Non-electrolytes" was originally conceived by Evans.

Outstanding as a physical chemist, M. G. Evans was equally outstanding as a person. His industry and great ability were matched only by his extraordinary modesty and a personal charm which won him the affection, as well as the admiration, of all those who had the good fortune to meet him. He combined without affectation the hard-headedness of a scientific administrator and the subtlety and sensitivity of a creative artist. His nomination to the Government's Advisory Council on Scientific Policy and to the Scientific Advisory Council of the Ministry of Supply imposed on him a heavy burden of additional responsibility. Nevertheless, in spite of the severe strain to which he undoubtedly subjected himself, Evans was always ready to help those who came to see him with scientific or personal problems, and there will be many of his friends who will sadly miss his wise and sympathetic counsel.

H. C. LONGUET-HIGGINS

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## Prof. V. N. Ipatieff

PROF. VLADIMIR NIKOLAEVICH IPATIEFF died in Chicago on November 29, 1952, just one week after his eighty-fifth birthday. Few men of science in our times have had more remarkable careers.

Born in Moscow in 1867, he attended a series of military schools and graduated from the Michaelovsky

Artillery School in 1892. He had developed an interest in chemistry several years before this and established a private laboratory from his small earnings; because of the nature of the curriculum and the instruction, most of his chemistry was self-taught. He remained at the Michaelovsky Artillery School as an instructor in chemistry and later became its first professor of chemistry. During 1896–97 he was sent to Western Europe, where he studied with von Baeyer in Munich and with Vielle and Sarraut in Paris, and in 1907 the chair of chemistry in the University of St. Petersburg was added to his duties.

During the First World War, Ipatieff was a lieutenant-general in charge of the Russian chemical industry, and because of his distinction he continued to hold high office during the Soviet regime. From 1921 until 1926 he was a member of the Supreme Economic Council of the Soviet Union, and in 1927 an institute for the study of high-pressure reactions was established for him. However, the scientific climate was increasingly distasteful to him and, in the company of his wife, he managed to leave Russia. After a short stay in Germany, he went to the United States in 1931 to become a lecturer in chemistry at the Northwestern University, Evanston, Ill., and director of research at the Universal Oil Products Co. In 1938, in order more easily to pursue purely academic research and to be able to teach his techniques to students, he established the Ipatieff High-Pressure Laboratory at the Northwestern University with the support of the Universal Oil Products Co., and he was actively engaged in his positions at the University and with the Company until two weeks before his death.

Commencing his career in the United States at an age when most men retire, Ipatieff published thereafter about a hundred and fifty scientific papers and obtained more than two hundred patents. He had already published some two hundred papers before he left Russia, starting with one in 1892, "Chemical Investigation of the Structure of Steel". The many honours that he received are too numerous to enumerate here, but mention should be made of the fact that he was the only man to have held regular membership in the national academies of science of both the U.S.S.R. and the United States (though his membership in the former, along with all other Russian honours, was cancelled by the Soviet Government in 1936 following his repeated refusal to return to the U.S.S.R. His wife, Barbara Demitrievna, with whom he had celebrated in 1952 their sixtieth wedding anniversary, survived him but a few days and died on December 9. Of their children, a son and a daughter still live in the U.S.S.R., one son was killed in the First World War and another lost his life while fighting tropical fevers in the Belgian Congo.

Ipatieff was a man of charm and kindness who enjoyed social contacts. He was always ready with encouragement and assistance to anyone interested in advancing science. He was an indefatigable worker who set himself a hard schedule, any disturbance to which upset him, and in particular his rare illnesses especially outraged his sense of order. While his life was primarily devoted to science, he had a number of other interests. He was a devout member of the Russian Orthodox Church, though no narrow sectarian, and he read widely in literature. In his earlier days he was an expert rider; fishing and swimming mainly occupied his vacations until a few years ago, and he was a great walker.

After some work of interest in ordnance and some in classical organic chemistry, of which that on the structure and synthesis of isoprene was particularly notable, Ipatieff became interested in heterogeneous catalysis, for he thought that high pressures of hydrogen would facilitate the hydrogenation of organic compounds. In testing this hypothesis he had to develop equipment for working at high pressures, in which task he was helped by his training as an artilleryman, and in 1903 he developed the first practical experimental autoclave for working at high pressures. He devoted much of his life to the exploitation of this discovery in a wide field of catalytic reactions, particularly hydrogenation. His pioneer work in high-pressure hydrogenation had revolutionary effects upon laboratory and technical procedures in many fields of chemistry. He was the first to recognize the use of promoters in heterogeneous catalysis. His work in the United States is notable for the discovery of the 'solid phosphoric acid' catalysis for the polymerization of olefines, for the discovery of the alkylation of olefines by *iso*paraffins and for work in the isomerization of alkanes. His research was one of the main sources of the revival of interest in hydrocarbon chemistry and of aliphatic chemistry in general and may be considered as the origin of much of modern petroleum technology.

Several months ago the Universal Oil Products Co. entered into negotiations with Northwestern University to establish the Vladimir Ipatieff research professorship, by which the Company will grant the University 25,000 dollars annually for the salaries of the professor and an assistant and for other expenses. It is a source of much gratification that Ipatieff had been informed of the final details of this professorship a few days before his death.

Robert L. Burwell, Jun.

## Dr. K. G. Blair

Kenneth Gloyne Blair, who at the time of his retirement was a deputy keeper of the Department of Entomology of the British Museum (Natural History), died at Freshwater, Isle of Wight, on December 11. Born at Nottingham on December 22, 1882, he was educated at Highgate School and Birkbeck College, London. After a brief period spent in other government offices, he transferred in 1910 to the Natural History Museum, being appointed assistant in the Department of Zoology, which then included entomology.

Under Dr. C. J. Gahan, Blair was put in charge of a large section of the Coleoptera comprising principally the Heteromera, which had perforce been largely neglected for many years. His systematic overhaul of these collections resulted in the publication of numerous papers concerned with the critical revision of genera and species, the description of new ones, the elucidation of the work of the early authors, a catalogue of the Pythidæ and Pyrochroidæ, and so on. Concurrently he published many papers of faunistic interest, based largely on collections made by various expeditions. These ranged from Mt. Everest, Krakatau, Samoa, Fiji, the Mentawi Islands, Christmas Island and the Marquesas in the East, through southern Arabia and South Africa to the Galapagos Islands.

But it would be wrong to base any estimation of Blair's contributions to entomology solely on the evidence of these works. He was at his best in the field among living insects, where he had a quite amazing flair for the 'good thing' and in consequence added considerably to our knowledge of the British fauna in nearly all orders of insects. Insect luminosity, and the complex inter-relationships of the inhabitants of plant galls, fascinated him and were the subject of several papers; fossil insects, myrmecophiles, insect stridulation and the morphology of beetle larvæ also attracted his attention. Up to the time of his retirement, due to ill health attributable to service with the Seaforth Highlanders during the First World War, he took a most active part in the proceedings of the societies to which he belonged. He was president of the South London Natural History Society in 1920, 1921 and 1931 and of the Royal Entomological Society during 1940–41. He is mourned by a very wide circle of friends, who will always remember gratefully the help he gave so freely and modestly to all who sought it, from his unusually wide store of knowledge and experience.

N. D. Riley

## Mr. E. G. Dymond

Edmund Gilbert Dymond died suddenly in Edinburgh on October 26. He was born at Hairwain, South Wales, in which town his father was engaged in business as a civil engineer. Between the ages of twelve and eighteen persistent ill-health made regular schooling impossible, but at the latter age he entered St. John's College, Cambridge, and thereafter lived an active and productive life. Only his early death reminded his friends that his energy and enthusiasm must often have outmatched his strength.

Dymond obtained first-class honours in physics in Part 2 of the Natural Sciences Tripos in 1922, and was awarded a Hutchinson research studentship by St. John's. In 1925 his College elected him to a fellowship. He had spent two of the intervening years in research at the Cavendish Laboratory, and the third as International Education Board Fellow at Göttingen. The following year he spent in Princeton. During the whole of this time, and throughout the next five years, when he was back in Cambridge, Dymond investigated various problems of electron collisions in gases.

In 1932 Dymond moved to Edinburgh, first as Carnegie Teaching Fellow, then as lecturer, and after 1948 as reader in natural philosophy. Soon afterwards his main research interest changed, and as a member of the Wordie expedition to North-West Greenland in 1937 he obtained records of cosmic ray intensity, using balloon-borne apparatus up to a height of about twelve miles. About the same time he released his first balloons from the Edinburgh district in similar investigations. This work remained interrupted throughout the Second World War, but Dymond continued his contribution to upper-atmosphere physics at Kew Observatory, where he developed and perfected the British *radio-sonde*. He returned to Edinburgh in 1946.

Building up equipment again after the War, and gathering a small research team around him, he was favourably placed to add considerably to our knowledge not only of cosmic radiation at great heights, but also of ozone distribution. However, only one major investigation was complete at the time of his death. The progress of the others will be slower for lack of his direction.

N. Feather

## Prof. L. Lapicque

Colleagues and friends in every country will regret the death, at the age of eighty-six, of Louis Lapicque, professor at the Sorbonne during 1919–36 and the leading figure in French physiology. His early researches were biochemical and they were followed by an expedition to the Andaman Islands to collect anthropological data; but in 1902, after his return to France, he took up the studies of excitability in nerve and muscle for which he became famous.

Lapicque used new methods to explore the relation between the duration and the strength of an effective electric stimulus: his curves showed the inadequacy of Nernst's treatment and led to new ideas based on the measurement of the 'chronaxie', a quantity giving the time factor of the excitation process. In collaboration with Mme. Lapicque he studied the chronaxie relations of a wide variety of tissues and demonstrated their essential similarity. The theory of isochronism which he afterwards developed may not have had all the far-reaching implications suggested by it, but his ingenious experiments and trenchant exposition have a classical quality which will be long remembered.

Between the two World Wars, Prof. Lapicque played a decisive part in the development of physiology in France. He was a welcome figure at international gatherings, where he spoke lucidly and with conviction on the problems of scientific co-operation. Vigorous in body as in mind, a keen yachtsman and a charming host, he was a worthy representative of the great traditions of his country.

E. D. Adrian

# NEWS and VIEWS

## Chair of Mining in the Imperial College, London: Prof. J. A. S. Ritson

Prof. J. A. S. Ritson vacated the University of London chair of mining at the Royal School of Mines, Imperial College, in October 1952, after a distinguished tenure of seventeen years. He is a graduate of the University of Durham, and started his professional career as inspector of mines in the Scottish, Yorkshire and South Wales coalfields. After distinguished service in the Army during the First World War he occupied the chair of mining in the University of Leeds during 1923–35, where he devoted much of his research to the improvement of mine rescue appliances and shot-firing techniques. Since his appointment to the Royal School of Mines, Prof. Ritson has maintained his keen interest in coal mining, and rapidly gained a high reputation as an expert on problems of metalliferous mining, based on experience won in various parts of the world. Among his multifarious duties he has acted for many years as Crown mineral agent, as a member of the Coal Commission, and as deputy chairman of the Mineral Resources Committee of the Ministry of Fuel and Power; during the Second World War he joined that Ministry for a few years as director of mining supplies and director of production. He served two sessions as president of the Institution of Mining Engineers and is now president-elect of the Institution of Mining and Metallurgy. Prof. Ritson has always been intensely interested in the education and training of mining engineers, and has played a leading part during recent years in organizing the expansion and intensification of courses in mining and mineral dressing at the Royal School of Mines.

### Prof. J. C. Mitcheson

PROF. J. C. MITCHESON, who has succeeded Prof. Ritson in the Royal School of Mines, comes of a family long distinguished for its outstanding services to the mining industry in the Midlands coalfields. After graduating at the University of Birmingham, he acted there for a year as lecturer in coal mining and demonstrator in mines rescue, before joining his father's consulting practice in Stoke-on-Trent in 1924. Afterwards he spent many years as agent and later as managing director of the Birch Coppice Collieries, near Tamworth, one of the largest collieries in the Warwickshire Coalfield. After serving as director of production for this coalfield, under the Ministry of Fuel and Power, he was appointed divisional chief planning engineer of the West Midlands Division, National Coal Board, returning in 1947 to practice as consulting mining engineer. During his twenty years experience in the management of collieries, he has been closely associated with research in mining and has pioneered many new methods of fuel efficiency, machine mining, coal preparation, underground lighting, accident prevention and roof control. Throughout this period he has served assiduously as a member or chairman of various education and training committees in the Warwickshire Coalfield. At the present time he is on the Mining Qualifications Board and the Safety in Mines Research Board set up by the Ministry of Fuel and Power, besides being intimately concerned with the new national certificate schemes for the mining industry. It is a happy augury that he should succeed to the chair of mining at the Royal School of Mines while serving as president of the Institution of Mining Engineers.

### Wilfred Hall Telescope

THE 15-in. visual refractor, with 15-in. photographic refractor attached, which formed the principal equipment of the late Dr. Wilfred Hall's private observatory near Newcastle, is now the subject of a bequest which it is proving regrettably difficult to accept. It was bequeathed in the first instance to the British Astronomical Association, and failing acceptance by the Association to the Royal Astronomical Society, provided that they "make use of it or cause it to be made use of on such terms and conditions as they may see fit, in some place chosen by them where in their opinion it can be of service to scientific research"; but it is estimated that to set it up will cost between two and three thousand pounds, even allowing for the fact that the will provides £500 towards the cost of removal—it cannot stay where it is.

It seems clear that only some permanent authority could properly be entrusted with such a long-term responsibility as this telescope must represent; if it is hard to find the money once, no scheme can be considered which would imply having to find it repeatedly, and a permanent loan to some educational body seems inevitable. The British Astronomical Association has been in touch with one body which hoped to pay half the cost, but after careful study it was decided that the number of members of the Association who would make any serious use of the telescope was too small, at any one site, to justify providing even half the cost from the Association's limited resources; it has therefore refused the bequest. It seems improbable that the Royal Astronomical Society could accept any financial liability either, and the telescope can thus be saved from the dealers' hands only if the entire cost of installation can be raised in some other way, before the Royal Astronomical Society in its turn refuses the offer. If the telescope is sold, the proceeds revert to Dr. Hall's estate. The will does not appear to demand that if accepted it shall be used purely for research, nor is it conspicuously a modern research tool. It could tackle certain tasks, and at the same time could introduce a number of people to some of the subjects and methods of research, and add greatly to a general knowledge of astronomy in its neighbourhood. It is to be hoped that some way may be found of grasping the opportunity that has arisen.

### World Power Conference: Annual Report for 1951

THE annual report for 1951 of the World Power Conference (pp. 32; from 201 Grand Buildings, London, W.C.2; 1952; 1s. 6d.) records a membership of forty countries, in thirty-seven of which National Committees have been formed; the German Federal Republic and Japan were admitted to membership at the July 1951 meeting of the international executive council. A brief chronicle of the sectional meeting held in New Delhi during January 10–16, 1951, is appended to the report; the technical sessions were held concurrently with sessions of the Fourth Congress of the International Commission on Large Dams and the First Congress of the International Commission on Irrigation and Drainage. The bound transactions of the former meeting have recently been published. An invitation to hold a sectional meeting in Rio de Janeiro during July–August 1954 was accepted by the international executive council, and an outline of the technical programme for this meeting is also appended: the topics to be discussed centre around the special energy problems of the tropical and sub-tropical countries. A report on the work of the World Power Conference in the field of water control and utilization was prepared for the secretariat of the Economic and Social Council of the United Nations. Statistical Year-book No. 6 of the World Power Conference is in the process of being published. A list of publications, issued or to be issued under the auspices of the international executive council, is also appended. At the annual general meeting of the British National Committee, Sir John Hacking was elected vice-chairman and Mr. F. G. Brewer honorary treasurer, in succession to Mr. H. Hobson and Colonel C. M. Croft, respectively.

### Pedo-botanical Surveys in the Belgian Congo

THE study of soils and the associated vegetation is now one of the principal tasks of the Institut National pour l'Étude Agronomique du Congo Belge (I.N.E.A.C.). A recent report ("Les Associations Végétales de la Plaine de la Ruzizi (Congo Belge) en Relation avec le Milieu". Publ. I.N.E.A.C., Sér. Sci. No. 52, pp. 1–321, 1952; 180 fr.), by R. Germain, deals with a pedo-botanical survey of the Ruzizi plain, the extensive and varied alluvial territory that lies between Lakes Kivu and Tanganyika. The physical environment, the flora, the several habitats —some nine, ranging from aquatic to forest paraclimax, are indicated—and their floristic associations are described in detail and illustrated by graphs and numerous excellent photographs. The plain is floristically rich, with 877 species of seed plants and pteridophytes, comprising 427 genera and 99 families. There is a marked dominance of species of the basic Sudanese–Zambesian flora (42·6 per cent) with 6 per cent of foreign species, chiefly from the west, the balance being transitional and widely distributed species.

## Electron Microscope and Microdissection

UNDER this title, R. Bovey (*J. Roy. Micro. Soc.*, Ser. III, **72**, 56; 1952) has described and illustrated a new technique for preparing biological specimens for study with the electron microscope. Using the de Fonbrune micromanipulator and an inverted microscope, the microdissection is made directly on a collodion film, or a film of 'Formvar', supported by a thin coverslip. The specimen is afterwards mounted on a grid. It is shown that the technique described can be successfully applied to the study of nuclear and cellular membranes and similar materials.

## Microbial Growth and its Inhibition

EIGHTEEN of the papers presented at the First International Symposium on Chemical Microbiology, which was held in Rome during June 1951, have been brought together under the title "Microbial Growth and its Inhibition" in No. 10 of the World Health Organization Monograph Series (pp. 285. Geneva: W.H.O.; London: H.M.S.O., 1952. 15*s*., 3 dollars or 12 Sw. francs); the papers had been previously published in the *Bulletin* of the World Health Organization. Many of the communications deal with the production, chemistry and testing of antibiotics, while problems of resistance are discussed by M. Welsch and L. L. Cavalli. The lag phase in the growth of *Pasteurella pestis* is investigated by S. S. Sokhey, and B. C. J. G. Knight discusses the physiological background to problems of growth inhibition. The role of the B group of vitamins in biosynthetic processes is dealt with by D. D. Woods, with particular reference to the metabolic functions of folic acid and $B_{12}$, and J. Monod presents his investigations concerning the specific inhibitors and inducers involved in the production of β-galactosidase in *Escherichia coli*. The collection of papers represents in general a number of contributions on specific aspects of microbial growth and of the properties of substances inhibiting such growth, rather than an outline or synthesis of present knowledge. Discussions are not published, but each paper concludes with useful summaries in both English and French.

## Centrifuges and *p*H Meters

A SURVEY of the requirements of biologists using centrifuges and *p*H meters has been made by the Institute of Biology. The analyses of the views expressed are given in two reports, which have been sent to all who collaborated in the survey and to all British manufacturers of the instruments. It is hoped that this presentation of the collected views of biologists, by making clear those features which are desirable but often lacking and the defects now experienced by users, will enable manufacturers to introduce the necessary modifications to existing models and to design future instruments to meet the expressed needs. Copies of the reports can be obtained from the General Secretary, Institute of Biology, Tavistock House South, Tavistock Square, W.C.1.

## A.S.T.M. Index of X-Ray Powder Diffraction Data

THE index, prepared by the American Society for Testing Materials, of X-ray powder diffraction data, widely known as the A.S.T.M. Index, has now been in use for about ten years, and it is recognized that it contains a number of wrong identifications which are likely to lead to confusion. The X-ray Analysis Group of the Institute of Physics therefore proposes to collect information on the errors which have been observed by users of the Index, and to publish as soon as possible in some suitable way a list of all those errors which seem to be substantiated. It is believed that many, if not all, of these errors have by now been noted by various workers and may in some cases have been mentioned casually in their publications; but in order to be of real use to others it is necessary that they should all be published collectively. Accordingly, everyone who has noted such errors is asked, whether he has already published them or not, to send the details to Dr. A. J. C. Wilson, University College, Cathays Park, Cardiff.

## Development of Mineral Resources in the United States

A PANEL of specialists in geology, mining and geophysics representing industry, government and the universities in the United States has been established to advise the National Science Foundation on policy questions connected with the recommendations of the President's Materials Policy Commission for development of the mineral resources of the nation. The first meeting of the panel was held in Washington, D.C., on November 29, 1952. In its report, the Commission recommended that "an intensive program of basic scientific research and technical development be undertaken on techniques and instruments of exploration for minerals", and the advisory panel of the Foundation will consider the need for an inventory of current research in exploration techniques and the formation of a committee to make such an inventory.

## Nineteenth International Physiological Congress, Montreal

THE Nineteenth International Physiological Congress will be held in Montreal during August 31–September 4, 1953, and one of the main concerns of the organizers of the Congress is to ensure that an adequate number of scientific workers from overseas countries will attend, despite the relatively heavy financial expenses that must necessarily be incurred by such participants. Physiologists, biochemists, pharmacologists and others from outside Canada and the United States who hope to attend the Congress are therefore asked to notify the secretaries of their national societies of that fact as soon as possible. This will aid the Congress organizers in arranging for special lectures and discussions to be held in the United States and Canada during the weeks preceding and following the Congress; it is hoped that those from overseas who are invited to take part in such functions will, in some cases at least, receive financial help that will appreciably reduce the cost of attending the Congress itself. Those who live in countries where there are no national scientific societies, and who hope to attend the Congress, should write directly to the executive secretary of the Congress at McGill University, Montreal. Arrangements are being made for an exhibition of scientific instruments and books at the Congress, and representatives of firms who wish to reserve space at this exhibition should write to the exhibit manager, Mr. Steven K. Herlitz, 280 Madison Avenue, New York, N.Y.

### Education in Chemistry: Discussion in London

A discussion on "Education in Chemistry", under the joint auspices of the London Sections of the British Association of Chemists and of the Royal Institute of Chemistry, will be held at 6.30 p.m. on February 18 at the Wellcome Research Institution, 183 Euston Road, London, N.W.1. The principal speakers will be Prof. C. K. Ingold, professor of chemistry, University College, London; Dr. J. W. Skellon, head of the Department of Chemistry, Acton Technical College; Dr. O. L. Brady, reader in organic chemistry, University College, London; Mr. R. W. Blount, chief inspector, Ministry of Education; and Dr. Norman Booth, research manager, British Oxygen Co., Ltd. Five themes to be covered will be: the aim of the revised regulations in science; external degrees in science; professional qualifications in chemistry; National Certificate in chemistry; and requirements of industry. Visitors are welcome to the meeting, and those who intend to participate in the general discussion should inform one of the secretaries, either F. C. Hymas, honorary secretary of the London Section, Royal Institute of Chemistry, 30 Russell Square, London, W.1, or T. Bewley, honorary secretary of the London Section, British Association of Chemists, Hinchley House, 14 Harley Street, London, W.1.

### Physical Society: Meeting in Leeds on Solid-state Physics

The spring provincial meeting of the Physical Society will be held in the Department of Physics, University of Leeds, during March 30–April 1. The subject of the meeting, "Aspects of Solid-state Physics", will be divided into three sessions as follows: analysis of magnetization curves; band theory of metals; and ferroelectricity and luminescence. Papers will be read by the following: A. F. Devonshire (University of Bristol); E. W. Elcock, J. Ewles, F. E. Hoare, K. Hunt, P. Rhodes, E. C. Stoner and R. S. Tebble (University of Leeds); H. Jones and E. P. Wohlfarth (Imperial College of Science and Technology, London); L. F. Bates (University of Nottingham); E. E. Schneider (King's College, Newcastle upon Tyne); W. Sucksmith (University of Sheffield). Non-members of the Society are welcome to attend the meeting, but must apply before March 9 to the offices of the Physical Society, 1 Lowther Gardens, Prince Consort Road, London, S.W.7, where all further particulars can be obtained.

### Institute of Biology: London Meetings

The Institute of Biology is holding three meetings in London, which are experimental in nature, one purpose being to determine whether there is adequate support for the formation of a London branch of the Institute on a permanent basis. They are experimental also in their form and subject; for example, it is thought that some future meetings might be held jointly with other societies, and that the formation of study groups might be considered. The first meeting, an illustrated talk by Dr. N. Tinbergen, reader in animal behaviour, University of Oxford, on "The Functions and Causation of Animal Courtship", was held on January 22. The other two are as follows: a whole-day visit on February 21 to the Zoological Gardens, Regent's Park; and a meeting on "Setting about Research for Oneself", to be held at 7.30 p.m. on March 26, at the Society for Visiting Scientists, 5 Old Burlington Street, London, W.1, at which the principal speakers will be Dr. T. E. Wallis (sometime reader in pharmacognosy, University of London), Dr. W. B. Turrill (keeper, Herbarium, Kew), G. A. Steven (fisheries naturalist, Marine Laboratory, Plymouth) and Dr. P. Alexander (Chemistry Department, Imperial College of Science and Technology). The visit to the Zoo, for which a fee of 7*s*., inclusive of luncheon, will be charged, is restricted to members of the Institute only, and application should be made to D. Wragge Morley, 47 Downshire Hill, London, N.W.3. For the third meeting, members may bring guests. Further information can be obtained from the Institute of Biology, Tavistock House South, Tavistock Square, London, W.C.1.

### Announcements

King's College of Household and Social Science, University of London, has been granted by H.M. The Queen a royal charter of incorporation as Queen Elizabeth College.

Dr. T. E. Allibone, director of the Research Laboratory of the Associated Electrical Industries, Aldermaston, Berks, has also been appointed director of research to the Edison Swan Electric Co. and to the board of that Company.

Appointments to chairs in University College, Dublin (National University of Ireland), have been made as follows: Dr. T. E. Nevin (experimental physics); Mr. P. E. Mullaney (veterinary pathology and bacteriology); Mr. W. R. Kelly (veterinary medicine and meat inspection).

The following staff changes in the University of Leeds have been announced: K. L. Butcher has been appointed Brotherton lecturer in chemical engineering; Dr. J. P. Danby, lecturer in the Department of Leather Industries, and Dr. B. D. Wyke, lecturer in the Department of Physiology, have resigned their posts.

Australian National University scholarships for work in the University's Department of Nuclear Physics under Prof. E. W. Titterton have been awarded to the following graduates: Mr. A. J. F. Boyle (University of Melbourne), Mr. H. J. Hay (University of Otago, N.Z.), Mr. D. W. Smellie (University of British Columbia), and Mr. A. C. Riviere (University of Western Australia, now at the National Physical Laboratory, Teddington). The scholars will take up residence in Canberra at the commencement of the Australian academic year.

The American Society for the Study of Sterility is offering a prize of a thousand dollars for the most outstanding contribution to the subject of infertility and sterility. Entries for the prize must consist of an essay based on research in this field, and all essays must be received not later than March 1. Further details of the competition can be obtained from the Society, c/o Dr. Herbert H. Thomas, 920 South 19th Street, Birmingham, Alabama.

Erratum. In the title of the letter by Eileen L. Blackall and Prof. E. D. Hughes in *Nature*, 170, 972 (1952), for "*C*-Nitration" read "*O*-Nitration".

# RESEARCH IN BRITISH COLONIAL TERRITORIES*

ALL the main research schemes in progress under the Colonial Medical Research Committee were continued during 1951–52, and its seventh annual report records the filling of thirteen vacancies, although recruitment still lags behind requirements. A malaria-research scheme in Jamaica was concluded and established, with similar objectives, in the Gold Coast. A small grant was made towards a new project, an investigation of goitre in Nigeria. Two regional standing advisory committees for medical research have recently been instituted in East and in West Africa, respectively, to advise on the needs and priorities for medical research in these regions and to promote the co-ordination of current research activities within the region and with research workers in the United Kingdom. Under the East African Medical Survey, which is intended to be in three phases, work has been commenced on Ukara Island on Lake Victoria, an area chosen because of the poverty of the land and people, and of the possibility later of attempting eradication of malaria vectors. Here the collection of reliable vital statistics and information on the health and sickness of the population has been finished and has shown that the major problems are not medical. Bukoba, on Lake Victoria, was chosen for study because it is peopled by a wealthy tribe thought to be dying out because of a high incidence of venereal disease, and Kurimba, Tanganyika, because of the high incidence of schistosomiasis and of the possibility of integrating the findings with those of an intensive agricultural survey in progress.

The filariasis project in East Africa, although handicapped by shortage of staff, has shown that bancroftian filariasis here appears to cause no inconvenience to most infected individuals and produces no symptom-complex like the 'mumu' of the Pacific. The incidence of late complications like elephantiasis is related to the intensity of infection in any area, as distinct from the incidence. Studies on the chemotherapy of malaria in Malaya have indicated that widespread use of proguanil as a suppressive drug in a malarious area may result in the appearance of proguanil-resistant strains of *Plasmodium falciparum* and *P. vivax*. Tests with window-trap huts, supplementary to a house-spraying programme, confirmed that DDT at 200 mgm. per sq. ft. and BHC at 40 mgm. gamma isomer per sq. ft. are effective for nearly six months, but suggested that lower doses last only about two months against *Anopheles maculatus*. At Tambunan, North Borneo, encouraging results have been obtained from the experimental jungle clearance for the eradication of *A. balabacensis* and the malaria it carries. Work is being continued in West Africa to relate human age groups to the natural infections in *A. gambiae*, *melas* and *funestus*. Preliminary results of an experimental malaria eradication scheme at Ilara, Southern Nigeria, are summarized in the report, and in field-trials on selected African children, the 2 : 4-diaminopyrimidine derivative, 'Daraprim', was comparable with 'Mepacrine' in its schizonticidal effect on the trophozoites of *P. falciparum*, but the effective dose per child was as low as 5 mgm.

The West African Virus Research Institute, Lagos, has undertaken work on the use of the vaccine produced by the Pasteur Institute, Dakar, in outbreaks of yellow fever in the Gold Coast, and in Onitsha Province field-trials with aureomycin indicated no beneficial effect on the clinical course of yellow fever or on the level of viraemia. The East African Virus Research Institute, Entebbe, has been associated with the World Health Organization's scheme for delimiting the southernmost boundary of the yellow fever area in Africa and is examining human bloods from the Belgian Congo, Angola, Tanganyika, Northern Rhodesia and Nyasaland. Work by the Scrub-typhus Research Unit in Malaya has been consolidated, and investigations made in Malaya during 1951 by the Scrub-Typhus Research Unit of the United States Army Medical and Graduate Research School, with its headquarters at Kuala Lumpur, are summarized in the report. Specific antisera of great value in the accurate identification of blood meals and tsetse flies have been prepared by a 'cross-immunization' technique at the Lister Institute of Preventive Medicine, London, while the investigation of serum proteins continues at Makerere College, where a thorough investigation of the biochemistry of kwashiorkor as seen in children is in progress. Progress is reported in all established lines of research at the Tropical Physiology Laboratory, Oshodi, Nigeria, where a linear relation has been established between sweat-rate and corrected effective temperature and an extensive investigation has been made in the deep mine of the Ashanti Gold Fields Corporation at Obuasi, Gold Coast.

At the Field Research Station, Fajara, Gambia, investigations, assisted by a large contingent from the Medical Research Council's Human Nutrition Research Unit, into nutritional disorders and into infections, particularly with malarial parasites, which contribute to ill-health, have continued and work on food technology has been resumed. In Nigeria studies of the use of adrenocorticotropic hormone (ACTH) and cortisone in leprosy have been made.

During the year, grants totalling £373,553 towards new and existing schemes were made by the Committee for Colonial Agricultural, Animal Health and Forestry Research, the seventh annual report of which pays special tribute to the assistance given by the Commonwealth Institute of Entomology, the Institute of Biological Control, Ottawa, and the Mycological Institute. The East African Agriculture and Forestry Research Organization moved into its new headquarters at Muguga South, Kenya, early in the year. Its work on the relation between calcium and phosphate in the soil system is now being extended to the analyses of plant samples from fertilizer trials. Studies on groundnut virus diseases continued, substantial progress was made in studies of canker disease of cypresses in elucidating the resistance of different species to strains of the fungus and the relation between age of tree and susceptibility, and work has begun on the incidence of the bud disease of the pyrethrum plant caused by *Ramularia bellunensis*. The East African Veterinary Research Organization continued its work on animal trypanosomiasis, including the use of 'Antrycide', and on animal helminthology and nutrition, and the mobile unit concluded its tuberculosis survey in the Southern Highlands Province of Tanganyika. In West Africa, regional research schemes into rice cultivation and the rust disease of maize caused by *Puccina polysora* have been started, while at the West African Cacao Research Institute a satisfactory method was devised of controlling capsid bugs on young cacao. The former Oil Palm Research Station of Nigeria has been converted into a semi-autonomous West African Institute for Oil Palm Research, covering the needs of all the British West African territories.

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* Continued from p. 114.

In cacao research in the West Indies, a study of the degree of pod-infection by witches' broom disease has indicated wide variations in the susceptibility of different clones to the disease. Research on the banana has shown that the most promising breeding programme is to raise primary tetraploids using the Gros Michel as the female parent, and that better male parents are required than those hitherto used in Trinidad and Jamaica. Arrangements have been made for research into leaf-scald disease of sugar-cane, a serious threat to the economy of British Guiana, and a small team of scientific workers is making an ecological land-use survey of British Honduras. Among work undertaken by Colonial Departments of Agriculture, Forestry and Veterinary Services mentioned in this report may be noted the investigations into the control of the root borer of sugar-cane, *Diaprepes abbreviatus*, in Barbados by the use of 'Agrocide' preparations and 'Aldrin', trials of insecticides in Fiji and the successful biological control there of *Cirphis unipuncta* in rice-fields, work on methods of rinderpest vaccine production in Kenya, on the sulphur content of 'gēlam' soils in coast alluvium in Malaya, on soil conservation in Sierra Leone, on coffee in Tanganyika and on the damage to coconuts caused by the coreid bug, *Theraptus* sp., in Zanzibar.

The fifth annual report of the Colonial Insecticides, Fungicides and Herbicides Committee gives fuller details of some work which is referred to elsewhere in these reports. The study of insecticidal surface coatings at the Colonial Insecticide Research Unit, Porton, has reached the development and field-trial stage. Treatment of various parts of ships voyaging through the tropics has given very promising results against cockroaches and ants, and appears to give some freedom from flies and mosquitoes entering at ports. In certain formulations the coatings are of value in protecting marine woodwork from barnacles and in the control of book insects in old libraries. Other work at Porton, at Rothamsted and at the Imperial College Field Station, Silwood Park, on the way in which contact poisons are picked up by insects, and the influence of particle-size and the type of surface on the amount picked up, should contribute to important improvements in insecticide formulations and methods of application.

Aircraft studies in East Africa in the application of chemicals to vegetation continued on a reduced scale: final observations on the treatment of 15 square miles of tsetse bush with DDT spray show a reduction of two species of tsetse by more than 99 per cent and of a third by more than 95 per cent. Two-year studies on the behaviour of *Anopheles gambiae* and *A. funestus* in huts treated with DDT, BHC and other insecticides do not support the view that DDT is ineffective against *A. gambiae* because it repels them from the huts, but 'Dieldrin' is more effective as residual spray against mosquitoes than either DDT or BHC. Trials of three new sprays for the residual spraying of houses for mosquito control are being carried out under Colonial conditions. Preliminary experiments have been conducted in Africa by the Unit of Experimental Agronomy, Oxford, on the use of defoliants and arboricides in control of tsetse fly.

In its fifth annual report, the Colonial Economic Research Committee reports extra difficulty in finding suitable candidates for undertaking research, and although several appointments were made to the regional institutes, recruitment of senior economists for short-term research appointments remains difficult. The Colonial Research Council has recommended the use of £100,000 of the remaining Colonial Development and Welfare Research allocation for promoting economic research, and part of this allocation will be devoted to research conducted by institutions in the Colonies. Considerable progress is reported in the Nigerian National Income Survey, which is being conducted by the Department of Applied Economics in the University of Cambridge, and Dr. P. T. Bauer's study of the structure and organization of trade in West Africa is almost complete.

The report of the Tsetse Fly and Trypanosomiasis Committee for the year ended March 31, 1952, states that the programme of work of the East African Tsetse and Trypanosomiasis Research and Reclamation Organization for 1951–56 provides for the continuance of the basic research of the past five years and for extensions into the field of animal trypanosomiasis when the facilities of the Central Trypanosomiasis Research Institute are available. Meanwhile, the prophylactic and curative properties of 'Antrycide' are being studied in co-operation with the East African Veterinary Research Organization. Full facilities at the West African Institute for Trypanosomiasis Research only became available during the year, but a tsetse breeding colony is being established in the laboratory. A new field-investigation on the epidemiology of human sleeping sickness was commenced in the Gambia, and a pilot experiment in Nigeria has shown that N'dama cattle show a remarkable tolerance to trypanosomiasis even when exposed to a severe challenge from *Glosina morsitans*. A zoologist has been appointed to collate information available on the mammalian fauna of Africa, and the Kenya Veterinary Department has further investigated delayed toxicity following the use of phenanthridinium compounds.

The annual report of the Colonial Fisheries Advisory Committee on Fisheries Research for 1951–52 reports a satisfactory recruiting position. There are now fifty-one fisheries officers, and at December 31, 1951, £1,532,500 had been allocated to thirty-four fishery research schemes, leaving a total balance in hand of £174,300, against which commitments for new schemes and the extension of existing schemes until March 31, 1951, amount to £120,000. At the Inter-Territorial Fisheries Research Station at Jinja on Lake Victoria, a comprehensive programme of research has been started with the object of acquiring an understanding of the principal factors which determine the density of fish populations in the various lakes of Central Africa. The importance of diatoms in the economy of the Lake has been demonstrated, and considerable light thrown on the rate of growth and sexual periodicity of fish living in tropical waters. Results obtained by the Inter-Territorial Marine Fisheries Research Station at

Zanzibar indicate that pelagic fishes haunt the edges of the shallow marginal waters. The large research trawler of the Western African Fisheries Research Institute has made her first six trips, and a hundred species of fish were identified; the Institute has also started a study of the ecology and biochemistry of mangrove swamp.

The report of the Director of the Anti-locust Research Centre on locust research and control for 1951–52 refers to the resumption of investigations on the conditions affecting the incidence of flight and the speed and direction of swarm displacements following the reappearance of desert locust swarms in East Africa at the end of 1950. The type of flight performed by locusts is of importance in determining the rate of displacement, and sustained flight appears to require high humidities. Research activities of the Desert Locust Survey included the exploration of less known desert locust areas in Arabia, and studies on locust biometrics, hopper behaviour and ecology. Intensive work has been carried out on the ecology and population dynamics of the Moroccan locust in Cyprus, and the Desert Locust Control Organization based on Nairobi was strengthened during the year. Growing international co-operation is an encouraging feature of the present control campaign. A memoir on the desert locust in the Indo-Pakistani-Persian area is being edited for the press, and completes the series of memoirs dealing with generalized seasonal breeding and migration of swarms throughout the desert locust invasion area.

## FISHERIES RESEARCH IN BRITISH COLONIES

IMMEDIATELY after the Second World War an extensive programme was set in motion under the Colonial Development and Welfare Act of 1945 to set up centres for fishery research in the British Colonies. It was realized that in fish there was a source of much-needed proteins which has scarcely been tapped. Of the research institutes to be developed the first to become established was that of the East African Fisheries Research Organization[*] at Jinja in Uganda under the directorship of Mr. R. S. A. Beauchamp. The publication of the Organization's annual report for 1951 affords evidence that the work of the Jinja laboratory is now beginning to bear fruit.

Research has been centred on Lake Victoria, and regular observations are showing how complicated are the conditions of a large tropical lake and how different they are from the classical picture supplied by the study of temperate lakes. The work is primarily aimed at finding out the economic possibilities of fishing, and to this end a study is being made of the fish populations, their food and ecology. With opportunities for regular observations over a number of years, it should be possible to answer outstanding questions on the growth and breeding of fish under tropical conditions. For this purpose a background knowledge of the conditions under which the fish live is essential, and investigations on the hydrology and algology are being made. Among results obtained to date, the possibilities of a new fishery for Mormyrids has been demonstrated; information has been gained about a number of fish which will help towards assessment of the effects of fishing on their populations[*]; the ability of fish to digest different types of algæ has been shown, as well as the notable importance of insect larvæ as food. Among other practical aims is the study of molluscs and the distribution of trematode parasites, especially *Schistosoma*.

But what is at once obvious from the report is the enormous and varied field for study, and the wealth of problems waiting to be solved in the teeming high-speed realm of tropical aquatic life. Many of these are fundamental questions which will need to be answered before the life-stories of the fish can be properly understood. In view of this it is most gratifying to note that visiting research workers from British and overseas universities are already finding their way to Jinja to work on their various private lines of research. In this way the work of the fisheries laboratory is advanced, and visitors and staff benefit enormously by mutual discussion and friendship. It is to be hoped that, when other laboratories are ready, more visiting research workers will seek the facilities they afford. The laboratory of the West African Research Organization at Freetown is reaching that stage.

F. S. RUSSELL

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[*] East Africa High Commission: East African Fisheries Research Organization. Annual Report. 1951. Pp. ii+49. (Nairobi: Government Printer, 1952.)

[*] Colonial Office. Fishery Publications, Vol. 1, No. 2: Report on the Tilapia and other Fish and Fisheries of Lake Nyasa, 1945–47. By Rosemary H. Lowe. Pp. x+126+7 plates. (London: H.M. Stationery Office, 1952.) 40s. net.

## HUMBER LABORATORY FOR FISH RESEARCH

A NEW laboratory for fish research, to be known as the Humber Laboratory, was opened in Kingston-on-Hull on December 5 by Sir Ben Lockspeiser, with Dr. Franklin Kidd, director of food investigation of the Department of Scientific and Industrial Research, in the chair. Some hundred representatives of all sections of the fish industry were present, as well as representatives of various official bodies. The new venture was heartily welcomed on behalf of the industry by Admiral Sir Robert Burnett, chairman of the White Fish Authority, and by Mr. J. Croft Baker, chairman of the British Trawlers' Federation.

The new laboratory is a sub-station of the Torry Research Station, Aberdeen, which since its inception in 1929 by the Department of Scientific and Industrial Research has been the base for practically all the research undertaken in Britain into the problems of the preservation of fish as food. Aberdeen has proved a most suitable centre for research owing to the close proximity of fishing grounds for supplying experimental material and the presence of the University and other local research institutes, particularly the Marine Laboratory of the Scottish Home Department. However, during the past twenty-five years the area habitually fished by British trawlers has extended to the regions of Bear Island and Spitsbergen, the Barents Sea and Greenland, and on occasion Newfoundland and the Davis Strait. Nearly three-fifths of the white fish brought to Britain during 1951 came from these distant waters. This distant-water fishing is concentrated on the Humber ports of Hull and Grimsby, which together accounted for more than three-quarters of the distant-water catch and just over three-fifths of Britain's total white-fish landings of more than eight hundred thousand tons.

This was six times the quantity landed in Aberdeen, and was worth five times as much, namely, £22 million.

The distance of these prolific fisheries makes it more difficult to keep the catch in good condition on the voyage home, a journey that can take up to a week, after which inland distribution has still to be undertaken. In comparison, voyages to the nearer waters of the North Sea and Faroe Islands are much shorter and the catches much smaller. Since 1947 the Torry Research Station has been paying particular attention to the problems of improving the preservation of the distant-water catch, most of which consists of cod and haddock, and the establishment of the new Laboratory will provide a permanent base on the Humber which will make further work in this field much easier.

In opening the Laboratory, Sir Ben Lockspeiser pointed out that, of the three main sources of animal protein, meat and dairy produce have to be largely imported, much of it from dollar areas, while fish is mostly obtained by our own efforts. In consequence, it is rather surprising that although the British are consuming substantially less meat to-day than before the Second World War, they are, in fact, consuming per head less fish. Sir Ben gave as an example the kipper, a typically British product, of which, he said, the consumption is now only about half of what it was in 1947 and 1948. People will not eat fish willingly unless it reaches them in good condition, fresh or processed, and this raises questions of refrigeration, storage, smoking and canning. It would be wise to assume that Britain will have to rely increasingly on fish in the foreseeable future, and it becomes, therefore, more than ever important that the resources of fish, which are obtained with such cost in capital and labour and all too often in human life, should be husbanded. The Department of Scientific and Industrial Research, continued Sir Ben, is opening the new Laboratory on the Humber in the heart of the white-fish industry in order to help to come to grips with the practical problems of distant-water fishing. Industrial science is in the nature of a joint enterprise between industry and science. Although every now and then science takes a leap forward, creating a revolution in thought and practice, which it is vital for an industrial nation to recognize and take advantage of, more frequently advance is step by step, often in very small steps, every one of which has to be tested in practice. The Department of Scientific and Industrial Research attaches great importance to working in partnership with all sections of the industries it serves.

After the opening, visitors saw an exhibition of some of the results of recent work of Torry Research Station. The bacteriological problems of keeping fish fresh were illustrated, and an account was given of the methods used and results obtained in an extensive survey of the conditions of handling fish aboard distant-water trawlers, showing the temperature distribution in the fish holds and the loss of weight of fish during transport. Even with the most careful handling aboard ship, however, not all fish can be landed from the distant waters in a really fresh condition by the normal process of gutting, washing and icing. Another exhibit described work on the problems of preserving fish by freezing at sea, with samples of fish frozen in a new type of contact freezer now being developed for the purpose. The deleterious effects of the cold storage of fish at temperatures of − 10° to − 15° C. for a few months was demonstrated by contrast with the perfect condition of similar fish stowed at − 30° C. for up to twelve months.

Various physical, chemical and engineering problems involved in the preservation of fish by smoking and drying were illustrated. Some demonstrations were given of the recently developed humidity-sensitive element which utilizes some electrical properties of anodized aluminium (see p. 177 of this issue). Several by-products of the fishing industry, and new methods of recovery, were described as well as current research on fish proteins, and work on fish skin being carried out at the Zoology Department of the University College of Hull for the Department of Scientific and Industrial Research.

The buildings for the new Humber Laboratory have been erected by the Ministry of Works and comprise four laboratories, a workshop, offices, a library, and space for handling, freezing and smoking fish on a semi-commercial scale. Altogether, this new establishment will function as an integral part of the Torry Research Station, providing facilities for workers from that Station as well as for its own as yet small staff, and continuing work on various fronts—for example, certain aspects of fish chilling, freezing, smoking and drying. It is hoped that, in addition to *ad hoc* problems, the programme will include basic biochemical and physicochemical studies in fish preservation.

# PROBLEM OF FUTURE WORLD FOOD SUPPLY

THE Nutrition Panel of the Food Group of the Society of Chemical Industry has arranged a series of meetings devoted to the subject "Food and the Future". The opening meeting of the series, under the title of "The Problem of Future World Food Supply", was held on December 10, with Dr. J. I. M. Jones in the chair.

Mr. F. Le Gros Clark spoke on the "Yardstick of Population" and posed the question, "Will there soon be too many of us ?", pointing to an eventual finite limit to the population that could be supported by the world. Famines have always been local and temporary, never of world dimensions, but the real cause for alarm is that no one can foresee in what precise corner of the world hunger may occur. Optimists, he said, believe that men, even after a long period of suffering, will learn to control their fecundity, while pessimists foresee only disaster.

Mr. Le Gros Clark traced the growth in population over the centuries, suggesting an eventual total of 8,000–12,000 million before stability is reached. The problem of their food supply requires not mainly a technological transformation but a revolution in the habits of men and methods of farming—an agrarian revolution on a world-wide scale. The initiation of this revolution, he said, should have started fifty years ago, before the pressure of population had become so great. Nowadays, we cannot be excused because of ignorance, as perhaps could our grandfathers, who had less factual knowledge.

Most nations to-day, protested Mr. Le Gros Clark, are not giving the agricultural scientist and food chemist half the chance they should have of meeting the challenge. This is a matter for governments and people who move governments. The task before us, he concluded, is that of agrarian reform, carried out in such a way as to convert a largely illiterate peasantry into alert, modern farmers who can manage the breeding not merely of their farm animals but also of themselves.

Dr. E. W. Russell dealt with the "Factors Limiting Food Production". In Great Britain differences in output between farms depend upon soil, varying use of fertilizers and varying degrees of farming skill. Large areas of hill lands are producing only a fraction of the food per acre produced by the lowland areas, principally due to climate, lack of plant nutrients in the soil and relatively poor farming-skill in these areas. Skilled and energetic farmers must be attracted back to the hills, and this requires the provision of reasonable living amenities such as housing, transport and recreation in districts very deficient in these.

In the world as a whole, food production is limited by three groups of factors. First there are the inherent factors of the site: lack of soil, water, nutrients or a short growing-season. Then there are factors that harm the growing crop such as diseases and pests. Finally, there are human factors, including lack of skill, low activity due to disease, and social, religious and political brakes on production.

Dr. Russell gave examples of yields of rice in different countries, and showed that the extremely low yield in India, less than a quarter of that in Italy, had been doubled in one area by using better varieties, better water management and simple manuring. Crop production is limited by cold, but new strains ripening in a short season could be grown in cold districts before the frosts came. At the present time, the principal factors limiting wheat production in the Canadian prairies are believed to be lack of men and lack of markets rather than lack of suitable land. Dr. Russell also dealt with irrigation, fertilization of the soil and soil erosion.

A. E. Bender

## ROYAL OBSERVATORY, CAPE OF GOOD HOPE

### REPORT FOR 1951

The report of the Royal Observatory, Cape of Good Hope, chronicling the activities of the Observatory during 1951, has recently been published*. It is satisfactory to know that the modernization of the reversible transit circle, which had been originally built in 1900, was completed in 1951 and it was ready for use in November. An important change was the replacement of the twelve declination circle microscopes by twelve cameras, six on either pier, which, on pressing a button, photograph the position of the declination circle and automatically wind on ready for the next exposure. Various troubles with instruments have been eliminated; one of these arose from the harshness in the sun-and-planet differential through which the guiding motion is applied to the impersonal micrometer; and after trying alternative methods for securing a suitable differential motion, it was decided to retain, with a few minor changes, the form of drive introduced in 1911 by Mr. Hough. The Hipp chronograph, which frequently gave trouble, has been replaced by a new chronograph built at the Observatory and driven by a synchronous electric motor.

The Victoria telescope, now more than fifty years old, was used on 177 nights, 121 for the parallax and proper motion programme, 25 for photoelectric photometry, 19 for Fabry photometry and 12 for obtaining direct photographs in connexion with various photometric programmes. The instrument was also used for observing occultations both photoelectrically and visually. Arrangements have been made for an examination of the declination axis of the telescope, around which the motion has become increasingly stiff during the past few years. The astrographic refractor was used on 146 nights and the 7-in. telescope on 120 nights in connexion with the "Bright Star Programme"; as this is now finished, it is proposed to use the latter telescope only for visual observations, such as occultations and the micrometric measurement of double stars. The 6-in. telescope has been used to observe long-period variables and also for occultation work as well as for visitors. The tower telescope has been used for observing occultations and variable stars, and the photoheliograph is used daily to take two photographs of the sun. There have been developments in the photoelectric equipment during the year, two D.C. amplifiers and two power-packs having been designed and constructed, while great improvements have been made in the occultation apparatus which was described in the 1950 report.

In April 1951 an agreement was signed between the Radcliffe trustees and the Admiralty by which one-third of the time with the 74-in. Radcliffe reflector at Pretoria is made available to observers from the Cape. The scheme is to use the Radcliffe telescope for long routine programmes for which the organization of the Cape Observatory is particularly suitable and which are not likely to be undertaken by individual observers of the Radcliffe Observatory, and two routine programmes have been already started: one of these is for determining the radial velocities of the southern stars; the other is a photographic *Durchmusterung* of the southern Kapteyn Selected Areas. Among the miscellaneous items of the report are included observations of the spectra of a selected list of planetary nebulæ, photographs of extragalactic nebulæ, spectrograms of a number of specially interesting stars, and certain experimental work. The last includes some experiments made in collaboration with the Electronic Division of the National Physical Laboratory as to the capabilities of the new E.M.I. tube for astronomical photometry. Full-scale deflexions were obtained with the 74-in. telescope on stars of magnitude 15 without the use of an amplifier.

So many other matters are dealt with that it is impossible to mention them all, but one or two additional points are worth noticing. Mr. A. N. Cox, of the University of Indiana, visited the Cape Observatory in September 1950 and installed on the Victoria telescope the photoelectric photometer that had been previously used in the United States and at the Radcliffe Observatory. After his return to the Kirkwood Observatory, he compared the stars that he measured in the regions $C2$ and $C12$ directly with the North Polar Standards, and the remarkable thing is that the results were not in agreement with those found at Cambridge. It is suggested that the non-agreement may be merely one more indication of the grossly unsatisfactory nature of the present standard magnitudes in the northern hemisphere. Short descriptions are given of the time service, meteorological observations and publication of results. Continuous records were obtained on self-registering instruments of barometric pressure, temperature, humidity, wind direction and wind velocity; observations were made daily at 8 hr. S.A.S.T. The report ends with a list of the personnel and of distinguished visitors to the Observatory during 1951. Regular visiting days, which were started in August 1950, were continued during 1951.

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* Report of Her Majesty's Astronomer at the Cape of Good Hope to the Secretary of the Admiralty for the year 1951. Pp. 20. (Cape of Good Hope: Royal Observatory, 1952.)

# HÆMOGLOBIN AND BILIVERDIN IN PARASITIC CIRRIPEDE CRUSTACEA

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In 1946, Pérez and Bloch-Raphaël[1] announced the presence of hæmoglobin in the rhizocephalan cirripede *Septosaccus cuenoti* Duboscq, parasitic on a hermit crab at Roscoff. This increased from three to four the number of orders in the Crustacea Entomostraca known to possess hæmoglobin[2]; it is present in the Branchiopoda, Ostracoda, Copepoda and Cirripedia, being unknown only in the small fifth order, the Branchiura (containing *Argulus*). It is curious that, in Copepoda and Cirripedia, hæmoglobin occurs only in parasites. In contrast to the Entomostraca, no member of the Malacostraca possesses hæmoglobin in the blood or elsewhere in the body, while two malacostracan orders, the Decapoda and Stomatopoda, have hæmocyanin in their blood.

The roots of the cirripede *Peltogaster*, parasitic on hermit crabs, are green, unlike the yellow roots of *Sacculina*. Lederer[3] discovered that the green pigment of the roots of *Peltogaster paguri* (Rathke) is biliverdin; he based his conclusion on solubilities and the Gmelin reaction. Pérez and Bloch-Raphaël[1], using the Gmelin reaction, detected this pigment also in the roots of *Septosaccus*. It was natural that the latter authors should consider the biliverdin to be a degradation product of the parasite's hæmoglobin, as it is in the Vertebrata. Their paper was followed by two more on hæmoglobin and biliverdin in *Septosaccus*[3,4]. I have now had the opportunity, at the Zoological Stations of Naples and Villefranche, of studying these pigments in three other members of the Rhizocephala.

At Naples, *Peltogaster curvatus* Kossmann parasitizes two species of the hermit crab genus *Eupagurus*; it is found, namely, on *E. prideauxi* (Leach) and *E. excavatus* (Herbst)[5]. All individuals of *E. prideauxi* studied by me, but none of *E. excavatus*, bore the commensal anemone *Adamsia palliata* (Bohadsch). *Eupagurus prideauxi* is the commoner species of hermit crab, but only about 1 per cent of individuals are parasitized by *Peltogaster*, whereas about a quarter of the individuals of *E. excavatus* bear a parasite. The external part of the parasite is orange in colour, with a reddish tinge which is more or less pronounced in different individuals; the orange pigment is soluble in acetone and is probably a carotenoid. The parasite possesses hæmoglobin in solution in its blood, which is most conveniently obtained from the external part of the parasite near the stalk. Drops of blood of a standard depth, held between coverslip and glass plate of a compressorium, were examined with a microspectroscope. In the blood of some individuals the oxyhæmoglobin absorption bands were strong and in others weak. The accompanying table gives the numbers of individual parasites which showed oxyhæmoglobin bands of five arbitrary intensities.

| Host | Numbers of parasites with oxyhæmoglobin bands of various strengths | | | | |
|---|---|---|---|---|---|
| | Very weak | Weak | Medium | Strong | Very strong |
| *E. prideauxi* | 8 | 3 | 4 | 2 | 1 |
| *E. excavatus* | — | 1 | — | 9 | 10 |

The data show not only a considerable variation in the hæmoglobin content of individual parasites, but also a difference in amount of hæmoglobin depending upon the species of host. Normally a host carries a single parasite, but four individuals of *Eupagurus prideauxi* were found each of which bore two *Peltogaster curvatus* and usually the two parasites had quite different hæmoglobin contents. (Pérez and Bloch-Raphaël[1] found no hæmoglobin in *Peltogaster*, but they do not give species, host or number examined.)

The roots of *Peltogaster curvatus* within the host have an intense green colour, easily seen through the abdominal wall of the host. The green is due to biliverdin; I was able to show this, not only by the Gmelin colours, but also in three other ways. The roots were dried and then dissolved in methanol. (1) When nitric acid was added to the green methanol solution, the resulting purple had a strong absorption band with its axis at 493 mμ and a weaker one at 604 mμ. (2) When zinc acetate and iodine were added to the methanol solution an absorption band appeared at 636 mμ. Pure biliverdin treated in the same two ways gave the same bands. The wave-lengths were determined with the Hartridge reversion spectroscope. (3) Additional evidence of biliverdin was furnished by the solution in methanol with zinc acetate and iodine showing a pink fluorescence in ultra-violet light, which changed to a green fluorescence on the addition of more iodine.

In one individual of *Peltogaster curvatus*, nearly fully developed nauplii were present in the mantle cavity, most of them still within their embryonic membrane. They were light yellowish-pink in colour and contained no detectable hæmoglobin, although the parent had the pigment in its blood. Bloch-Raphaël[4] found biliverdin in the ripe eggs of *Septosaccus* and "bile pigments" in the nauplii. She remarks that these degradation products of hæmoglobin which are in the larva will be able "in the host" to take part in the synthesis of hæmoglobin. This statement is unjustified, since bile pigments are not known to be a step in hæmoglobin synthesis.

The second rhizocephalan species examined was *Parthenopea subterranea* Kossmann, parasitic on the anomuran *Callianassa laticauda* Otto. This is the only existing species in the genus *Parthenopea*, and it is known only from the Gulf of Naples, where 1–2 per cent of individuals of the host species are parasitized. The external parasite has a pinkish-orange colour, this pigment again being soluble in acetone. Eight parasites were examined spectroscopically but no oxyhæmoglobin bands were detectable, even in the pinkest specimens. The blood contains a variable quantity of a violet-pink pigment which has no absorption bands. With pyridine the blood gives only a weak α-absorption band of hæmochromogen: thus little hæm is present.

The part of *Parthenopea* internal to the host consists of ramifying green roots. Again the green colour is due to biliverdin, giving Gmelin's test. The colour is not so striking as in *Peltogaster*, but this is probably because the roots are more slender and are not bunched together. Here we have an animal with a bile pigment but no hæmoglobin. Biliverdin is already known from a crustacean lacking hæmoglobin, namely, an American 'crawfish'[7], in which it has been found in the liver. This fact, together with the presence of biliverdin without hæmoglobin in *Parthenopea*, suggests that in *Septosaccus* and *Peltogaster* the biliverdin is not necessarily derived from the hæmoglobin. As stated above, *Parthenopea* has a hæm compound, although no hæmoglobin, in its blood, and the biliverdin in the roots may perhaps be a breakdown product of this hæm. Another example of animals that have a bile pigment but no hæmoglobin is provided by insects with green integument or blood, the colour of which is due to a blue bile pigment together with a yellow carotenoid[8]; the insects possess, of course, a hæm compound in the form of cytochrome. The mollusc *Aplysia* has urobilin in the liver and also in the externally secreted pigment aplysiopurpurin[9] without having hæmoglobin in the blood, but there is abundant hæmoglobin in the buccal muscles.

It has been known for a long time that the liver of some decapod Crustacea contains a hæmochromogen[10]. With a reducing agent its α-absorption band becomes visible, and a more intense band can be obtained when pyridine is added, through the conversion of this hæmochromogen and of other hæm compounds to pyridine hæmochromogen. In *Callianassa laticauda* it was therefore not surprising to find a hæmochromogen present in the liver. An examination was made of forty-four individuals, half of them parasitized, and it was found that more pyridine hæmochromogen is obtainable from the liver tissue of unparasitized than of parasitized animals. This suggests at first that the hæm in the part of the parasite external to the host is derived from hæm in the host. But this tentative conclusion is not well founded, for the lobes of the parasitized host's liver are visibly atrophied. Their deficit in hæm may therefore well be due to the disturbance in the normal development and functioning of the liver, rather than to a draining away of its hæm into the parasite.

*Peltogaster* and *Septosaccus*, which are parasitic on hermit crabs, contain hæmoglobin, while *Parthenopea*, parasitizing an anomuran, and *Sacculina*, on crabs, lack the pigment. In the first two genera the external parasite is within the hermit-crab's shell, or enveloped by the anemone *Adamsia*, in a situation where the oxygen content of the water may not always be high, whereas in the other two genera the external parasite is freely bathed by the sea water. This suggested that the hæmoglobin of *Peltogaster* and *Septosaccus* might be synthesized in response to oxygen deficiency as in *Daphnia*[11]. But, for the following reason, this cannot be so. The anomuran *Galathea squamifera* Leach at Villefranche is parasitized by the rhizocephalan *Galatheascus squamifera* Pérez. I was able to examine four parasites, on separate hosts. They were pinkish-orange in colour, had hæmoglobin in the blood and possessed green roots. In two specimens the hæmoglobin was strong, in two it was weak; there is thus the same variation in quantity as in *Peltogaster curvatus*. In *Galatheascus* the external part of the parasite is freely bathed by sea water, and so the possession of hæmoglobin cannot be ascribed to lack of oxygen. Thus neither causal nor functional reasons are as yet known for the presence or absence of hæmoglobin in Rhizocephala. [Sept. 24.

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# GENETIC INTERACTION BETWEEN INFLUENZA VIRUSES

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It is now well established that when bacteria are doubly infected with appropriately chosen strains of bacterial virus, 'recombinant' virus types may be obtained among the progeny liberated on lysis[1,2]. No final interpretation of the phenomenon has yet proved acceptable, Luria's hypothesis[3] of independent gene multiplication followed by reaggregation of the genetic apparatus of the virus from the resulting gene pool having been withdrawn as inadequate by the author on the basis of Dulbecco's results[4].

Technical difficulties make it impossible to handle animal viruses on the scale, or with the quantitative precision, possible with bacterial viruses. The use of growth in the allantoic cavity of the chick embryo and hæmagglutination methods, however, provides some approach to such precision in work with well-adapted influenza virus strains. There are now many convenient ways by which influenza virus strains can be characterized, and it is not difficult to find, for example, two influenza *A* strains which can be differentiated from one another by six or more conveniently demonstrable differences. Evidence for genetic interaction between two such virus types has been sought for some years in this laboratory, and in 1949 results were obtained indicating that by double infection of the mouse brain with a neurotropic influenza virus, *NWS*, and a non-neurotropic virus of different serological type (*MEL*, *SW* or *Oc.I.*) strains could be obtained of the second serological type but carrying the neurotropism and some of the other characters of *NWS* (Burnet and Lind[5]). This phenomenon is readily reproducible, but the interpretation that it represents an example of genetic recombination has not yet found acceptance among other workers.

In the hope of obtaining a more readily analysed example of such interaction between two viruses, attention has now been turned to double infection in the chick embryo. For the first series of experiments, the two strains *NWS* and *MEL* which had been used for most of the work previously reported were chosen. In a sense, the neurotropism of *NWS* for mice finds expression in the chick embryo by its capacity after inoculation on to the chorioallantois to invade the embryo and produce hæmorrhagic lesions particularly in the brain and muscles. Virus *MEL* has no such action. If mixtures of the two viruses with *MEL* in 100- to 1,000-fold excess are placed on the chorioallantois, hæmorrhagic brain lesions develop after three to four days incubation. Most such lesions contain both *NWS* and what we have called *NM* virus. The latter, which is serologically *MEL* and capable of producing hæmorrhagic lesions in the embryo, may be present in excess, so that it can be isolated by simple titration in the allantoic cavity or it may require the use of an anti-*WS* serum to suppress an excess of *NWS* before this can be done. When isolated and re-isolated by limit titration in the allantoic cavity, the *NM* strains derived solely from chick embryo manipulations are identical in all respects with those formerly obtained in mouse brain experiments. It is of particular interest that a considerable proportion are capable of producing fatal encephalitis on intracerebral inoculation in mice. Of nine tested, four were consistently lethal, one strain produced a proportion only of deaths and four gave rise to no recognizable symptoms. This is very much the same distribution of pathogenicity which was found among the *NM* strains (defined on certain *in vitro* characters) obtained in mouse experiments[6].

On the hypothesis that *NM* virus was liberated from cells doubly infected with *NWS* and *MEL*, it was decided to use a method developed in this laboratory by Cairns[7] for obtaining 'first-cycle' virus from the allantoic cavity. Briefly, a large dose of a mixture of *MEL* and *NWS* virus, adjusted to approximately equal concentration of the two viruses on the basis of their hæmagglutinating titres, was inoculated into each of four to six 11-day embryos. After one hour's incubation, 2,000 units of semi-purified receptor-destroying enzyme of *Vibrio choleræ* was introduced into the cavity to liberate any adsorbed but non-infecting virus and to prevent loss by adsorption of the liberated first-cycle virus. The allantoic sacs were repeatedly washed out with warm saline and then left until half-hourly tests showed a rising hæmagglutinin titre. The fluids were then harvested and a pool of all satisfactory fluids tested for its content of virus. By appropriate titrations with and without antisera against the two viruses, one such pooled first-cycle fluid was found to contain *MEL* $10^{8 \cdot 3}$ and *NWS* $10^{8}$ infective units. An artificial mixture of the same composition was prepared and the two tested in parallel by titration on the chorio-allantois in the presence of anti-*NWS* serum. Three consistent experiments showed death of embryos with hæmorrhagic lesions from which *NM* virus was isolated, when the first-cycle fluid was used. The artificial mixture gave in two experiments only one out of twelve and one out of eleven embryos with lesions, in each case due to *NWS*. This was taken as evidence that the production of *NM* virus was possible in a single cycle of infection. It also seemed to eliminate any possibility that the *NM* strains arise by simple mutation from *MEL* or by some direct effect of the tissue environment.

The next step was to replace *NWS* by another *WS* variant, namely, *WSE*, which has no neurotropic activity in the mouse but is equally invasive and lethal for the chick embryo. It differs, too, in growing much more freely in the allantoic cavity than *NWS*, reaching the same level of hæmagglutinin as *MEL*. The choice of this pair of viruses was very fortunate, for in both the two extensive experiments so far completed the first-cycle fluid has been shown to contain in more or less equal amount four types of virus, namely, the two original forms *MEL* and *WSE* and two new types *M*+ and *WS*−, each of which combines some of the characters of both original forms. There are six well-defined characters which can be used to differentiate *MEL* and *WSE* viruses, and it is convenient to use these to designate *MEL* as *ABCDEF* and *WSE* as *abcdef*, each letter corresponding to one of the differentiating characters as follows:

*Aa*. Serological type *WS* or *MEL* as shown by hæmagglutinin inhibition tests with appropriate immune sera.

*Bb*. Heat stability: *MEL* hæmagglutinin resists 30 min. heating at 62°, whereas *WSE* hæmagglutinin is destroyed.

*Cc*. Conversion to 'indicator state' by simple heating at 56° for 30 min. When tested with ovomucin or meconium inhibitor, heated *WSE* hæmagglutinin is strongly inhibited; heated *MEL* virus is unaffected except by very high concentrations.

*Dd*. Reactivity of heated virus with sheep salivary gland inhibitor[8] *WSE* is strongly inhibited; no treatment of *MEL* has ever given a hæmagglutinin inhibited by this substance.

*Ee*. Production of hæmorrhagic lesions in the chick embryo after inoculation on the chorioallantois: this is characteristic of *WSE* but never shown by *MEL*.

*Ff*. Pathogenicity for mice by intranasal inoculation; with a dose equivalent to one agglutinating unit, *WSE* kills all mice usually four or five days after inoculation; *MEL* produces non-fatal lesions, grading 1–2 on the conventional scale.

The four types obtained then are represented:

| | | | |
|---|---|---|---|
| *ABCDEF* | *ABcDeF* | *abCdEf* | *abcdef* |
| *MEL* (22) | *M* + (6) | *WS* − (9) | *WSE* (4). |

The numbers in parentheses give the number of strains of each type isolated from thirty-seven virus-containing fluids obtained from embryos inoculated with dilutions of first-cycle fluid 85678 at or very near the limit of infectivity. From four fluids two types were isolated, accounting for the forty-one isolations shown. The only deviation from the four patterns shown above was that some *M*+ strains showed lower invasiveness for the embryo (*C*) than others, and in some tests two of the subinoculations from these have shown no lesions in the four embryos used, so they would be represented *ABcDEF*.

It will be seen that two characters only, *Cc* and *Ee*, appear to be transferable. It is particularly interesting that, in our experiments at least, one 'virulence' character, namely, the capacity to produce hæmorrhagic lesions in the chick embryo, is transferable, whereas another, pathogenicity for the mouse lung, is not. Similarly, one 'indicator' character, reactivity with ovomucin or meconium inhibitors, is transferable whereas behaviour toward sheep salivary mucoid is not.

These results at once exclude the possibility of simple mutation being responsible for the appearance of the new types. Some form of genetic interaction is clearly taking place, but there is no indication of a random reassortment of characters. Only four types have been observed, and the relationship between the new types *M*+ and *WS*− is a reciprocal one. It would be premature to speculate about the nature of the genetic interaction involved. The method used, however, may be one of general application and seems likely to provide an important approach to the interpretation of differences between virus strains.

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# PHYSICAL PROPERTIES OF PAPER PULPS

## Elastic Properties of Wet Mats of Paper-making Fibres

In the manufacture of paper, the initial formation of the fibre web on the wire of the paper-machine takes place in the presence of a large excess of water, the removal of which constitutes an important problem in paper technology. Bulk removal, for example, by draining, suction and pressing, is employed before resorting to the more expensive method of drying by evaporation, but the physics of the former process has not been extensively studied. Most of the water is present as liquid water within the inter-fibre capillaries, and is sometimes, though incorrectly, called 'free water' to distinguish it from water molecularly adsorbed.

The hydrostatic tensions associated with different regains have been studied on textiles by Preston and co-workers[1]. In their technique, similar to a method used by Haines[2] and Schofield[3] for soils, bundles of immersion-wet fibres are placed on a fine sintered-glass plate, to the underside of which a hydrostatic tension is applied barometrically. This tension is transmitted by the continuous water channels to the water in the fibre bundle.

Using suspensions of papermaking fibres, small cylinders (1 cm. in diam. and 1·5 cm. high) were formed by drainage in a manner resembling the formation of the wet paper web on the machine wire. At moisture contents (gm. water per 100 gm. dry fibre) up to approximately 1,000 per cent, these cylinders will retain their structure for experimental purposes, although they are soft and easily deformed under small stresses. As well as changes in their moisture content, it has been found possible to measure changes in their dimensions with changes in tension. Figs. 1 and 2 show results of such measurements for a sample of an unbeaten commercial kraft pulp. The sensitivity of the apparatus allows volume changes to be measured to an accuracy exceeding 0·5 per cent and tensions to 0·01 cm. mercury. The smallest measurable tension is equivalent to a controlled relative humidity of 99·99999 per cent. In the present experiments, liquid tensions up to 20 cm. mercury have been used, covering a range in relative humidity from saturation to 99·98 per cent.

At low tensions, when no air is present in the matrix, it may be assumed that an approximately uniform hydrostatic stress acts throughout. The volume of water removed per c.c. of cylinder represents a volumetric strain, so that a bulk modulus may be calculated (Fig. 3). Since the water is completely free to move, the modulus, $k$ (1 bar = $10^6$ dynes/cm.$^2$), will be that of the fibre matrix only. This is the modulus which, on the paper machine, determines the resistance of the wet paper web to further loss of water during drainage and suction. Compared to a material such as wood ($k \approx 400$ bars) where the fibres are everywhere in contact, the modulus is very low. As the moisture content falls the bulk modulus rises, due doubtless to the tighter packing of the fibres. By applying small directional stresses to the cylinder, it is hoped to investigate other elastic and plastic properties of the fibre system.

At higher tensions the entry of air into the system (at the point *A*) renders uncertain the significance of the measured bulk modulus. This occurs when the tension is sufficient to empty the largest capillary present and is followed by a more rapid fall in the moisture content. Following entry of air, there is frequently a marked increase in slope in the tension-strain curve (Fig. 2). In some cases, due to elastic rebound of the fibres, there is even a slight increase in dimensions despite increasing applied tension. Thereafter, progressively smaller capillaries empty and the desorption isotherm (Fig. 1) gradually becomes much steeper. Large increases in tension here produce little drying effect. This region corresponds to the condition under which air is drawn continuously through the wet paper web at the suction boxes.

It will be seen (Fig. 1) that there is considerable hysteresis between the sorption and desorption curves. This has been observed invariably, even when no air enters the system. On sorption to very high moisture contents, where further swelling of the cylinder is opposed by its own weight, it has been found practicable to surround it with a non-miscible liquid of appropriate density. By thus counteracting the gravitational forces, repeated cycles of sorption and desorption may be followed to very small tensions, at which the volume may increase to several times its former value. It is hoped to make these matters the subject of further research.

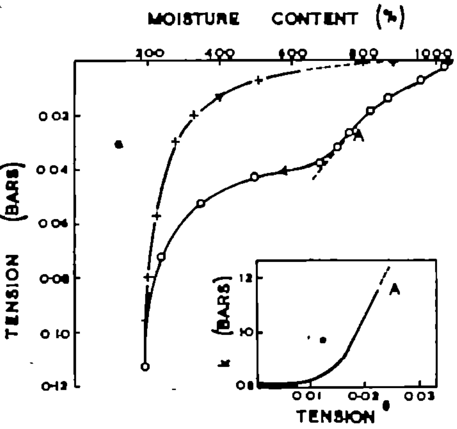

Fig. 1

Fig. 3

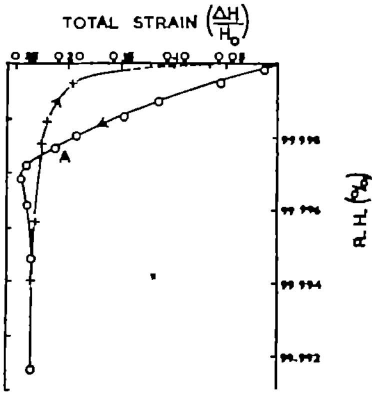

Fig. 2

One of us (G. N. C.) holds a research studentship from the Commonwealth Scientific and Industrial Research Organization of Australia.

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## 'Freeness' of Paper Pulps and the Forces of Capillary Water Retention

In the manufacture of paper, the cellulosic raw material is first dispersed into separate fibres by chemical or mechanical methods and is then subjected to a mechanical process called beating, which alters the properties of the fibres and has a profound influence on the quality of the finished paper[1]. Standard methods which have been developed to give an objective measure of the degree of beating (for example, the Canadian freeness test[2]) all depend on the rate of drainage of water from the fibre suspension. A light beating gives a 'free' pulp, which drains quickly, whereas a heavy beating gives a 'wet' pulp, which drains slowly.

Experiments have been made in the past to see whether a wet pulp shows greater hygroscopicity than a free pulp in the usual (vapour pressure–moisture content) isotherm between zero and near saturation humidity. The results show either no difference[3] or only a small increase with beating[4]. This suggests that beating is influencing only water held by capillaries at humidities which are too close to saturation to be controlled by conventional methods. Experiments have also been made in this capillary-range by using the centrifuge, and these show a correlation with beating times[5,6], but true equilibrium was probably not attained. Also, in centrifuging, the increased gravitational field directly affects the packing of the fibres themselves, whereas, on the wire of the paper-machine, the water drains away under gravity and is drawn out at the table rolls and suction boxes, so that the mat itself is subjected only to the normal gravitational pull, except for the hydrostatic tension of the water in the capillary spaces.

The porous plate technique, described in the preceding communication, affords a simple and reliable method of maintaining relative humidities very close to saturation, since the liquid tension is thermodynamically linked with the vapour pressure of the capillary water[7]. The distribution of pore size depends on the initial packing of the fibres in the mat, and a method had therefore to be evolved which assured a controlled and reproducible formation. Using this technique, curves of moisture content against hydrostatic tension were obtained on an easy-bleaching sulphate pulp which had been beaten for various times in the Lampén mill[8]. The results are given in Fig. 1. The curves all show hysteresis between desorption and adsorption, but for the sake of clarity the adsorption curve is shown only for the unbeaten sample. For the same reason, the desorption curves for the intermediate beating times are not shown at low tensions. It will be seen that at the higher tensions the desorption curves are very similar in shape and are displaced parallel to the moisture-content axis according to the time of beating. Thus any arbitrary tension may be taken as standard (for example, 14 cm. mercury = 0·187 bar). In Fig. 2 the desorption moisture contents at this tension are plotted against the Canadian freeness figure. The general correlation is seen to be satisfactory.

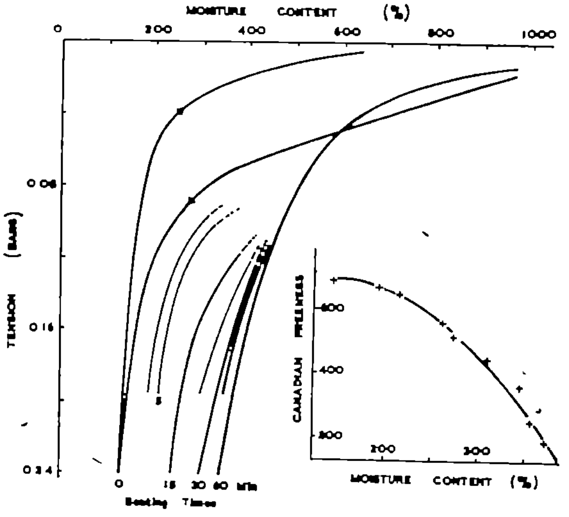

Fig. 1

Fig. 2

The porous plate technique is a static method, but the Canadian test is dynamic and therefore involves the rate of percolation of the water through the fibre mat rather than the tenacity with which the water is held. It may be argued on this basis that the porous plate method gives more direct information about the properties of the pulp from which the paper is eventually made. However, the rate of drainage is itself an important factor in paper-making since, on the machine, the water in the paper web may have no more than a few seconds in which to drain through the machine wire.

The main interest attached to these experiments is that they give, probably for the first time, a measure of wetness or freeness in exact thermodynamic terms, and that the data so obtained when used in conjunction with other experimental results described in the preceding communication may give precise information about the properties of the wet paper web under the conditions of manufacture.

One of us (R. H.) holds a research fellowship of the Norwegian Forestry and Forest Industries Research Organization.

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[8] See ref. 2, p. 153.

# LETTERS TO THE EDITORS

*The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications*

## Effect of High-energy Radiation on Long-chain Polymers

A NUMBER of long-chain polymers, when subjected to high-energy radiation such as is provided in the B.E.P.O. pile at Harwell, are found to become cross-linked. Among the polymers which behave in this way may be mentioned polythene, polystyrene, 'Terylene', nylon and unvulcanized rubber. In other polymers, for example, methyl methacrylate, decomposition sets in after a very short irradiation period.

The degree of cross-linking produced in these polymers is proportional to the radiation dose over a wide range of values, so that it is possible to prepare specimens of any required degree of cross-linking without the introduction of foreign atoms or heat treatment. Apart from its commercial implications, this treatment offers considerable advantages in the study of long-chain polymeric structure, and in the investigation of rubber-like elasticity.

Principal attention has been given to the changes in properties of polythene when cross-linked. Above a certain short irradiation dose, corresponding to about two cross-links per molecule, polythene becomes insoluble in organic compounds, and no longer melts even at temperatures considerably above 120° C. After greater irradiation doses polythene becomes somewhat more elastic, and cold flow is largely suppressed at room temperatures, while above the usual melting temperature it acquires rubber-like elasticity. When subjected to considerable radiation, polythene becomes completely amorphous, hard and glass-like in character, even at room temperature.

Above 120° C., Young's modulus for cross-linked polythene is found to obey the theoretical law of rubber-like elasticity both so far as the variation with temperature and with degree of cross-linking is concerned. This enables one to obtain a relationship between the radiation dosage and resultant cross-linkage produced. Similar results are obtained when the amount of radiation needed to produce insolubility is determined.

During irradiation of polythene, gases are emitted, consisting mainly of hydrogen, with smaller amounts of methane, ethane, etc. In addition, surface oxidation takes place when the irradiation takes place in air. The weight changes $\Delta M$ depend on the radiation dosage $R$, and on the initial mass $M$ and surface area $A$ of the specimen:

$$\Delta M = -\alpha_1 MR + \alpha_2 MR^2 + \beta_1 AR + \beta_2 AR^2,$$

where $\alpha_1$, $\alpha_2$, $\beta_1$, $\beta_2$ are constants; $\alpha_2$ is very small. This formula is explained in terms of a volume evolution of hydrogen ($\alpha_1$), a surface oxidation ($\beta_1$), and evolution of paraffinic gases from near the surface only ($\beta_2$). As a result, values for the probability of breaking of C—H and C—C bonds have been derived[2].

The density of cross-linked polythene in the amorphous state (that is, above about 115° C.) has also been investigated. It is found that the variation of volume $V$ per gram with temperature $T$ and degree of cross-linking $c$ can be expressed in a form very reminiscent of the Van der Waals equation for a gas:

$$\left\{P + \frac{P_0}{1 - \beta c}\right\}(V - V_0) = RT/M,$$

where $\beta \sim 1$, $P_0$ is the internal pressure, and $V_0$ is a constant independent of $c$. The values of $V_0$ and $P_0$ are very close to those found by Spencer and Gilmore[1] in their studies of compressibility of ordinary polythene above the melting point.

Among other problems which may be mentioned is a study of the relationship between the degree of cross-linking and the swelling ratio for cross-linked polystyrene in benzene. This and other work will be reported in fuller detail elsewhere.

I wish to thank the Director, Atomic Energy Research Establishment, and Dr. H. M. Finniston, head of the Metallurgy Division, for permission to carry out this work and to publish the results.

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June 20.

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## A New Focusing Principle applied to the Proton Linear Accelerator

A NEW design of synchrotron magnet has been announced recently by the bevatron group at Brookhaven[1]. It is stated that the novel focusing principle involved is applicable also to linear accelerators, but details are not given as to how the necessary apparatus is to be incorporated into an efficient radio-frequency accelerating structure. We wish to point out that there is only a minimum of interference with the radio-frequency system if the necessary fields are set up in the drift-tubes of a Berkeley-type accelerator[2]; and in particular that, if electric rather than magnetic fields are used, then a rather simple modification of the drift tubes is all that is required.

The fields considered strongly focus the particles in one direction transverse to the motion, but defocus them in the direction at right angles. Overall focusing can result if these two planes are interchanged periodically along the accelerator; this is the discovery of the Brookhaven group. Alternatively, the field structure could be made to spiral more or less continuously along the machine.

A method of applying electric fields is illustrated in Fig. 1. The drift-tube is divided by four longitudinal gaps and a potential difference applied between adjacent quadrants. If the gaps are small, the radio-frequency field will not penetrate to the centre of the tube, so that the shielding action of the latter

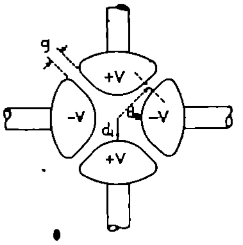

Fig. 1

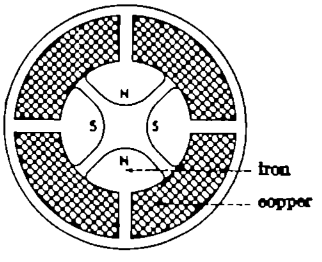

Fig. 2

is unimpaired. The inner surfaces are shaped as rectangular hyperbolæ to provide a better field distribution; at the drift-tube ends it might be desirable to change this shape, or to use guard rings, to avoid asymmetries in the radio-frequency radial forces.

My calculations indicate that with $d_1 = 1$ cm., $d_2 = 2$ cm., $g = 0{\cdot}5$ cm., and $V$ of order 6 kV., we should be able to focus protons of energy about 45 MeV. or more in an accelerator with synchronous phase 30°, operating frequency 200 Mc./s., and accelerating rate 2·3 MeV./metre. The field would be alternated every three or four drift-tubes. With the same accelerating rate and lower velocities, the radio-frequency defocusing forces are larger, and correspondingly greater potentials are needed. These can be avoided if the accelerating field is reduced in the initial part of the machine; or alternatively, grid focusing might be used in this section.

Protons of 45 MeV. travel with almost one-third the velocity of light ($\beta = 0{\cdot}3$). The electric field of 24 kV./cm. can then be replaced by a magnetic field of 270 gauss. This is to be established over the 0·5-cm. gap in Fig. 2. The current needed is 107 amp. per quadrant; with 10 sq. cm. of copper winding in each quadrant and a space factor of 0·75, the power dissipation is 1·2 watts per metre of drift-tube. With the same accelerating rate at lower velocity, the magnetic field required is larger; if only the current in the coils is changed, then the dissipation per unit length varies inversely as the fourth power of the velocity.

The divided drift-tube for electrostatic focusing is the outcome of an idea pursued by us for some time which involved the introduction of a charged conductor into the ordinary tube. I am indebted to my colleagues for much valuable discussion of all these methods. The Director of the Atomic Energy Establishment is thanked for permission to publish this communication.

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Nov. 3.

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## A 'Zero' Synthesis for Fourier Refinements

In the determination of crystal structure by means of X-ray diffraction data, the Fourier method[1] has long enjoyed the foremost place. Attempts have been made to substitute purely analytical techniques[2] depending upon either (*a*) the direct solution of the structure factor equations:

$$F_o(h,k,l) = \sum_r f_r \exp i\,\theta_r, \qquad (1)$$

where $f_r$ is atomic scattering factor of $r^{\text{th}}$ atom, $\theta_r$ is $2\pi(hx_r/a + ky_r/b + lz_r/c)$, $(x_r y_r z_r)$ are co-ordinates of the $r^{\text{th}}$ atom, and the summation extends over all atoms in the unit cell; or (*b*) by means of a process[3] which attempts to minimize the difference between some non-negative sum function of the difference between the observed structure factor amplitudes and those calculated on the basis of an assumed approximate structure, for example:

$$\sum_{h,k,l} (|F_o| - |F_c|)^2, \qquad (2)$$

$|F_o|$ and $|F_c|$ being respectively the observed and calculated structure amplitudes.

When the system of equations (1) is taken as the basis of solution, an immediate difficulty lies in the fact that only the modulus of $F_o$ is known *a priori*, so that the relatively simple equations (1) have to be replaced by a more complex set obtained by separation of real and imaginary parts and subsequent squaring. Despite these difficulties, formal analytical techniques have been devised[1] for handling the solution; these, however, depend (in general) upon obtaining large runs of observations having, say, fixed $k$ and $l$ values and consecutive $h$, which are not usually available.

It is clear that in principle the problem posed by the equations (1) should be solvable given any set of $F_o(h,k,l)$ values having at least $3n$ members, $n$ being the number of independent atoms in the unit cell. Actual sets of experimental data would be almost invariably grossly redundant when considered from this point of view, and it is interesting to consider if any method of solution exists in this case.

The general case, in which all phases are known, is, of course, trivial, since a straightforward Fourier synthesis

$$\rho(xyz) = \frac{1}{V} \sum_3 |F_o| \cos(\theta - \alpha) \qquad (3)$$

gives a density map the maxima of which occur at the roots of the set of equations (1). In two other cases, however, phase-angle data are available: (*a*) in those planes of which the phase is given by inequality theory; (*b*) in those planes of which the observed magnitude is zero. It is the second of these cases to which particular attention is to be directed in this communication, not only because of the ease with which such observations (or rather lack of them) can be obtained but also on account of the possible removal of ambiguity produced by the implied knowledge of phase.

At first sight, an application of the Fourier method to such a set of observations looks unpromising, since they are all zero; however, when the difference synthesis is considered, a more hopeful situation is apparent. It has been shown[4] that the synthesis:

$$(\rho_o - \rho_c) = \frac{1}{V} \sum_3 (|F_o| - |F_c|) \cos(\theta - \alpha_c) \qquad (4)$$

has the property that if the positions of the $(x_r y_r z_r)$ used to calculate $\alpha_c$, $|F_c|$ are marked upon it, the directions of steepest ascent at these points give the directions in which the $(x_r y_r z_r)$ must be moved in order to bring the trial structure into better agreement with the true one, and that magnitudes of shift can be estimated by a slightly more detailed analysis.

The reasoning of the original paper (*loc. cit.*) is still valid when $|F_o|$ is zero, and when only those terms for zero $|F_o|$ are included in the summation; thus the simplified expression:

$$\rho_c = \frac{1}{V} \sum_3{}' |F_c| \cos(\theta - \alpha_c), \qquad (5)$$

where $'$ indicates that only those planes for which $|F_o|$ are zero are included in the $\sum_3$, will give the directions in which the atoms of a trial structure must be moved in order to produce the most rapid convergence to a true structure.

It is not to be expected that such a refinement technique will lead to very precise co-ordinates, since to say that $|F_0|$ is zero can, in fact, mean only that it is less than some arbitrary lower limit of size. However, in view of the great ease of obtaining the observational material, it is suggested that the above technique may prove a useful addition to the existing armament of structure analysis.

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## Internal Stresses caused by Disorder in Vitreous Materials

It is now generally recognized that one of the main characteristics of a vitreous material is that its atomic structure has no long-range order[1]. This means that the individual interatomic bonds will not have the length and direction which they have in a crystal, and, because of this, these bonds will not have their normal strength. If it is assumed that the bonds within a certain small region are subjected to a similar distortion, then it will be correct to think of this region as being subjected to a mechanical stress. It is of some interest to calculate the order of magnitude of these internal stresses.

It is clear that the resultant of all the internal stresses in the material must be zero. One of the simplest cases of a distorted structure in which the internal stresses are balanced is the edge dislocation. The equations governing the stresses in such a dislocation have been derived by Nabarro[2]. It can be shown from his equations that the stresses near the centre of the dislocation are of the order of $2G/\pi$, where $G$ is the shear modulus of the material. (It should be realized that this value is obtained from equations based on the assumption that Hooke's law applies for strains of the order of those present in a dislocation; this is, of course, not strictly true.) It is reasonable to assume that regions exist in a typical glass where the distortion is of a type similar to that existing in an edge dislocation, that is, it is a shear distortion; and that the stresses resulting from this distortion will be of the same order as those in a simple edge dislocation.

One consequence of this assumption will now be examined. Griffith[3] has shown that the theoretical strength of glass is of the order of 1,000 kgm. per sq. mm. Now it has just been suggested that internal stresses may exist in glass which cannot be removed by annealing, and which may be of the order of $2G/\pi$. Taking a typical value of $G$ for glass of $0{\cdot}25 \times 10^4$ kgm./sq. mm., the value for the internal stresses is calculated to be about 1,600 kgm./sq. mm. Of course, the internal stresses cannot be greater than the theoretical strength of the material. The values just given for the theoretical strength of glass and for the stresses due to disorder merely indicate the order of magnitude of these stresses; but the values obtained do suggest that, because of the large internal stresses of the material, it may be necessary to apply only a relatively small external stress to cause fracture of the material. It is therefore suggested that the relatively low breaking strength of glass may be partly due to its disordered structure; but it is realized, of course, that in massive glass articles (bottles, sheet glass, and so forth) at least, the flaws in the material which are always present as a result of the manufacturing process and the handling of the article in service may also have a marked effect on the strength.

The expression for the maximum stress of the centre of a dislocation suggests that there may be some relationship between the tensile strength and the shear modulus of glass. This is confirmed, to some extent, by experiment. Thus Murgatroyd[4] has found that, for fibres of a soda lime silica glass between 10 and 100 microns in diameter, the tensile strength increases with decreasing diameter and, at the same time, the shear modulus decreases. This is in agreement with the views just put forward; a decrease in the shear modulus will cause a decrease in the stresses due to disorder, so that a larger external stress will have to be applied for the internal stresses to reach the theoretical strength of the glass. If it is assumed that the greatest internal stress is given by the expression $2G/\pi$, then it is found that the sum of the greatest internal stress and the applied breaking stress is almost constant. This is shown by the results given in the accompanying table.

| Fibre dia. ($\mu$) | $G$ ($10^5$ kgm./sq. cm.) | Max. internal stress $= 2G/\pi$ ($10^5$ kgm./sq. cm.) | Applied breaking stress ($10^5$ kgm./sq. cm.) | Max. internal stress + applied breaking stress ($10^5$ kgm./sq. cm.) |
|---|---|---|---|---|
| 40 | 2·49 | 1·585 | 0·170 | 1·755 |
| 80 | 2·63 | 1·675 | 0·100 | 1·775 |
| 110 | 2·68 | 1·705 | 0·070 | 1·775 |

Other measurements which have been carried out on finer fibres of fused silica are not consistent among themselves. Thus Reinkober[5] has found that, for silica fibres of diameter less than 20 microns, there is a rapid increase in the shear modulus with decreasing fibre diameter, whereas Eberhardt, Kern and Klumb[6] have found that for silica fibres of the same diameter there is a slight decrease in shear modulus with decrease in diameter.

I am indebted to Mr. J. E. Stanworth, of this laboratory, for a number of useful discussions during the preparation of this communication; I am also indebted to Mr. L. J. Davies, director of research, British Thomson-Houston Co., Ltd., for permission to publish the work.

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July 21.

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## Closed Pores in Synthetic Graphite

It is well known that the bulk density of a synthetic graphite is much lower than the density of the crystallites obtained from X-ray measurement: 25–30 per cent of the volume must be empty pore space. By measurement of the real density with three different fluids, we have shown that about 20 per cent of the total pore space cannot be reached by a liquid or gas unless the graphite is reduced to a very fine particle-size, or part of the structure is removed by oxidation.

The synthetic graphites studied were pure grades (99·9 per cent carbon), prepared in a commercial graphitizing furnace, having a bulk density of 1·6 gm./cm.$^3$. The displacing fluids used for density measurements were methanol, *n*-hexane and helium. The liquid densities were measured after prolonged refluxing in the liquid used. The standard density-bottle method was used for specimens 6 mm. or less in diameter, and larger specimens were weighed in air and in liquid. The densities of helium were measured after outgassing at 300° C. to a pressure of $10^{-4}$ mm. of mercury or less; no measurements were taken until two hours after admitting helium, and measurable drifts with time were seldom recorded after that period. The results are considered accurate to ± 0·3 per cent.

In all cases where they were directly compared, the liquid and helium densities agreed closely. For example, the density of a cylinder (15 mm. diameter) of synthetic graphite was measured as 2·091 gm./cm.$^3$ in *n*-hexane and as 2·093 gm./cm.$^3$ in helium after pumping off the hexane; the density of an oxidized dust was 2·224 and 2·220 gm./cm.$^3$ in methanol and helium respectively. There was no evidence of a molecular sieve effect, as has been reported for some cokes[1], that is, the measured density was independent of the molecular size of the displacing fluid.

The density of pure flakes of natural Ceylon graphite (99·5 per cent carbon) was measured as 2·253 gm./cm.$^3$ in methanol and 2·251 gm./cm.$^3$ in helium; these values amount to 99·3 per cent of the value derived from X-ray crystallographic data, which is[2,3] 2·266 gm./cm.$^3$. In contrast to this, the densities of specimens of the synthetic graphite were always lower than 2·21 gm./cm.$^3$. The densities of bulk specimens, that is, cylinders and plates, varied from 2·06 to 2·13 gm./cm.$^3$ with no systematic variation with specimen size or with the original position of the specimen in the large manufactured block. The densities of dusts (particle diameter less than 0·4 mm.) milled from the same blocks as provided the bulk specimens were uniformly higher, ranging from 2·15 to 2·21 gm./cm.$^3$, and these densities showed a tendency to increase as the particle-size of the dust decreased. For one dust examined, the sieve fraction − 36 + 72 B.S.S. had a density of 2·154 gm./cm.$^3$, whereas the density of the fraction passing a 240 B.S. sieve was 2·191 gm./cm.$^3$.

Thus all measured density values found for artificial graphite were 2–8·5 per cent lower than the experimentally determined value for natural graphite. The calculated X-ray density of a synthetic graphite comparable to that used by us (sample *A* 1, ref. 3) was only 0·2 per cent lower than the X-ray density of Ceylon graphite. The low observed densities therefore suggest the presence of inaccessible pore space in the micro-structure of synthetic graphite, formed either by the disordered stacking of the graphite crystallites or by intercrystalline linkages of non-graphitic carbon. Some of the blockages in the pores must be fairly far apart, since reducing the particle size to 70 microns opens up an appreciable fraction of the closed space.

The densities of some bulk and dust samples were re-measured after oxidation at 430°–500° C. in an air stream. The density always increased on oxidation, the increase being normally greater the larger the loss of weight. The density increase was most marked in the initial stages of the oxidation—the density of a 14-mm. diameter cylinder increased from 2·130 to 2·194 gm./cm.$^3$ on oxidation to 0·55 per cent loss of weight, and to 2·226 gm./cm.$^3$ on oxidation to 2·7 per cent loss of weight. It is suggested that slight oxidation may remove the pore blockages, either by first removing poorly crystallized material, or by oxidation occurring first at the edges and corners of crystals, and closed spaces may thus become accessible to the measuring fluid.

The significance of these results will be more fully discussed in conjunction with parallel adsorption measurements to be reported elsewhere. We wish to acknowledge experimental assistance afforded by Mr. E. A. Harper and Mr. H. Small, of this Establishment.

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July 25.

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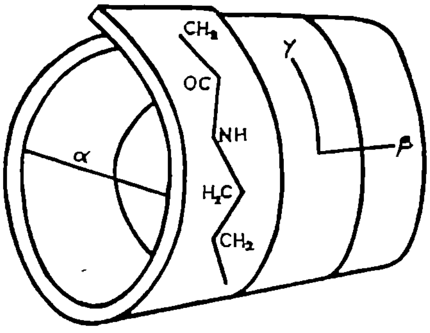
## Morphology of Crystalline Synthetic Polymers

In a previous communication[1], it has been reported that when polyethylene terephthalate crystallizes, it forms spherulites, which consist of radiating helically wound ribbons, and that other synthetic polymers behave similarly. The present communication describes effects observed with polyethylene and polyamides.

In order to observe the phenomena to be described, polyethylene and polyamide (nylon) melts were crystallized in thin layers between cover-glasses at a constant temperature within 20° C. of the softening point. Between crossed Nicols, spherulites were seen which, in addition to the usual black cross, showed a system of concentric extinction rings, and in some cases also the beginning of a zig-zag distortion of the crosses[1]. With decreasing temperature of crystallization, the extinction rings become gradually narrower and more closely spaced, until they can no longer be resolved with the optical microscope. The sign of birefringence of the polyethylene spherulites was negative, and that of the polyamides nearly always positive; by this it is meant that, regarding the spherulite as uniaxial, in the first case the major refractive index lies tangentially and in the second radially with respect to the spherulite. In very rare instances isolated negative polyamide spherulites have been seen, but the conditions for producing these are not known. All these effects can be explained by the morphology proposed in ref. 1. Accordingly, the above observations correspond to cases in which the radiating needles are closely coiled helices (helical angle only a few degrees), and the increasing separation of the rings with increasing temperature of crystallization would be due to the increasing diameter of the needles.

Thinner layers of melt crystallize to a felted mass of interpenetrating needles, which aggregate into airscrew-like structures with voids between. Still thinner layers produced isolated needles which direct observation showed to be helically coiled ribbons, as postulated from the extinction pattern.

Some conclusions could be reached about the orientation of the molecules within the ribbons themselves. It will be assumed that the chains are parallel to the length of the ribbons, as this is consistent with our ideas about aggregation of fibre-forming molecules. Owing to the close coiling, γ, the largest refractive index (coincident with the chain direction), will be perpendicular to the helical axis. In polyethylene, α and β, minor and intermediate refractive indices respectively, are nearly equal[2], whence the birefringence of the spherulites will be negative as observed. In polyamides the conditions are complicated by the fact that β is more nearly equal to γ than to α, as a result of the strong polarizability of the CO- and NH-bonds[3]. We assume that the hydrogen bonds lie in the plane of the ribbon, as this is most likely in view of the crystal structure[3]. Then if the ribbon is closely coiled so that its plane is parallel to the axis of the helix, the position of the refractive indices will be as shown in the diagram. When the same beam of light goes through a number of helices, γ and α will be averaged, the resultant being smaller[3] than β, which lies along the axis of the helix, and hence along the radius of the spherulite. Consequently, the birefringence will be positive as observed.



Schematic illustration of the arrangement of the molecules and the refractive indices of a polyamide within a helix

An X-ray photograph has been taken of a circular area 30 μ in diameter near the periphery of a spherulite of polyhexamethylene sebacamide, using the microbeam method of Herbst[4]. The diameter of the spherulite was 200 μ and the thickness 20 μ. The photograph showed that the planes containing the hydrogen bonds were parallel to the radius, and that the molecules were arranged tangentially. This picture is the same as that deduced from birefringence evidence. These X-ray findings differ from those of Herbst, who concluded that the hydrogen-bonded planes were perpendicular to the radius. Such an arrangement would give a negative sign of birefringence; but Herbst's note does not contain any statement about the birefringence.

The picture of the radiating helices has now been proved in several ways, and the frequent special case when the helices are closely coiled gives a satisfactory morphological explanation of the hitherto unexplained tangential molecular orientation often described in the literature of polymer spherulites.

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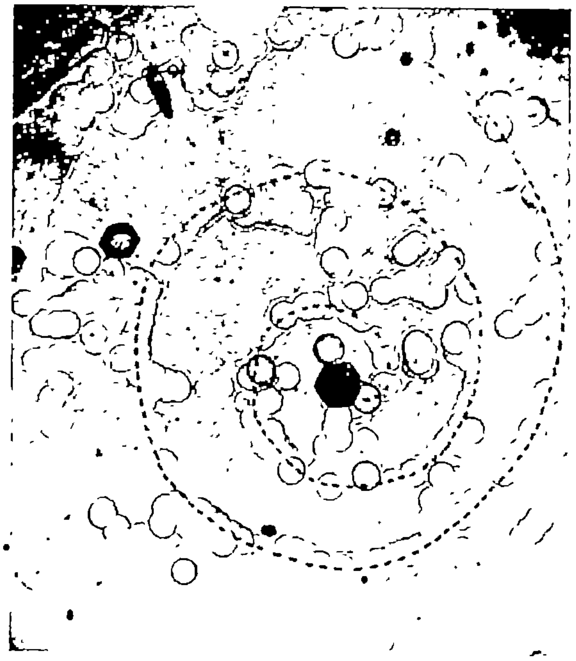
## Etch-pits and Dislocations

Prof. S. Tolansky and M. Omar have reported[1] the appearance of spirals on octahedral faces of diamond, after etching. The hypothesis was put forward that etch-pits had been formed along a spiral-shaped growth-front; but no proof was given.

In the course of a detailed interferometric study of etch-pits, a report on which will be published elsewhere[2], we made very similar observations on c-faces of silicon carbide. Crystals on which growth-spirals were present were etched in fused borax and silvered before examination. It was found that etch-pits had been formed all along the spiral growth-fronts, proving the correctness of Tolansky's point of view.

The accompanying photograph shows the crystal face after etching; the original spiral (step-height of the order of 600 A.) has been marked by a broken line. At the end of the dislocation line a very deep etch-pit (several wave-lengths) was formed, proving that the presence of dislocations makes etching easier. This last point is also strikingly shown on prism faces (110) of very perfect topaz crystals, where etch-pits form preferentially at the top of growth pyramids.



These observations suggest that etching at dislocations will take place following a mechanism which is formally analogous to the Frank mechanism for growth[3]. A striking feature is the difference between the deep polygonized etch-pits generated at the emergence of screw dislocations and the shallow rounded etch-pits formed elsewhere on apparently perfect areas of the crystal face.

This work is part of a research scheme supported by I.R.S.I.A. I wish to thank Prof. W. Dekeyser and Dr. S. Amelinckx for advice.

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# Exudation of Material from Slip Bands at the Surface of Fatigued Crystals of an Aluminium–Copper Alloy

No satisfactory explanation of the fatigue mechanism of metals has yet been advanced. The generally accepted idea involving work-hardening and subsequent 'brittle' fracture cannot be substantiated by observation as being the only cause of fatigue failure. Observations I have made on pure aluminium and aluminium–½ per cent silver specimens have shown that the mechanisms of failure at high and low stresses are fundamentally different[1].

A type of crystal breakdown which it is believed has not been observed before, and which may contribute to the understanding of the initiation of fatigue cracks, has recently been observed during the fatiguing of an aluminium–4 per cent copper alloy in the solution heat-treated condition. During the early stages of the fatigue life of this material, some of the grains become covered with fine slip bands, as is usual with most of the materials examined. The new observation is that, as the cyclic stressing continues, certain slip bands become more heavily defined, and thin ribbons of material are exuded from these bands. These ribbons usually curl over at the leading edge as shown in Figs. 1 and 2. It is only possible to estimate an upper limit for the thickness of the exuded ribbon because of these curled edges. The diameter of the curled portion is usually about 1 micron; thus the ribbon thickness may be considerably less than the limit of resolution of the microscope. These ribbons may be continuous along the length of the slip band, but they usually break into shorter lengths. The wrinkled appearance of these short lengths suggests that the 'extrusion-rate' is varying along the band. These ribbons often

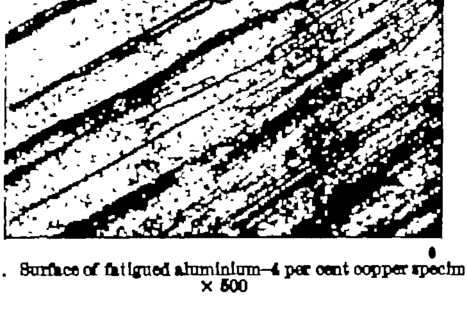
Fig. 1. Surface of fatigued aluminium–4 per cent copper specimen. × 500

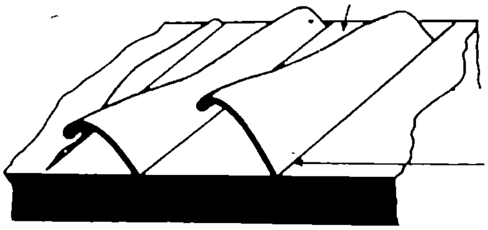

Fig. 3. Schematic diagram showing crystal debris at surface of crystal

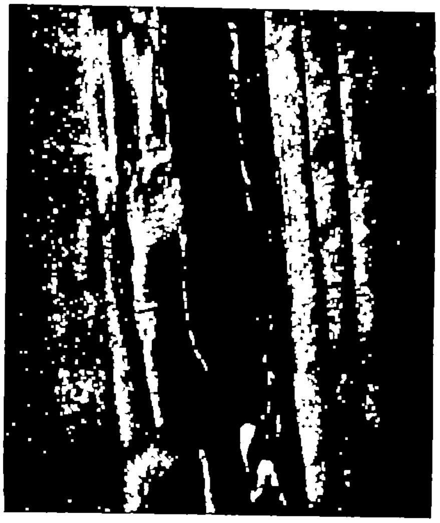
Fig. 2. Ribbon of exuded material showing 'extrusion' markings. × 1,500

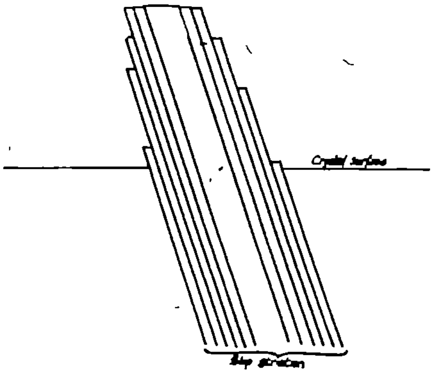

Fig. 4. Schematic diagram of a slip striation in which a layer of material may be exuded from the crystal surface

showed 'extrusion' markings as indicated in Fig. 3, and often other markings at right-angles to these are also observed.

The effect of the loss of this coherent material from the crystal surface must be to leave crevasses which will form very effective stress raisers. The mechanism by which this material is exuded from the surface is not clear, but it may be the result of slip movements as suggested in Fig. 4. Further investigations into this phenomenon are being made.

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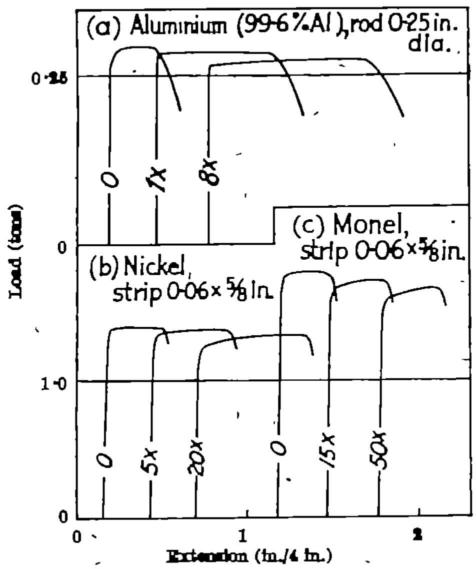
## Softening of Cold-worked Metals under Cyclic Strains

It is well known that ductile metals in the soft condition work-harden progressively when subject to cyclic straining, for example, in fatigue testing. On the other hand, I have shown[1] that metals originally cold-worked soften when plastically deformed under conditions in which a Bauschinger effect is operative. Since a Bauschinger effect is to be expected whenever the original and superimposed methods of deformation differ, it can be anticipated that initially cold-reduced metals may soften when later exposed to cyclic plastic strains. This is confirmed by the following experiments (see graph).

Diagram (*a*) refers to a rod initially cold-drawn 15·6 per cent, and in the as-drawn condition extension curve *O* was obtained. After an additional single reversed torsion cycle of 0 ± 45° per in. of length, the extensometer record altered to 1 ×, and after eight such cycles curve 8 × was recorded.

The nickel and Monel strips (*b*, *c*) were first cold-rolled 20 per cent and afterwards bent forwards and backwards over a 4-in. diameter cylinder. Curves 0 refer to the as-rolled condition. The others were obtained after subjecting the strips to the indicated numbers of reversed bending cycles.



Effect of reversed torsion cycles (*a*) and reversed bending (*b*, *c*) on tensile properties of certain cold-worked metals

There was a fall of surface hardness, yield and tensile values in each case, and a pronounced increase of elongation in most cases. Similar results were obtained with copper and carbon steel and for initial reductions up to 60 per cent (to be reported in detail elsewhere). Relevant effects noted in industrial straightening of rod and wire[2] can thus be accounted for on a rational basis.

Thanks are due to Mr. H. W. G. Hignett (The Mond Nickel Co., Ltd., Birmingham) for presenting samples of nickel and 'Monel' metal.

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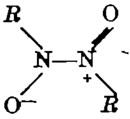
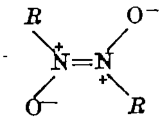
## Perfluoroalkyl Nitroso Compounds

A preliminary study[1] of the photochemical properties of the first fluorocarbon iodide, trifluoroiodomethane, showed that a trifluoromethyl radical is produced the primary reactions of which parallel those of the hydrocarbon free radicals. A direct method thus became available for the preparation of perfluoroalkyl nitroso compounds, by irradiation of the iodide in the presence of nitric oxide and of mercury (to remove iodine), with the difference that the product would then be stable, in contrast to alkyl nitroso compounds, which dimerize, and re-arrange to form oximes[2]. (Ruff and Giese[3] had previously reported as a by-product of the action of elementary fluorine on silver cyanide containing the oxide and nitrate as impurities, a 1 : 1 mixture of $CF_3NO$ and $FCONF_2$, from which the former could not be separated. Some properties and reactions were recorded, not all of which agree with the present work, or with what one would expect of the compound perfluoroformamide.)

Assuming, as seems likely, that the aliphatic nitroso compound dimers have the same constitution as their aromatic analogues, the structures of which are known[4], dimerization would here be inhibited by the strong inductive pull of the perfluoroalkyl group (cf. Pauling's adjacent charge rule[5]), and isomerization to form the aldoxime analogue would be impossible with the electronegative fluorine replacing hydrogen.



(two forms), with some contribution from



Perfluoro-1-nitrosopropane has been made by irradiating gas mixtures, at just below atmospheric pressure, of perfluoro-*n*-propyl iodide and nitric oxide (with a slight excess of the latter) in a silica bulb of 220 c.c. capacity containing about 5 c.c. of mercury. Osram high-pressure mercury vapour lamps (type *MB/V*, 125-watt, with the glass envelope removed) were used as sources of ultra-violet light. Purification of the gas was found to be difficult, but was effected by repeated distillation in a Fenske-packed column, with reflux temperature − 78·5°, middle cuts being taken. The pure nitroso compound, obtained in *c.* 80 per cent yield from the iodide, is a gas of very deep blue colour tinged with green; the liquid is deep blue, and the solid almost purple.

Preliminary values for the physical constants were measured on samples of which the molecular weight, determined by the gas density method, was within 1 per cent of 199, the theoretical value.

Saturation vapour pressures are given by

$$\log P\ (\text{mm.}) = 9{\cdot}035 - 1{,}593/T,$$

according to which the boiling point (extrapolated) is − 14·5° C., the latent heat of evaporation at the boiling point 7,270 cal., and the Trouton constant 28, suggesting that the liquid is strongly associated. The melting point was determined in a Stock apparatus as − 151° C. Analysis by the calcium fluoride method, after sodium fusion, gave 66·1 per cent fluorine (theoretical value, 66·8 per cent).

The spectrum of the gas was measured at room temperature, with a transmission-reading Cary recording spectrophotometer. The vapour was contained in a 4-cm. silica cell, filled to pressures between 5 and 75 cm. of mercury.

The blue colour of the gas is due to a very weak absorption band, for which $\varepsilon_{\text{max.}} = 19{\cdot}0$ at 6840 A., of oscillator strength (*f*-value) 0·00020 in the red. This band is markedly asymmetrical, but apart from six irregularly spaced and very poorly resolved vibrational bands, is almost structureless. The following are representative of the spectral slit-widths used in this region: 45 A. at 7000 A., 17 A. at 6500 A., 7 A. at 6000 A.

A region of more intense absorption begins at 2400 A. Between these two chief band systems there was invariably very weak banded absorption ($\varepsilon$ less than 0·2), the intensity of which varied from sample to sample, and which is therefore confidently ascribed to small and variable quantities of impurity.

This spectrum closely resembles that of di*iso*propyl bromonitrosomethane given by G. N. Lewis and M. Kasha[6] over a similar range, and those of other α-substituted aliphatic nitroso compounds observed in the visible region by D. Ll. Hammick *et al.*[7].

The liquid, in a sealed tube at room temperature, was found by the Gouy method to be diamagnetic (cf. nitrosyl chloride[8,9], nitrosobenzene[10]), and the molecular susceptibility agrees, within an experimental error of some 5–10 per cent, with the sum of the atomic susceptibilities (− 102 × $10^{-6}$ c.g.s.u.). The magnetic and optical properties support the formulation of $C_3F_7NO$ as a nitroso compound, in a singlet state[4,5,11].

The perfluoroalkyl nitroso compounds are readily oxidized, and are completely absorbed in alkali. Further studies of these compounds are in progress and will be offered for publication elsewhere.

I wish to thank Dr. I. G. Ross for measuring and commenting on the spectrum, Imperial Chemical Industries, Ltd. (General Chemicals Division), and the Minnesota Mining and Manufacturing Company, St. Paul, Minnesota, for gifts of fluorochemicals, and members of the Department of Chemistry (including Dr. N. Kornblum) at University College for help and encouragement.

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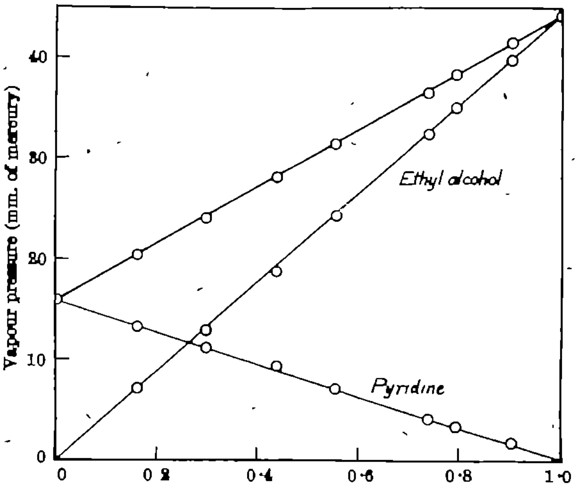
## Raoult's Law: a Pseudo-Ideal System

RELATIVELY few binary liquid mixtures obey Raoult's law in their vapour pressure relationships. Most of those which do so are mixtures of either isomers or close homologues. The components of the remainder are not, in general, highly polar substances[1].

In the course of other investigations, we have had occasion to measure the total and partial vapour pressures at 20° of the system pyridine – ethyl alcohol. The results (see graph) approximate closely to the behaviour required by Raoult's law. In this system, however, not only is association of one component (ethyl alcohol) possible, but also there can be intermolecular attraction, by hydrogen-bonding, between the two components. Evidence that such hydrogen-bonding does occur (to give a 1 : 1 molecular compound) is provided by the Raman spectra of the mixtures and the ultra-violet spectra of their solutions in non-polar solvents[2].

The only other results in accordance with Raoult's law from appreciably polar components of which we



Total and partial vapour pressures in the system pyridine–ethyl alcohol are aware are from an isobaric investigation of the system pyridine – acetic anhydride[3]. Here, however, there is no free hydrogen atom to allow of the extensive hydrogen-bonding which can occur between pyridine and ethyl alcohol.

It is interesting to note that the total pressure curves for the system pyridine – ethyl alcohol at 0° and at 40° show no deviation from linearity, within the limitations of the method used[4].

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## Moving-Boundary Electrophoresis of Colloidal Electrolytes using Concentration Boundaries

OWING to the difficulty of finding sufficiently slow indicator ions, it is doubtful if the direct moving-boundary method for transference numbers can be fully applied to solutions of colloidal electrolytes. Hartley's 'balanced' boundary method[1], in which the colloidal ion forms the indicator ion, involves the determination of 'Kohlrausch concentrations' and a knowledge of the transference number of the leading ion.

The differential method, in which a boundary is formed between two concentrations of the same electrolyte, reveals the change in transference number between these concentrations across the boundary. Smith[2] and Longsworth[3] have shown that the transference number increments thus obtained with ordinary salts agree well with those from the direct moving-boundary method.

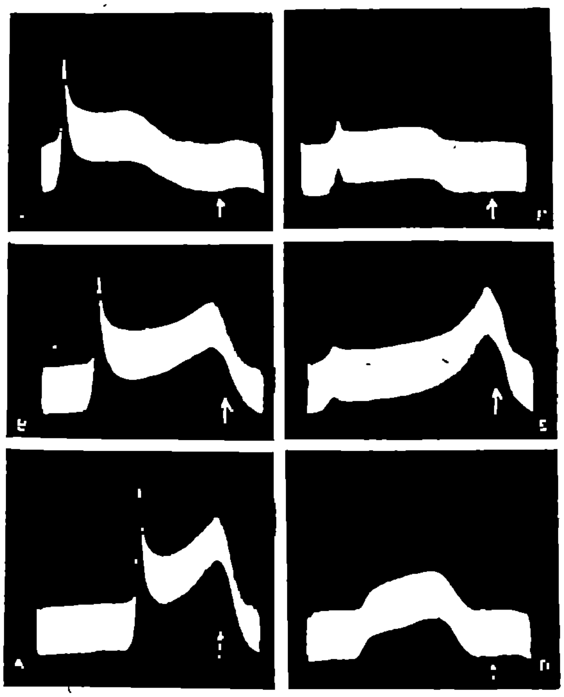
We have applied this to potassium laurate and lauryl sulphonic acid solutions at 0·5° C. For potassium laurate solutions, an excess of 4 equiv. per cent of potassium hydroxide on the basis of soap was added in the concentrated solution to prevent hydrolysis. The concentration of potassium hydroxide in the dilute solution was kept the same as in the stronger solution to prevent a concentration boundary due to potassium hydroxide. A Tiselius electrophoresis apparatus (Perkin Elmer Model 38 [4]), utilizing a 2-c.c. Tiselius cell and Longsworth's scanning method for photographing boundaries, was employed.

Preliminary results have been obtained with the 'open' electrode system and are reported in this communication. For accurate determination of the transference number increment over the interval $\Delta C$ across the boundary, however, the boundary displacements need to be measured with reference to a plane fixed with respect to the solvent. This is best accomplished by closing one electrode chamber, so that volume changes on this side alone affect the disposition of the boundaries. The necessary volume corrections may then be applied with a knowledge of the partial molal volumes of the electrolyte solutions. The determination of partial molal volumes of potassium laurate and laurylsulphonic acid solutions is in progress. The results described here are, however, of interest in that concentration boundaries have been used for the first time to investigate 'association' colloids.

Three concentration boundary systems were investigated for potassium laurate solutions. (1) Both solutions were below the critical concentration for micelle formation. The boundaries in the two limbs of the Tiselius cell moved towards each other irrespective of the direction of current. This was possibly due to convective flow caused by a great disparity of heat generated in the two solutions across the boundary. Similar phenomena have been observed by Smith[2] and Longsworth[3] with concentration boundaries involving simple electrolytes. (2) The dilute solution was fixed at a concentration ($\sigma''$) of 0·25 per cent and the concentrated solution ($\sigma'$) varied from 0·7 to 2·00 per cent. The anion transference number increment ($T_{\sigma'} - T_{\sigma''}$) showed a sharp rise when $\sigma'$ exceeded the critical concentration for micelle formation. (3) The concentrated solution was fixed at 2·0 per cent and the dilute solution varied from 0·25 to 1·50 per cent. The boundaries moved in the opposite direction to the positive current and the anion transference number increment ($T_{\sigma'} - T_{\sigma''}$) showed a maximum in the region of $\sigma''$ (equal to critical concentration for micelle formation).

Further experiments were carried out with boundary systems in which the dilute solution was fixed at a concentration corresponding to the critical concentration for micelle formation, being 0·83 per cent (0·035 *M*) and 0·25 per cent (0·010 *M*) for potassium laurate and laurylsulphonic acid solutions, respectively[4].

These boundary systems have a special significance in that the increments of anion transference number thus obtained represent the transport due to the associated colloid ion or ions. The anion transference



Moving boundary electrophoresis of colloidal electrolytes at 0·5°; ascending patterns. The arrow indicates the initial position of the boundary. The direction of current, 8 m.amp. in each case, is from left to right.
Potassium laurate solutions. (*A*) 3·00–0·83 per cent; 1,200 sec. (*B*) 3·00–0·83 per cent; 1,800 sec. (*C*) 2·00–0·83 per cent; 1,800 sec. (*D*) 2·00–1·00 per cent; 1,200 sec.
Laurylsulphonic acid solution. (*E*) 2·00–0·25 per cent; 1,200 sec. (*F*) 0·75–0·25 per cent; 1,200 sec.

number increment ($T_{c'} - T_{c.m.c.}$) passed through a maximum at $c' = 3{\cdot}0$ per cent ($0{\cdot}126\ M$) for potassium laurate and at $c' = 1{\cdot}5$ per cent ($0{\cdot}060\ M$) for laurylsulphonic acid solution[6]. These maxima correspond to concentrations at which the solutions have reached the fully colloidal state as shown, for example, by the solubilization of dyes by aqueous potassium laurate and laurylsulphonic acid[7].

The schlieren patterns obtained are of interest. There is a sharpening effect at the descending boundary which moves as a steady state almost from the moment the current is switched on. There is a spreading effect at the ascending boundary which splits into two component boundaries. This may, or may not, be due to the presence of more than one kind of colloidal particle. A few representative ascending patterns are illustrated in the accompanying photographs. It may be noted that the area under the faster component of the ascending pattern remains practically unchanged for either electrolyte over a considerable range of concentration. If, however, the concentration of the dilute solution across the boundary were increased from 0·83 to 1·00 per cent (for potassium laurate solutions), the faster boundary disappeared (compare patterns *C* and *D*). The faster boundary of the ascending pattern may therefore be due to a rapid increase of anion transference number over a narrow range of concentrations just above the critical concentration for micelle formation.

I am grateful to Prof. J. W. McBain and Dr. S. S. Marsden for their interest in this work.

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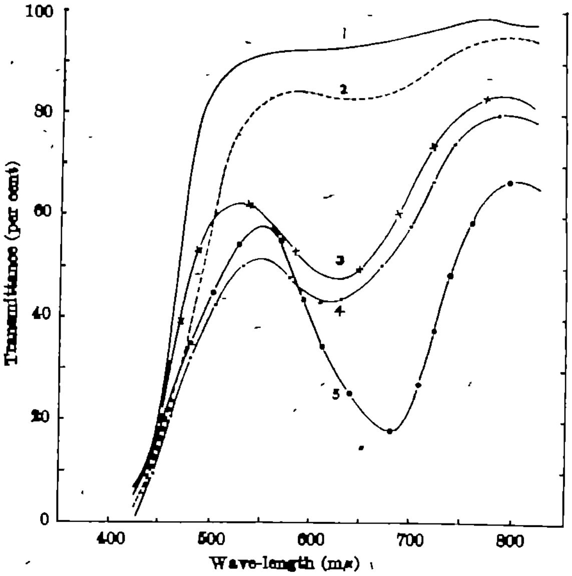
## Interference of Pentose in the Estimation of Hexose Sugars with Anthrone

IN the course of investigations on methods for the determination of sugars in the study of the trashy leaf phenomenon in Australian flue-cured tobacco[1], it was soon apparent that the anthrone reagent of Dreywood[2] was well suited to the routine estimation of hexose and polyhexose sugars in plant materials. It was found, however, that the quantitative estimation of sugars with anthrone requires rigid control of variables such as the rate of evolution of heat of hydration of sulphuric acid in the development of the green-coloured sugar–anthrone complexes.

It has now been found that pentose sugars may interfere appreciably in the determination of hexoses. This matter could be of some importance in view of the extensive use of anthrone in estimating hexose and polyhexose sugars in biological materials[3]. The colour intensity of the pentose–anthrone complex is negligible compared with that of the hexose–anthrone complex, when sugars are compared individually on an equimolecular basis. Anthrone might therefore be regarded as virtually specific for hexose and polyhexose sugars when applied to separate test solutions. This specificity does not apply when pentose and hexose are present in the same solution.

Absorption curves have been determined for analytical grade purity and recrystallized laboratory reagent hexose, dihexose and pentose sugars (that is, glucose, fructose, sorbose, sucrose, xylose, arabinose and ribose) and for pentose plus hexose solutions anthronated before and after mixing. Curves 1, 2 and 3 of the accompanying figure are typical spectral curves for anthrone reagent alone, pentoses (arabinose 100 μgm. per 12 ml.) and hexoses (glucose 50 μgm. per 12 ml.) respectively. Curve 4, typical for mixtures of pentoses and hexoses, was obtained when equal volumes of separately anthronated solutions of arabinose (200 μgm. per 12 ml.) and glucose (100 μgm. per 12 ml.) were cooled to 20° C. and mixed just before spectral measurements. Curve 5 was obtained when the pentose–hexose solutions were mixed before anthronation. The standard anthronation procedure adopted in this laboratory was followed in all cases. The spectral measurements were made on a Beckman spectrophotometer (model *D.U.*), and the coloured complexes obtained proved stable at room temperature, with no perceptible colour deterioration within 60 min. Curve 4 for the mixture of separately developed pentose–anthrone and hexose–anthrone complexes follows closely that of the hexose–anthrone complex (curve 3), with minimum transmittance at about 625 mμ, and appears to be the resultant of the two curves; whereas curve 5 (pentose–hexose–anthrone), obtained with the mixed sugars, differs markedly and shows maximum absorption at about 680 mμ. It is clear that, when pentoses and hexoses are anthronated together, a complex is formed of a very different nature from that formed when hexoses are anthronated alone.

The accompanying table presents values for glucose estimated by the anthrone technique in known mixtures of glucose with arabinose, using a Hilger absorptiometer with a filter of 620 mμ maximum transmittance. The 'error' expected from the inclu-



Absorption curves for sugar–anthrone complexes. (1) ———, anthrone reagent only; (2) - - - - -, arabinose, 100 μgm. per 12 ml.; (3) —×—×, glucose 50 μgm. per 12 ml.; (4) ——·——, mixture of separately anthronated solutions containing complexes of 100 μgm. arabinose and 50 μgm. glucose in 12 ml.; (5) —○—○, complex of anthronated solution containing 100 μgm. arabinose and 50 μgm. glucose in 12 ml.

INTERFERENCE BY PENTOSE IN ESTIMATION OF HEXOSE SUGARS WITH ANTHRONE

| Mixture of | | Glucose found* (µgm.) | Error found expressed as glucose (µgm.) | Approximate error expected† (µgm.) |
|---|---|---|---|---|
| Arabinose (µgm.) | Glucose (µgm.) | | | |
| 0 | 30 | 30 | 0 | — |
| 25 | 30 | 37 | 7 | < 1 |
| 25 | 60 | 67 | 7 | < 1 |
| 50 | 60 | 74 | 14 | < 2 |
| 100 | 60 | 88 | 28 | < 4 |
| 100 | 90 | 120 | 30 | < 4 |
| 100 | 120 | 154 | 34 | < 4 |
| 150 | 120 | 171 | 51 | < 6 |

* Values read off a standard glucose graph. They are means of four separate estimates, each based on two duplicates. The 95 per cent confidence limits to these means are given by mean ± 1·2 per cent of the mean.

† Absorption readings for various amounts of anthronated pure arabinose read off the standard glucose graph and expressed as glucose

sion of the arabinose was determined by measuring the colour development from a pure arabinose solution, and expressing this in terms of glucose. It was found that 100 µgm. of arabinose gave a colour development equivalent to less than 4 µgm. of glucose. The errors actually observed in solutions containing both sugars were far greater than this, approaching 30 per cent when the molecular concentration of arabinose equals that of glucose.

This finding indicates that, when using the hexose–anthrone complex in hexose sugar estimation, any pentoses present should be corrected for or removed. The procedure adopted for separation of pentose and hexose sugars from their mixtures, and the quantitative estimation of both groups, will be published elsewhere.

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## Liesegang Rings on Metallic Bases

WE have repeated the experiment described by Christomanos[1], and observe the formation of good Liesegang rings in all cases on clean, pure silver and other more noble metals; but either no rings, or badly distorted ones, on less noble metals and silver alloys. If the silver surface is previously darkened by exposure to sulphide, the rings are distorted but none the less appear in most cases. If, however, the clean metal is previously heated to darkening, or dipped in hydrogen peroxide solution, the rings that are eventually formed are decidedly inferior.

These observations suggest a modification of the normal ring formation by interruption of the straightforward precipitation of silver chromate, and appear to be compatible with the supersaturation theory rather than requiring an electrochemical explanation.

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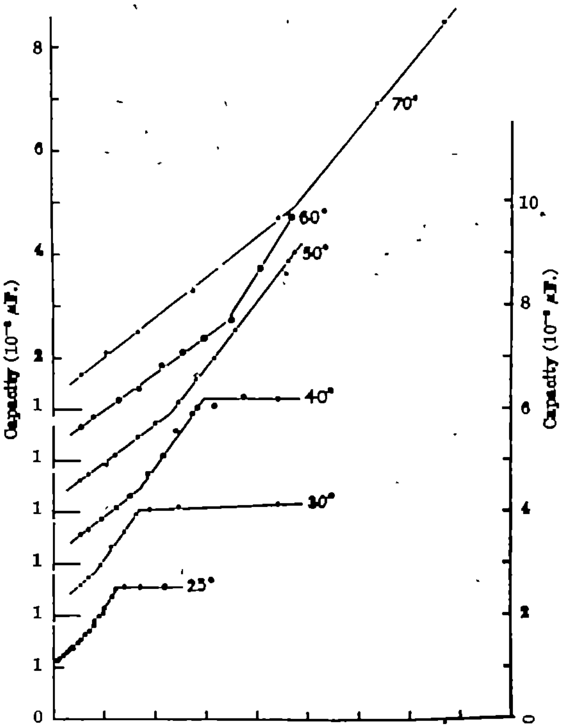
## Effects of Water Vapour on the Electrical Properties of Anodized Aluminium

IN connexion with experiments on semiconductors, one of us[1] noted the very considerable change of capacity which took place when a condenser containing aluminium oxide as the dielectric material was placed in a system which was then evacuated. The change of capacity was ascribed to the removal of adsorbed water from the porous aluminium oxide. In the above investigation, the condenser consisted of an aluminium sheet, of an aluminium oxide layer formed electrolytically (by 'anodizing') on the sheet, and of a thin metallic layer of aluminium evaporated on to the oxide film. The aluminium sheet and the evaporated surface then formed the plates of the condenser.

We measured the capacity of a condenser formed in a similar fashion on an aluminium wire of commercial purity, of approximately 1/16 in. diameter, which was placed in an enclosure in which water vapour was admitted under controlled conditions. Some measurements of the leakage resistance of the condenser were made concurrently with the capacity measurements. A typical sample of useful length 3 cm. had a capacity of 1,200 pF. at zero humidity. The oxide layer was formed at 50 V. in a 3 per cent chromic acid bath. The thickness of the oxide film is estimated to be about 1 micron.

A family of curves relating the capacity of the condenser to water vapour pressure at various temperatures of the condenser is shown in the accompanying graph. Several features are worthy of comment: (1) each curve may be represented by two intersecting straight lines; (2) the initial



Variation of capacity with water vapour pressure in the enclosure for various temperatures of the element. (For clarity, the capacity ordinate of successive curves has been displaced one unit vertically) straight line is in each case the same; (3) the maximum capacity is attained when the measured vapour pressure corresponds to the saturation vapour pressure at the temperature of the condenser; (4) the slope of each curve changes sharply when the vapour pressure approximates to half the saturation vapour pressure at the temperature of the condenser; (5) the slope of the second portion of each curve is almost identical.

The results for each set of points may be expressed in a non-dimensional form:

$$R_c = 0{\cdot}73\,R_H \qquad \text{when } 0 < R_H < 0{\cdot}5 \quad 1(a)$$

$$R_c = 1{\cdot}12\,R_H - 0{\cdot}18 \qquad \text{when } 0{\cdot}5 < R_H < 1 \quad 1(b)$$

where $R_c$ is the change of capacity relative to the maximum change of capacity (that is, at the saturation vapour pressure) and $R_H$ is the relative humidity.

The leakage resistance, $R$, of the aluminium oxide at 50° C., 60° C. and 70° C. was found to decrease exponentially with increasing water vapour pressure, $p$. In each case the relationship can be expressed by the equation:

$$R = R_0 \exp\,(-\,p/p_0), \qquad (2)$$

where $R_0$ is the resistance at zero vapour pressure and $p_0$ is a constant at a given temperature. The accompanying table gives the value of the parameters $R_0$ and $p_0$ in (2) for the three temperatures at which these investigations were carried out.

| Temperature (° C.) | $R_0$ ($10^7$ ohms) | $P_0$ (mm. mercury) |
|---|---|---|
| 50 | 940 | 13·0 |
| 60 | 93 | 36·5 |
| 70 | 2·95 | 118 |

Preliminary experiments have shown that the capacity element is also sensitive to the vapours of most other substances, and that the magnitude of the effect is related to the saturation vapour pressure and to the dielectric constant of these substances.

It is believed that the effects briefly described above will have many applications in addition to the measurement and control of humidity[2]. Further work is being carried out and a more detailed account will be given elsewhere.

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Aug. 12.

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## Effects of Methyl *bis* (beta-Chloroethyl) Amine Hydrochloride on Haploid and Diploid Embryos of *Habrobracon*

X-RADIATION of the parasitic wasp, *Habrobracon*, has shown that haploids and diploids are differentially radiosensitive. During the larval, prepupal and pupal stages, diploids are more resistant than haploids[1]. During the cleavage stages of the embryo, however, haploids are more resistant than diploids, and immediately after cleavage, haploids and diploids are equally sensitive to X-rays[2]. Some of the mustard compounds are highly mutagenic and cause chromosome breakage[3]. We decided, therefore, to test the effects of the nitrogen mustard, methyl *bis* (beta-chloroethyl) amine hydrochloride on haploid and diploid embryos of *Habrobracon*.

In *Habrobracon*, haploids develop from unfertilized eggs and diploids from fertilized eggs. Haploid cultures are obtained from unmated females, whereas cultures containing both haploid and diploid eggs ('mixed cultures') are obtained from mated females. Normally, about 65 per cent of the eggs from mated females are fertilized and, accordingly, are diploids. In material used in the present report, all haploids develop into males and all diploids into females. Eggs stored in the uterine sacs of the females remain in first meiotic metaphase, and further development does not take place until the eggs are laid[4]. It is therefore easy to obtain embryos of known stages.

Eggs were placed in bags made of lens paper and immersed in solutions of nitrogen mustard for half an hour. The nitrogen mustard solution was made up immediately before use and was kept at pH 7 by means of the Teorell buffer. Kolmark and Westergaard[5] have shown that the toxic action of the nitrogen mustard on *Neurospora* is dependent upon pH, temperature, concentration, and age of the solution. We have found (unpublished experiments) that these same factors have a marked effect on the hatchability of eggs of *Habrobracon*. Embryos after treatment were washed in a glycine – sodium bicarbonate solution to stop the reaction of the compound and then in distilled water. Afterwards, they were either (*a*) placed in a mineral oil and the incidence of hatchability obtained, or (*b*) placed upon their host (*Ephestia* larva) and the incidence of adult males and females obtained.

Embryos in the cleavage stage were immersed in the nitrogen mustard solution. On the basis of hatchability, the haploid plus diploid cultures (mixed cultures) (0·222 ± 0·014) were much more affected than were the haploid cultures (0·581 ± 0·017) (Table 1). Treated embryos from mated females were permitted to develop into adults in order to determine the incidence of haploids (males) and diploids (females). Of the treated embryos, 22 per cent hatched and most of these developed into adults. There is a significant difference in the incidence of females from treated embryos (0·231 ± 0·037) and the females from controls (0·643 ± 0·020) (Table 2). These results show that haploid males are much more resistant than diploid females when treated during the cleavage stage. No such differential toxic effect was noted between haploids and diploids treated at later embryonic stages.

Table 1. HATCHABILITY RATIOS FOR EGGS FROM MATED AND UNMATED FEMALES TREATED WITH NITROGEN MUSTARD (0·001 PER CENT)
(Eggs treated during the Cleavage Stage)

| | From mated females (haploid + diploid) | | From unmated females (haploid) | |
|---|---|---|---|---|
| | No. eggs | Hatchability | No. eggs | Hatchability |
| Controls | 286 | 0·944±0·014 | 217 | 0·967±0·012 |
| Treated | 878 | 0·222±0·014 | 837 | 0·581±0·017 |

Table 2. SEX RATIOS OF ADULTS FROM EGGS OF MATED FEMALES TREATED WITH NITROGEN MUSTARD (0·00075 PER CENT)
(Eggs treated during the Cleavage Stage)

| | No. adults | No. ♂♂ | No. ♀♀ | ♀♀ / Total adults |
|---|---|---|---|---|
| Controls | 560 | 200 | 360 | 0·643±0·020 |
| Treated | 130 | 100 | 30 | 0·231±0·037 |

When eggs are treated during cleavage, the effects of the nitrogen mustard are apparent prior to hatching, and those that hatch develop normally into adults. Embryos treated in late stages of development, however, even though they may hatch, are arrested in the larval or pupal stages. Haploid embryos that were treated with nitrogen mustard during cleavage were fixed at a stage when somites would normally be present and stained with the Feulgen reagent. Microscopical examination showed that these embryos had been arrested in cleavage. The nuclei and nucleoli were greatly enlarged and mitosis was halted at interphase. The same effects reported here were obtained with X-rays[3].

Differential effects of chemical agents on individuals differing in the number of chromosome sets have been reported by other investigators, although not with the view of correlating their findings with mutagenesis. Fankhauser[6] showed that young pentaploid larvæ of *Triturus viridescens* are more susceptible to chloretone than are diploid larvæ. Briggs[7] treated androgenetic haploids and normal diploids of *Rana pipiens* before or after gastrulation with hexenolactone. He found no differential effects during pre-gastrula development, but treatment after gastrulation showed that haploids were more sensitive. Hexenolactone has been found to be effective in stopping early cleavage[7]. Smith and Srb[8] have shown that a closely related substance, beta-propiolactone, induces mutations in *Neurospora* and causes chromosomal aberrations in *Vicia faba*.

These results show certain similarities between the effects of methyl *bis* (beta-chloroethyl) amine hydrochloride and of X-rays upon haploids and diploids of *Habrobracon*. Studies in progress on mutagenic and non-mutagenic substances should determine to what extent a differential effect upon haploids and diploids can be used to distinguish substances that are mutagenic and/or cause chromosomal aberrations.

The methyl *bis* (beta-chloroethyl) amine hydrochloride was kindly furnished by Merck and Co., Inc. This work was done under contract No. *AT*(30-1)-953 for the United States Atomic Energy Commission.

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## Inhibition Effects in Back-Mutation Tests with Mutants of *Neurospora*

THE observation of Grigg[1] that large numbers of conidia of biochemically deficient mutant strains of *Neurospora crassa* strongly inhibit the growth of 'wild-type' conidia when plated on minimal medium containing 0·2 per cent sucrose and 0·4 per cent sorbose led him to question the validity of back-mutation tests. On the other hand, Kølmark and Westergaard[2] have reported that in comparable experiments (using an adenine mutant *W* 40) the substitution of a minimal medium containing 2 per cent glucose completely abolishes the growth inhibition. They suggest that the inhibition of 'wild-type' conidia on sorbose medium results from a removal by the large population of germinating mutant spores of the limited amount of sucrose available; they conclude, therefore, that the growth inhibition has no relation to back-mutation tests as usually conducted.

In connexion with our own studies of chemical mutagenesis[3], we have tested a number of mutant strains to ascertain whether this inhibition phenomenon may affect our tests of mutagenic activity. Biochemically deficient, colonial (70007), macroconidial mutants (induced by mustard-type compounds) were tested for their capacity to inhibit growth of wild-type macroconidia carrying the colonial gene (70007). In reconstruction experiments[1] using a minimal medium containing 1·5 per cent sucrose or 2 per cent glucose, a *p*-aminobenzoic acid mutant *WSC* 4-176 (*paba*) and a leucine mutant *WSC* 7-267 (*leuc*) were found to inhibit the growth of colonial conidia. As shown in the accompanying table, pronounced inhibition occurs under conditions commonly employed in back-mutation tests. Not only was the number of colonies decreased in the presence of the mutant, but the colonies were also smaller and many appeared a day or two later. An inositol mutant 37401 (*inos*), as previously observed[4], showed no inhibitory effect. Comparable experiments have been carried out using, in place of colonial (70007) conidia, *paba*+ and *leuc*+ strains isolated from back-mutation experiments with mustard-type compounds. These strains were also inhibited by mutant conidia (see table). Doubling the concentration of the constituents of the minimal medium did not affect the inhibition of colonial by mutant conidia, but if the minimal medium was supplemented by a mixture of amino-acids and vitamins, inhibition was decreased in the case of the *leuc* mutant.

EFFECT OF MUTANT CONIDIA ON GROWTH OF NUTRITIONALLY INDEPENDENT STRAINS OF *Neurospora*

| Mutant strain used | No. of mutant conidia (per plate) | Nutritionally independent conidia used | Average inhibition of nutritionally independent conidia (per cent) |
|---|---|---|---|
| *paba A* | $7 \times 10^6$ | colonial *a* | 30 |
| " | $7 \times 10^6$ | colonial *A* | 65 |
| " | $7 \times 10^5$ | colonial *A* | 20 |
| " | $7 \times 10^6$ | *paba*+ (heterocaryotic) | 30 |
| " | $8 \times 10^5$ | | 0 |
| " | $7 \times 10^6$ | *paba*+ (homocaryotic) | 70 |
| " | $7 \times 10^5$ | " | 0 |
| *leuc A* | $8 \times 10^6$ | colonial *A* | 45 |
| " | $8 \times 10^6$ | *leuc*+ (homocaryotic) | 55 |
| *inos A* | $8 \times 10^6$ | colonial *A* | 0 |

The growth inhibition by different mutant strains can also be demonstrated using a 'half-plate' method. In this technique the suspension of mutant conidia is spread over one-half of the surface of minimal medium in a Petri-dish, allowed to dry for a few hours, and colonial conidia added at a point at the border-line; radial growth is then measured in both directions. The 'giant' colonies grew unilaterally away from the side on which the *paba* or *leuc* mutant had been spread, but no such inhibition was observed with the *inos* mutant. Two cytidine mutants (*WSC* 7-168 and *WSC* 5-25), a cystine mutant (*WSC* 7-303) and a purple adenine mutant (*WSC* 5-298) were found to inhibit colonial growth in varying degrees.

Although both the inhibitory and non-inhibitory types of mutant germinate on minimal medium, experiments indicate that they do not survive equally well in the absence of added supplement. Mutant conidia were plated out in dilute solution (20–200 conidia per plate) on minimal medium, and the compound required by the respective mutant added after a specified number of days. No colonies of the *inos* mutant survived after two days; in contrast, in the case of the mutants which produce growth inhibition, a large proportion of the colonies survived even after six days on minimal medium.

The demonstration of the inhibition of growth of colonial conidia by conidia of certain mutant strains under conditions commonly used in back-mutation experiments reopens the question to what extent this phenomenon affects such results. Grigg suggests the possibility that the back-mutants supposedly induced by the mutagen are already present in the population of untreated conidia but are inhibited either by the large numbers of mutant conidia present or by an intraconidial effect of mutant nuclei. The mutagen, by virtue of its toxicity, would then appear to produce back-mutants simply by killing off inhibiting mutant cells or nuclei. Dilution experiments similar to those described by Grigg[1] were performed with the *paba* and *leuc* mutants. In no case did extra *paba*+ or *leuc*+ colonies appear as a result of plating the mutants at lower concentrations. As a further test, conidia of the mutant strains were treated with a nitrogen mustard, $(C_6H_5CH_2)_2NCH_2CH_2Cl$, which in previous experiments[2] had shown negligible mutagenic activity. In a total of eighteen experiments with *paba* and *leuc* mutants, in which the mortality ranged from 30 to 98 per cent, no induced mutation-rate was recorded. These results provide evidence that, with the particular mutant strains tested, the suggestion of Grigg does not apply. It seems probable that, depending on the nature of the particular mutant employed, the growth inhibition of wild-type by mutant conidia can result in apparent mutation rates which are either higher or lower than the true values.

This work was supported in part by a fellowship to one of us (A. M.) from the Washington Division, American Cancer Society, and in part from funds for biological and medical research, State of Washington Initiative Measure 171.

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Pullman. Sept. 15.

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## Auxins and Auxin Precursors in Plants

The principal auxin in higher plants is generally believed to be indoleacetic acid, which is supposed to arise from tryptophane (*a*) *via* indoleiminoacetic acid, indolepyruvic acid and indole acetaldehyde, or (*b*) *via* tryptamine and indole acetaldehyde[1]. The general occurrence of tryptophane in the plant kingdom is well established. Indoleacetic acid has been isolated from seeds; White[2] found tryptamine in *Acacia*; and there is considerable indirect evidence for the occurrence of indole acetaldehyde in pea, pineapple and potato. Synthetic indolepyruvic acid and tryptamine can be converted to indoleacetic acid by certain living plant tissues and enzyme preparations made from them; but the actual function of either of these substances as an intermediary in the biosynthesis of indoleacetic acid from tryptophane has not been proved.

Since certain crude enzyme preparations are able to convert tryptophane and some of the suggested intermediaries to auxin, they may be used as means for detecting naturally occurring intermediaries in the biosynthesis of indoleacetic acid. In experiments carried out at the Department of Botany, University of Chicago (supported in part by a grant from the Dr. Wallace C. and Clara A. Abbott Memorial Fund of the University of Chicago), it was found by Bonde[3] that ether extracts of pea internodes contained no active neutral growth-substance if the extraction was made at 0° C., whereas extracts made at 22° C. contained an abundance of neutral growth-substance, presumably indole acetaldehyde, active in the *Avena* curvature test. It was assumed that this neutral growth-substance was formed during the extraction at the expense of precursors which might possibly be present in the extracts made at 0° C. Various fractions of such extracts, therefore, were treated with fresh coleoptile juice as a source of conversion enzyme. The acid and non-acidic fractions were examined in the *Avena* curvature test. The tests showed that the non-acidic fraction, originally inactive itself, contained an acid growth-substance, presumably indoleacetic acid, after treatment with coleoptile juice. This result indicates the presence in the original extract of a non-acidic precursor of indoleacetic acid. The formation of a neutral growth-substance (indole acetaldehyde) could not be demonstrated, but the possibility of its intermediary formation is not excluded; the aldehyde may become very rapidly converted to the acid.

Similar experiments with the non-acidic fraction of juice exuded from the internode sections during the ether extraction yielded identical results. The acid fraction of the juice was active in the *Avena* test, but its activity increased gradually under the influence of coleoptile juice. These results indicate the presence in pea juice of both a non-acidic and an acid precursor of indoleacetic acid.

Juice exuded from the inner, etiolated leaves of heads of cabbage was treated in the same manner as juice from pea internodes. Again, the non-acidic fraction, originally inactive, yielded an acid growth-substance upon treatment with coleoptile juice. Cabbage juice, however, differed from the juice of pea internodes in that the acid fraction of the juice yielded a neutral growth-substance upon such treatment. These results indicate the presence in cabbage juice of a non-acidic precursor of indoleacetic acid as well as an acid precursor of the neutral growth-substance.

The acid auxin found in all these experiments is undoubtedly indoleacetic acid. The non-acidic precursor found in both ether extract and juice can scarcely be tryptamine because it behaved as a neutral substance, and not as a base, when partitioned between ether and water at either alkaline or acid reaction. The acid precursor present in the juice of pea internodes might be indolepyruvic acid.

Larsen[4] assumed the neutral growth-substance in heads of cabbage to be indole acetaldehyde. The assumption was based on the considerable amount of indirect evidence for the aldehyde nature of the neutral substance in pea (see also Gordon and Sánchez Nieva[5]), but no actual identification was attempted. Jones *et al.*[6] isolated indole acetonitrile from brussels sprouts. This compound is active in the *Avena* curvature test, the straight-growth test with coleoptile sections, and various other auxin tests. The nitrile is probably also present in heads of cabbage, but further experimentation will now be needed to determine whether or not indole acetaldehyde is present in addition. At present, it is impossible to say whether the above-mentioned acid precursor of a neutral growth-substance in cabbage juice is a precursor of indole acetaldehyde or of indole acetonitrile or both.

Jones *et al.*[6] placed sections of *Avena* coleoptiles in a solution containing 10 mgm. of indole acetonitrile per litre. After 20 hr. the solution contained an amount of acid growth-substance which, if computed as indoleacetic acid, was equivalent to about 1 per cent of the initial amount of nitrile. The amount of unconverted nitrile was not reported. This result, however, does not necessarily indicate that no more than 1 per cent of the nitrile has been converted to acid. As shown by Larsen[7], coleoptile sections inactivate indoleacetic acid very rapidly, and there can be little doubt that indoleacetic acid formed in the experiments by Jones *et al.* would become inactivated to a very considerable extent during the 20-hr. duration of the experiment. The production of indoleacetic acid in their experiments, therefore, may actually have been much higher than 1 per cent of the amount of added nitrile. Coleoptile juice does not inactivate indoleacetic acid and will probably be more suitable than living sections for demonstrating the capacity of *Avena* coleoptiles to convert indole acetonitrile to indoleacetic acid.

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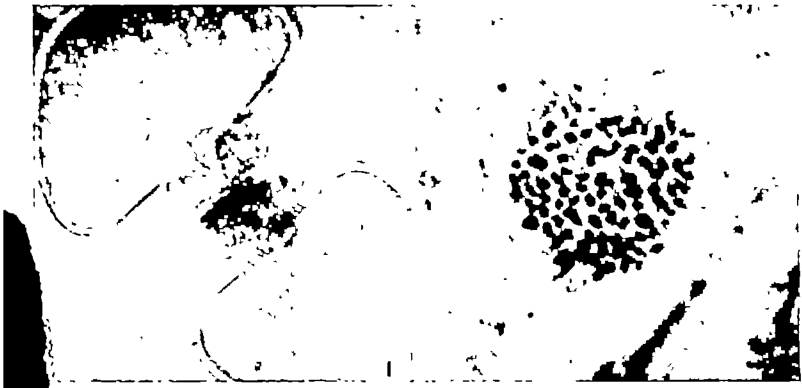
## 'Diffuse' Centromere, and other Cytological Observations on Two Desmids

Cytological studies of the Desmidiaceae now in progress in this department have shown that the chromosomes of *Cosmarium botrytis* and *Pleurotaenium kallis* have a polycentric or diffuse centromere type of organization, which results in the parallel separation of the chromatids at anaphase (Fig. 1). This type of organization has been previously described in *Spirogyra*[1], and among the higher plants in *Luzula*[2] and *Carex*[3].

The chromosome complement of *Cosmarium botrytis* is $n = 18$ and of *Pleurotaenium kallis*, $n = 104$. In the former, the chromosomes at metaphase are loosely joined together, so as to form one or more sinuous threads, while in the latter they are evenly distributed over the equatorial plane of the spindle (Fig. 2). In both, the spindle, like that of *Spirogyra*, is so truncated as to appear sub-rectangular in side view.



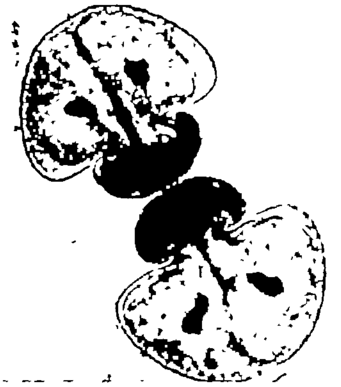


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Fig. 1. *Cosmarium botrytis* showing the parallel separation of the chromatids at anaphase. × 1,100

Fig. 2. Polar view of the metaphase plate of *Pleurotaenium kallis*. × 1,350

3. *Cosmarium botrytis*. Discharge of nuclear material into the protoplasm of the developing semi-cell. Stain: iron aceto-carmine. × 475

The re-establishment of the resting nucleus after division in *Cosmarium botrytis* is peculiar in that the nucleus remains as a plate-like mass at the apex of the developing semi-cell, where it discharges, into the protoplasm of the new semi-cell, material which has a great affinity for iron (this material is presumably ribonucleic acid). So great is this discharge that, with staining, the contents of the semi-cell become obliterated by the intense coloration, which, however, grades off towards the isthmus (Fig. 3). Cells which have been only slightly stained show that at this stage the nucleus begins to migrate to the isthmus, where it is reformed. By this time the new semi-cell is almost fully grown. The re-formation of the resting nucleus at the isthmus goes hand in hand with the progressive loss of affinity for iron of the protoplasm.

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# FORTHCOMING EVENTS

(*Meetings marked with an asterisk * are open to the public*)

## Monday, January 26

Royal Geographical Society (at 1 Kensington Gore, London, S.W.7), at 5 p.m.—Mr. B. H. Farmer: "Problems of Land Use in the Dry Zone of Ceylon".

Physical Society, Acoustics Group (in Room 4, University College, Malet Place, London, W.C.1), at 5.15 p.m.—Mr. H. Aspinall and Mr. J. Y. Morton: "An Acoustical and Mechanical Impedance Measuring Set, and some Results of Measurements on Human Ears and Mastoids".

Institution of Electrical Engineers, Radio Section (at Savoy Place, Victoria Embankment, London, W.C.2), at 5.30 p.m.—Discussion on "The Relative Merits of Harmonic and Intermodulation Measurements in Assessing Distortion in Audio Equipment" (to be opened by Mr. H. W. Barth-Jones).

## Tuesday, January 27

Royal Institution (at 21 Albemarle Street, London, W.1), at 5.15 p.m.—Prof. D. M. Newitt, F.R.S.: "Experimenting at High Pressures". (Further Lectures on February 3 and 10.)

University of London (at King's College, Strand, London, W.C.2), at 5.30 p.m.—Dr. R. Matalon. "Colloid Science and some of its Industrial Applications".* (Further Lectures on February 10, 24 and March 10.)

## Wednesday, January 28

Institute of Petroleum (at Manson House, 26 Portland Place, London, W.1), at 5.30 p.m.—Dr. D. T. Germain-Jones: "Geophysics—its Problems and Trends".*

Institution of Electrical Engineers, Supply Section (at Savoy Place, Victoria Embankment, London, W.C.2), at 5.30 p.m.—Mr. A. F. B. Young: "Some Researches on Circuit-Breaking by means of High-Voltage Circuit-Breakers with special reference to Current-Chopping".

Illuminating Engineering Society (at the Royal Institution, 21 Albemarle Street, London, W.1), at 6 p.m.—Dr. E. D. Adrian, O.M., Pres.R.S.: "The Nervous Reactions of the Retina" (Trotter–Paterson Memorial Lecture).

Society of Chemical Industry, Nutrition Panel of the Food Group (at the Chemical Society, Burlington House, Piccadilly, London, W.1), at 6.15 p.m.—Dr. G. A. C. Herklots and Prof. J. Yudkin: "Food and the Future", 2: "Some Present-day Methods of Attack on the Problems of Food Production".

## Thursday, January 29

Royal Society (at Burlington House, Piccadilly, London, W.1), at 10 a.m.—Discussion on "V-Particles and Heavy Mesons" (to be opened by Prof. C. F. Powell, F.R.S.).

Linnean Society of London (at Burlington House, Piccadilly, London, W.1), at 10.30 a.m.—Discussion on "Problems of Distribution of Animals and Plants in Africa".

University of London (in the Anatomy Theatre, University College, Gower Street, London, W.C.1), at 1.15 p.m.—Dr. D. M. Ross: "Scholarship and Practice in the History of Biology".*

Royal Institution (at 21 Albemarle Street, London, W.1), at 5.15 p.m.—Dr. S. R. Nockolds: "Trace Elements in the Earth". (Further Lectures on February 5 and 12.)

University of London (in the Anatomy Theatre, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Mr. John Wilks: "The Influence of R. W. Chambers on the Development of University Libraries" (Chambers Memorial Lecture).*

Royal Aeronautical Society (at the Institution of Mechanical Engineers, Storey's Gate, St. James's Park, London, S.W.1), at 6 p.m.—Major P. Litherland Teed: "Titanium—a Survey".

Society of Public Analysts and other Analytical Chemists, Microchemistry Group (at the Sir John Cass College, Jewry Street, London, E.C.3), at 7 p.m.—Annual General Meeting; Dr. Cecil L. Wilson: "Microchemistry, an Appraisal".

## Friday, January 30

Institution of Mechanical Engineers (joint meeting with the Steam Group, at Storey's Gate, St. James's Park, London, S.W.1), at 5.30 p.m.—Mr. H. Hillier: "Scale Formation in Sea-Water Distilling Plants and its Prevention".

Royal Institute of Philosophy (at University Hall, 14 Gordon Square, London, W.C.1), at 5.30 p.m.—Mr. D. A. Rees: "Greek Views of Nature and Mind".

Society of Public Analysts and other Analytical Chemists, Physical Methods Group (in the Mason Theatre, The University, Edmund Street, Birmingham), at 6.30 p.m.—Discussion on "Chromatography".

University of London (at Westfield College, Kidderpore Avenue, Hampstead, London, N.W.3), at 7.45 p.m.—Very Rev. H. A. Jones: "The Scientist's Universe and the Christian's Faith".* (Further Lectures on February 13 and 20.)

Royal Institution (at 21 Albemarle Street, London, W.1), at 9 p.m.—Sir Harold Spencer Jones, F.R.S.: "The Mountains of the Moon".

## Saturday, January 31

London County Council (at the Horniman Museum, London Road, Forest Hill, London, S.E.23), at 3.30 p.m.—Miss Winifred M. A. Brooke: "The Bolivian Andes and its People To-day".*

# APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Experimental Officer at the Fuel Research Station, Greenwich—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting C.754/52A (January 31).

Scientific Officer (with a first- or second-class honours degree, or equivalent, in chemistry) with sound knowledge of electrochemistry and electrodeposition of metals, at a Ministry of Supply Establishment, Aldermaston—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting F.817/52A (January 31).

Assistant (with a university degree, preferably in economics or mathematics, and experience in operational research or similar work) in the Operational Research Section, Generation Operation Branch, headquarters Bankside—The Director of Establishments, British Electricity Authority, British Electricity House, Winsley Street, London, W.1, quoting Ref. AH.302 (February 2).

Head of the Department of Mechanical and Electrical Engineering—The Principal, Wigan and District Mining and Technical College, Wigan (February 2).

Meteorological Officers (with an honours university degree covering physics, mathematical physics or mathematics, or a university degree in meteorology, or an academic qualification equivalent to either) in the Department of Industry and Commerce, Dublin—The Secretary, Civil Service Commission, 45 Upper O'Connell Street, Dublin (February 3).

Scientific Officer (with a good honours degree, an interest in biological problems and, preferably, some research experience) in the Chemistry Department, to take part initially in researches on the chemistry of the milk proteins and enzymes—The Secretary, National Institute for Research in Dairying, Shinfield, Reading, quoting Ref. 53/2 (February 7).

Biochemist (principal or senior grade) in the Group Pathological Department—The Secretary, South Worcestershire Hospital Management Committee, Royal Infirmary, Worcester (February 9).

Scientists (with honours degree or equivalent and a good know[illegible]ledge of at least one of the following subjects: physical metallurg[illegible] engineering metallurgy, including knowledge of machinery, to[illegible] materials, hard metals, etc., physical chemistry, corrosion) at t[illegible] Central Research Establishment, Isleworth, Middlesex—The Nation[illegible] Coal Board, Establishments (Personnel), Hobart House, Grosve[illegible] Place, London, S.W.1, quoting TT/578 (February 9).

Assistant Lecturer or Lecturer in the Department of Ci[illegible] Engineering—The Registrar, The University, Liverpool (Febru[illegible] 11).

Research Assistant in the Department of Anatomy, for w[illegible] mainly on central nervous system—The Secretary, University Coll[illegible] Gower Street, London, W.C.1 (February 13).

British Coke Research Association Fellowship tenable in t[illegible] Department of Coal Gas and Fuel Industries, for research at post[illegible]graduate standard on a subject connected with the coke industry—The Registrar, The University, Leeds 2 (February 14).

Lecturer in Pure Mathematics (preferably qualified in algebra and geometry)—The Registrar, University College, Singleton Park, Swansea (February 14).

Research Officer (with a University honours degree in science with botany and chemistry as major subject or in agricultural science or equivalent qualifications) to the Division of Plant Industry, Plant and Soils Laboratory, Brisbane, to undertake studies on the factors limiting legume establishment in sub-tropical areas and southern Queensland—The Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting No. 4119 (February 14).

Rutherford Scholarship for research in any branch of the natural sciences—The Assistant Secretary, Royal Society, Burlington House, Piccadilly, London, W.1 (February 15).

University Demonstrator in Zoology—Dr. A. S. Watt, Department of Botany, Downing Street, Cambridge (February 15).

Senior Agricultural Economist, and an Assistant Agricultural Economist—The Registrar, King's College, Newcastle-upon-Tyne (February 16).

Senior Lecturer in Zoology at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (February 28).

Physicist to Dundee Royal Infirmary, associated with a Lectureship in the Department of Physics in University College, Dundee—The Medical Superintendent, Royal Infirmary, Dundee (March 1).

Senior Lecturer in Mechanical Engineering at the University of Melbourne—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (March 13).

Lecturer in Civil Engineering with particular interest in hydraulics—The Secretary, Queen's University, Belfast (March 15).

Senior Lecturer or Lecturer in Physics at the University of Otago, Dunedin, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (March 15).

Carden Research Fellow (graduate in medicine, science or veterinary science) for research into the cause and cure of cancer, at the University of Melbourne—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (March 31).

Associate Professor of Pathology and Associate Provincial Pathologist for the Province of Nova Scotia (combined position)—Dr. N. G. B. McLetchie, Provincial Pathologist, Dalhousie Medical School, Halifax, Nova Scotia, Canada.

Chief Scientific and Administrative Assistant (with a degree in botany or agriculture, or equivalent qualification) in the Official Seed Testing Station—The Secretary, National Institute of Agricultural Botany, Huntingdon Road, Cambridge.

Superintendent in Charge of the Plant Engineering Division—The Personnel Officer, British Iron and Steel Research Association, 11 Park Lane, London, W.1, quoting "Plant Engineering".

# NATURE

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*Editorial and Publishing Offices of "NATURE"*
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# MECHANISM OF GOVERNMENT IN A DEMOCRACY

THE proliferation of government and quasi-government activities, including problems inherent in nationalized industries, all compel attention to the question of the structure of government, centralization and accountability. Even if Mr. Harold Macmillan finds the measure of agreement which he stipulates as a condition for taking up the question of local government reform, he is likely to be confronted with problems of regional and central administration demanding clear thinking and prompt and firm decision, as is apparent, for example, from Mr. D. N. Chester's study of the financial and administrative relations of central and local government.

It is all to the good that fresh material for the public discussion of the wider and fundamental issues should continue to be forthcoming, if not by Government action, at least from impartial and authoritative sources. The survey of "British Government since 1918", which appeared two years ago, has been followed recently by a like survey limited to Parliament itself*; and, besides two recent broadcasts in which Mr. Christopher Hollis and Mr. John Strachey have discussed the position of parliament in relation to the party system and the survival of democracy, a recent book by Prof. G. W. Keeton, "The Passing of Parliament", has stated even more cogently the argument advanced three years earlier by Mr. Hollis in "Can Parliament Survive?". Fundamental issues in the functioning or survival of democratic institutions have been raised by discussions at the Present Question Conferences on "Freedom and Responsibility", "People at Work" and "Leadership in a Free Society", and also in studies like those on the nationalized industries by the Acton Society Trust, of Dr. Joseph Goldstein on the government of British trades unions, of Dr. W. H. Scott on industrial leadership and joint consultation, and of Mr. J. F. Scott and Mr. R. P. Lynton on management in its social context.

The position the Government has adopted in regard to the renewal of the Supplies and Services (Transitional Powers) Act, 1945, and the Expiry Laws Continuance Bill, makes consideration of the underlying issues a matter of urgency. The Home Secretary indicated on November 20 that the Government is very willing that an inquiry should be held into the procedures for exercising parliamentary control over delegated legislation. The inquiry, however, should be conducted by a more influential body than the Select Committee of the House of Commons suggested by Sir D. Maxwell Fyfe.

What is required is a thorough survey of the problem, comparable with that made twenty years ago by the Committee on Ministers' Powers under the chairmanship, first of Lord Donoughmore and then of Sir Leslie Scott. The multiplication of controls through war-time or security demands, as well as the increased responsibilities which the State has assumed by social legislation and economic stringency, makes it imperative to provide Parliament with some means of supervising really important emergency regulations more effectively than the power merely to accept or reject them outright. It is equally imperative to check any tendency for controls to proliferate.

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* Parliament: a Survey. By Lord Campion, L. S. Amery, D. W. Brogan, J. J. Craik Henderson, Sir Arthur Salter, H. H. Dale, Ivor Thomas, F. W. Lascelles, H. O. S. Wade, Sir Cecil Carr, A. L. Goodhart, G. M. Young. Pp. 296. (London: George Allen and Unwin, Ltd., 1952.) 22s. 6d. net.

Credit should be given to the present Government for an attempt to classify and sift the regulations and powers it proposes to retain; but this is no substitute for the process of analysing those powers and defining their scope and purpose, and their relation to the part which the State should play in the society and economy which the Government in power envisages. The vigilance in regard to individual liberties and rights manifested in the debate in the House of Commons on November 20 may nevertheless induce the Government to look again at the whole problem before coming to the House another year and asking for renewal of these Acts. Mr. Boyd Carpenter gave specific assurances that the Government would not maintain greater powers than the existing situation demanded, and that the situation would be watched carefully to ensure that excessive powers were neither held nor sought.

The broad question of the safeguards required to reconcile individual freedom as well as the sovereignty of Parliament and the supremacy of the law with national security and the efficient discharge of the responsibilities of government is discussed impartially and at some length in "Parliament: a Survey", not merely by Sir Cecil Carr in his chapter on delegated legislation but also by Prof. E. C. S. Wade in a chapter on the courts and the constitution, and by Mr. G. M. Young in the concluding chapter on the future of parliamentary government. The difficulties are also noted by Mr. L. S. Amery in discussing the nature of British parliamentary government and by Mr. J. J. Craik Henderson in considering the dangers of a supreme parliament, as well as by Lord Campion, who contributes chapters on parliament and democracy and on parliamentary procedure. Although the protest may be less emphatic than those of Prof. G. W. Keeton or Mr. Hollis, it is no less firm; and in this book it has the further merit of being accompanied by constructive criticism.

Chiefly, such criticism comes from Mr. G. M. Young. Mr. Young sees no prospect of any change in the fundamental composition of the House of Commons, but leans to the idea of some collateral chamber, not exactly on the lines of the industrial parliament suggested by Mr. Hollis, and earlier still by Mr. Churchill in his Romanes Lecture of 1930 and by Mr. Harold Macmillan. He seems to have in mind a body in which group representation of such interests as the universities, local government authorities, and the like would provide the means for a regular and well-informed review of primary legislation and at the same time perhaps also a solution of the difficult problem of the relations between the national boards, [illegible], the trades unions and others. Besides this, he suggests that a committee on statutory instruments should be constituted, on similar lines to the Public Accounts Committee, with the duty of reviewing secondary legislation. Supplemented by regular, informal conferences between Ministers and their chief officials and interested groups in Parliament and the appointment of a Minister of State as 'general visitor' of the Civil Service, and assisted by a rotating team of experienced Civil servants, Mr. Young thinks we might well achieve a running audit of our administration and supply a steady wind of mutual intelligence and understanding, sufficient to keep the atmosphere clean and lively.

These interlocked proposals might well secure the essential conditions required to make the Select Committee Mr. Young proposes effective; but they promise little relief of Parliamentary time. That is a main problem, and while the contributors to this book in general fully recognize that an excessive burden is at present placed on Parliament—partly in consequence of legislative programmes in excess of the capacity alike of Parliament and the Civil Service—surprisingly little is said as to the possibility of devolution in some form or other, or of a vigorous reform of local government which might bring new life and efficiency to local institutions.

The view so strenuously urged by Mr. Hollis that we need to find a means of returning from the professional politician of to-day to conditions in which the average member of Parliament is able to take an active part in the life of the community, and is no longer called upon to sacrifice everything else to his Parliamentary duties, finds little support. Bagehot wrote in 1868: "The great defect of the House of Commons is that it has no leisure". We can scarcely hope to go back to a position in which Parliament only sits for a small part of the year—Burke's essential condition for Parliamentary government to be tolerable; but we must at least, if Parliament is to survive, provide the conditions in which a member of Parliament can respect Burke's great principle that he owes his electors not his industry only, but also his judgment, and that he betrays, instead of serving, them if he sacrifices it to their opinion.

Nevertheless, the contributors to this book agree with Mr. Hollis that the growth of party discipline is deadening and dangerous. The diminishing independence of members of Parliament may well tend to depreciate their quality; but the immediate issue is that, while there is general belief here and elsewhere in parliamentary traditions, Government powers can scarcely be curbed and controlled unless, as Prof. Wade rightly suggests, Government supporters themselves own a higher loyalty than party. Such opposition to Government action may demand a great sacrifice by a supporter of the party in power; but both Mr. Hollis and Mr. Strachey, in their broadcasts, were in agreement that on occasion such a revolt is both necessary and justifiable if democracy is to survive. It is, in fact, on such a spirit that the survival of Parliament and of democratic institutions depends. Devices for reducing the demands on Parliamentary time, for the devolution of functions to local, regional or even functional bodies, for the resolution of the problems of co-ordinating an increasing number of Ministries and Departments of State and for securing efficient public accounting and departmental efficiency, can only have their full effect when both Parliament and the Cabinet are inspired by a belief in democratic processes and respect Parliamentary tradition and procedure. Unless responsibility and power are thus allied, there are no effective safeguards, nor is it easy to see how even much more drastic constitutional changes than are here suggested could prove adequate. Ultimately, it depends on the extent to which not only Parliament but also the electorate generally understands what is involved, respects the democratic process and parliamentary procedure and is vigilant and resolute to act against any abuse, no matter what party considerations or private interest may require to be sacrificed.

In spite of its failure to relate, in any adequate sense, the functioning of Parliament itself with that of a virile system of local government, the book does bring out the dependence of Parliament on public understanding and support rather than on any system of checks and counter-checks. Less than justice is possibly also done to the need for wise and efficient central government, and no great contribution is made to the thinking out of how mutual intelligence can be made to permeate and ultimately to control the relations between Government and people. But on the price to be paid for the survival of Parliament, and of liberty as we understand it in a democratic State, there is a large measure of agreement, and that price is clearly indicated.

Mr. Craik Henderson insists, for example, that loyalty to something greater than party is the final safeguard against the abuse of executive or parliamentary supremacy. Prof. E. C. S. Wade sees in vigilant and enlightened criticism the only sure safeguard, outside the limited field controlled by the courts, against abuse of power by the executive, and Sir Cecil Carr calls for the "inbred insubordination" and "natural impulse" to resist authority with which Bagehot characterized the English people. Above all, the consistent protest against the abuse of party is accompanied by plain warning that there is no mechanical way of preserving democracy—the real dangers are within. No system of organization, however efficient, will preserve the form and spirit of democracy if there is lacking either vigilance or the will to act resolutely against abuse by those who reject the democratic tradition. If the pursuit of party policy is once placed above the sanctity of the democratic process of discussion, consultation and 'give and take', it is a short step to totalitarian tyranny.

These essays could contribute something to that vital task of education required for a clear understanding by the general body of the electorate of the nature and functioning of Parliamentary government in Britain and the conditions for its survival and success. They should also discourage efforts to make Parliamentary institutions more rigid, thus reducing the inherent flexibility which is part of their strength. At the same time, they help to bring home to every reader the need not only for vigilance against abuse but also for self-discipline, in order that the tradition and privilege of freedom may be preserved both in Parliament itself and in re-invigorated local government institutions. The reconciliation of power and responsibility is never finally achieved: it endures so long, and only so long, as the electorate is able and willing to discriminate between the true and the spurious, and is not deluded by whatever screen of propaganda may be spread by those who seek to pervert or destroy Parliamentary institutions.

# ANTOINE LAVOISIER

Antoine Lavoisier

Scientist, Economist, Social Reformer. By Dr. Douglas McKie. Pp. viii+335+18 plates. (London: Constable and Co., Ltd., 1952.) 30*s.* net.

LAVOISIER'S fame as "the founder of modern chemistry" has overshadowed his achievements as an administrator, a social reformer and an economist. These have had comparatively little attention, although his scientific work only took a fraction of his busy day, and from time to time he was occupied entirely with his other tasks.

Dr. Douglas McKie's earlier biography, published seventeen years ago, dealt mainly with Lavoisier's great reform of chemistry, comparable with the contribution of Newton to mechanics and astronomy and of Darwin to biology. Now the author has again earned our gratitude by this new life, with its comprehensive picture of Lavoisier's varied activities, which will be new to most readers. About a third of the book is devoted to Lavoisier's scientific work, and here Dr. McKie breaks little fresh ground. This must wait presumably for the publication of his laboratory notebooks.

When he turns to Lavoisier's record of public service, Dr. McKie's scholarly studies of French social history and politics in the eighteenth century give us an intimate picture of the background of Lavoisier's work. Lavoisier was only twenty-five when he "took the most fateful, and indeed ill-fated, step in his life" by joining the Tax-Farm, a financial corporation that leased from the Government the privilege of collecting the indirect taxes. He soon became one of its most efficient administrators and was constantly striving to remedy abuses and eliminate waste. His business journeys and his observant eye gave Lavoisier an unrivalled knowledge of social and economic conditions in France, and the statistics he collected through the officials of the Tax-Farm made possible his report on "The Territorial Wealth of France", which was a pioneer effort in national statistics giving for the first time an accurate estimate of the national income and its taxable limits. As the *Moniteur* said, "the work comprised in small compass the whole basis of political economy".

For seventeen years Lavoisier was one of the commissioners in charge of the production of gunpowder. He lived at the Arsenal, where again his organizing ability and his rapid drafting of reports and instructions were invaluable. Production was increased, great economies were made and the range of French weapons was increased by 60 per cent. He knew the miserable conditions of French agriculture, and in 1778 he bought an estate at Fréchines and started an experimental farm with the object of improving the most vital of all French industries. Dr. McKie describes the skill with which Lavoisier applied to farming the scientific analysis that marked all his researches and the great improvements in farming methods that he achieved.

When provincial assemblies were established in 1787, Lavoisier was elected a member of the assembly of Orléanais, and he was soon its outstanding figure. He saw so clearly the reforms that were long overdue: his memoranda on the *corvée*, on the state of agriculture, on old-age insurance, on savings banks and on the need for a geological survey show his modern outlook and his vision and imagination. Even in the dark days of the Revolution he never relaxed his efforts for France; in 1793 he presented a report to the National Convention on national education, envisaging the complete democratization of opportunity with free primary education for all children. He foresaw, too, the need for science and industry to work together. "Much that he urged in the organization and application of science has been realised only in our own time."

Dr. McKie tells the sad story of the final tragedy, adding fresh evidence about a packet of letters "written in English" which might have contributed to Lavoisier's death. This book gives an admirably balanced story of Lavoisier's many-sided life. It is written with fullness of knowledge, with great sympathy and understanding, and has the lucidity that characterised the writings of Lavoisier himself. It is clearly destined to be a standard history of Lavoisier's unique record of intellectual and practical achievement.

HAROLD HARTLEY

## BIRTH AND GROWTH OF EXPLOSIONS

### Initiation and Growth of Explosion in Liquids and Solids

By F. P. Bowden and A. D. Yoffe. (Cambridge Monographs on Physics.) Pp. xii+104+5 plates. (Cambridge: At the University Press, 1952.) 22*s*. 6*d*. net.

GREAT progress has been made during the past twenty years in the understanding of propagation of detonation in condensed explosives by the development of the hydrodynamic theory of detonation. This theory is purely mechanical, and like thermodynamics it has no curiosity, so that it tells us nothing about the nature of the decomposition or reaction of the explosive itself. It is all the more important, therefore, that collateral experimental work on the nature of the initiation and growth of explosion in condensed explosives should be prosecuted vigorously. Dr. F. P. Bowden and his school have carried out such work, first in Australia (with the then Commonwealth Council for Scientific and Industrial Research) during the Second World War and afterwards in Cambridge in the Research Laboratory on the Physics and Chemistry of Surfaces, and the results of the work are collected in the present monograph written by him in collaboration with Dr. A. D. Yoffe. Bowden's interest in explosives arose naturally from his work on the friction and lubrication of solids, which is described in a recent monograph written with Dr. D. Tabor as co-author (see *Nature*, **167**, 252; 1951). It was natural to utilize similar techniques for the study of the decomposition of explosives since these have always been tested by the now classical empirical tests involving impact and friction. Bowden and his school have, however, made a major advance in the understanding of the phenomena of the birth and growth of explosions in small quantities of material by demonstrating very elegantly that initiation is due to the formation of 'hot spots' of small but finite size in the explosive, and that such 'hot spots' are readily formed by adiabatic compression of minute gas-pockets trapped in the explosives. It is the essential simplicity of the disclosed mechanism which makes it such a valuable contribution.

The introductory chapter deals with the two principal theories of initiation of explosives by mechanical shock, namely, the tribochemical and thermal theories. As a result of their investigations, the authors favour the thermal theory and demonstrate that usually initiation is produced by the formation of a local 'hot spot'. Effective 'hot spots' can be produced in several ways; but the most important were found to be boundary friction between solid particles of high melting-point at points of rubbing contact, and adiabatic compression (and consequent heating) of minute gas or vapour bubbles in the explosive. The last chapter of the book deals with the growth and propagation of explosions from these minute 'hot spots'.

The book is illustrated with numerous photographs taken on rotating-drum cameras and showing the development of the explosion in various substances. In a considerable number of cases the 'hot spot' is succeeded by a phase of burning before detonation ensues, but in certain cases detonation ensues immediately after the 'hot spot'.

The book is readable and the arguments are readily followed; but it could have been more valuable to the specialist if more detailed and quantitative descriptions of the ingenious apparatus and methods used had been given. Nevertheless, the monograph is a very useful contribution to the literature and will be welcomed by both research workers and technicians in the explosives field.

JAMES TAYLOR

## HEALTH EDUCATION TO-DAY

### Health Education

A Guide to Principles and Practice. By Cyril Bibby. (Heinemann Education Series.) Pp. x+222. (London: William Heinemann, Ltd., 1951.) 17*s*. 6*d*. net.

WHAT should be expected of health education to-day? Many valuable and useful manuals of hygiene exist giving us the facts of health and health education; but a well-considered account of the judgment of the present-day experienced experts on the principles and practice of health education has been wanted for some time. In this book Mr. Cyril Bibby has now written such an account, and many will be most rewarded by a first perusal and subsequent constant reference. To-day we have reached that point in health education where our principles must be put into practice (even if improvisation is still often required through lack of funds or resources), otherwise the facts of health which we offer to individuals in the communities of to-day will fail to produce any lasting or worth-while effect. This is a particularly salient comment for the teachers of the young of all age-groups; for sister tutors in the training schools; for the teachers of future medical men and women; and especially for lecturers in health education in the training colleges for future teachers. Every individual passes through some teacher's hands at some time or other, and it is absolutely essential that all teachers, not just the scientific worker or the physical educationist, should know what part they can play towards inculcating habits, imparting information, fostering attitudes and responsibilities, and inspiring ideals for a balanced harmony in living. Thus the physical, mental, emotional and social aspects of health should be woven together for the individual within the community. To-day we are convinced that the immunization of babies and young children against diphtheria has reduced child mortality from diphtheria and lessened human suffering and sadness. Yet to-day there is a very great danger that parents are not going to practise the principle of diphtheria immunization for their children, because they do not appreciate the necessity for it or because they are apathetic. Hence the latest diphtheria poster "If——"; hence health education and its modern emphasis; hence the value of the book under review.

This book should be in the library of all teaching institutions—the training colleges for teachers and social workers, and the medical and nursing schools—because it is a book for educators, both lecturers and those students who are preparing themselves as widely as possible to be of use, example and inspiration to their future flocks. Some students and all teachers of health education should possess this book as a comprehensive reference book, while public libraries could well stock the book for members of the public and for those parents who will seek such information as it reliably gives.

Mr. Bibby has divided his book into two parts. The first part consists of eight readable chapters emphasizing sanely and in a manner fully approved by present-day pioneers what is really implied by health education to-day. It deals with aims, aspects, facts, media and with health education in the home, school, college and community. The second part consists of most valuable appendixes of schemes, curricula, syllabuses and programmes with a seasonable bias, together with a directory of health education organizations, useful statistics, recommendations for films, film strips, books and other media, all of which will be much appreciated by busy teachers and lecturers.

If we know whither we want to go, this excellent book will probably tell us the way from our present stage; if our aims are not really up to date, it will start us on the right road in health education.

P. M. TAYLOR

# BOTANY OF THE SCOTTISH HIGHLANDS

## Plant Life in the Scottish Highlands

Ecology and Adaptation to their Insect Visitors. By Alexander Edward Holden. Pp. xv+319+64 plates. (Edinburgh and London: Oliver and Boyd, Ltd., 1952.) 30*s*. net.

THOUGH the flora of the Scottish Highlands is comparatively poor as regards the number of species represented, this relative poverty is more than compensated by the interest and rarity of many plants which are not found elsewhere in Britain. The occurrence, distribution and affinities of the local species present some of the most fascinating problems connected with the British flora, and a systematic account of Highland botany dealing authoritatively with all aspects is long overdue.

The title and price of the work now under review suggest that this subject has at last been adequately treated. The book will certainly whet the appetite of field botanists, nowadays a vigorous and knowledgeable body in Britain, who at some time or other must visit the Highlands of Scotland if they wish to see species not occurring elsewhere. But, to students of the British flora, it will be a great disappointment, and particularly to those who have enjoyed memorable days plant-hunting in the Scottish mountains, and exciting hours afterwards in identifying their specimens. The professional botanist, and many amateurs also, will find little, if anything, original in the author's observations; but, on the other hand, will have much to criticize. The informed reader with a knowledge of plants and their ways will be rather chary of accepting the author's invitation early in the first chapter to regard plants "as sentient beings with hopes and fears and ambitions much like our own". This teleological theme is not a promising approach to the study of the vegetation of the Highlands, and it sets the tone of the whole work, which can scarcely be regarded as a serious contribution to the study of Scottish botany. It is quite clear that modern advances in the taxonomy of the British flora and the recent exciting discoveries of new plants in the Highlands have completely escaped the author's notice.

No attempt is made to give a scientific appreciation of the alpine and other habitats mentioned, and their plant communities, and the ecologists will have to look elsewhere for a critical appraisal of the physical conditions which influence plant life in the Highlands. The author deals with the vegetation in a most arbitrary way by selecting various habitats and describing rather cursorily one or two typical species.

The book will not greatly assist a beginner in the identification of plants, and it is necessary to point out that the nomenclature and taxonomy are often widely at variance with modern concepts. The serious divergences are too numerous to deal with in detail, and it is unfortunate that there are so many misleading statements that the author's generalizations must be read with caution. Nor are the distributional data always reliable, and one or two confident statements certainly need modification. It is no longer true that *Saxifraga cernua* is confined in Britain to the broken schist near the summit of Ben Lawers (p. 18); *Pinguicula alpina* (p. 194) has been extinct (since the beginning of the century) at its only certain Scottish station; and *Eriocaulon septangulare* (p. 222) is much more widely spread in Ireland than indicated, and the localization of the plant in Scotland is only partially correct.

A small chapter of four pages is considered sufficient to deal with the important aspects of distribution and affinities of the flora. As a result of this severe compression the picture of the sequence of geological events and climatic changes which have influenced the plant life of the Highlands is confused, and, in several respects, unsupported by scientific evidence.

It is a pity that this book cannot be recommended as an acceptable work on the vegetation of the Scottish Highlands. The typography is excellent and a wide selection of magnificent monochrome photographs by Mr. R. M. Adam illustrate many of the species and their habitats.

GEORGE TAYLOR

## A Textbook of Evolution

By Prof. Edward O. Dodson. Pp. xviii+419 (Philadelphia and London: W. B. Saunders Co., 1952.) 5 dollars; 25*s*.

THE past few decades have seen very noteworthy contributions to the study of evolution by such authors as Dobzhansky, Goldschmidt, Simpson, Mayr, Huxley, Haldane, Wright and others, but there are few text-books in which this modern work has been summarized in a form suitable for students in the first two years of their university career. This is the gap which E. O. Dodson has attempted to fill for American students, as G. S. Carter has for British. The book under notice is characterized by extreme clarity of exposition, both of the theoretical problems involved and of the factual material. It does perhaps attempt rather too much in some respects. Is it possible to summarize the whole comparative anatomy of the animal and plant kingdoms, from viruses up to the primates, in about 130 pages? Is it even necessary in a text-book devoted to evolution? British students of zoology, at any rate, will deal with such topics more fully in other parts of their course. The most valuable part of the book is the fourth, which is devoted to the recent studies on natural selection, species formation and similar evolutionary mechanisms. This contains a selection, on the whole judiciously made, of material which can otherwise only be found in original papers or books addressed to a much more advanced audience. The book is well illustrated and has a good index.

## Government Information and the Research Worker

Lectures delivered at a Vacation Course of the University of London School of Librarianship and Archives in April 1951. Edited with an Introduction by Ronald Staveley. Pp. vi+228. (London: Library Association, 1952.) 24*s*.; to members of the Association, 18*s*.

A PAPER by Mr. W. Cox on "H.M. Stationery Office Publications", given at the Aslib Conference in September 1949, provoked some discussion on Government publications. The subject was also raised at subsequent meetings of Aslib, both in Glasgow and in Manchester, in the following year, when difficulties being experienced in locating or obtaining such publications were stressed. In the following year a series of lectures, dealing with the resources of the major Government ministries and departments likely to be of value as sources of information to the research worker, were delivered at a vacation course of the University of London School of Librarianship and Archives. The interest taken in this course, which was attended by more than a hundred librarians and information officers, has now led the Library Association to publish these lectures, with the exception of two.

These exceptions, however, are important. The first was Mr. E. M. Nicholson's introductory address on "The Government and Research", and the second was that in which Dr. W. R. Francis described the present Government agencies and departments in which scientific research is undertaken or sponsored. These lectures are omitted at their authors' request because the subjects have since been covered in the official pamphlet "Government Scientific Organisation in the Civilian Field". Accordingly, the claims of the book on the interest of the scientist are slender, and are largely limited to Dr. D. J. Urquhart's brief chapter on the "Department of Scientific and Industrial Research as a Source of Information for Research Workers", and Mr. L. R. Poole's account of "The Technical Information and Documents Unit". The account of the research resources of the Ministry of Supply is also brief, due to the same security requirements which led to the omission of the three Service Ministries and the Ministry of Civil Aviation. This is not to say that the scientist or technologist will not find the accounts of some other departments, such as the Ministry of Fuel and Power or the Ministry of Works, of interest; but, by and large, the book is mainly of interest to the social scientist rather than to the scientist in general.

Subject to the omissions mentioned above the book covers the ground fairly thoroughly, and the various chapters bring out the extent to which the needs of both librarian and research worker are appreciated at a high level in most ministries, and the extent to which the departments are anxious to be of service.

R. B.

## Avicenna, Scientist and Philosopher

A Millenary Symposium. Edited by G. M. Wickens. Pp. 128. (London: Luzac and Co., Ltd., 1952.) 15*s*.

IN the year A.D. 980 was born within the borders of Afghanistan one who came to be nicknamed Ibn Sina. During the fifty-seven years of his life he became a figure of world renown in the person whom the medieval schoolmen called Avicenna. A Persian of the Persians, he was an intellectual prodigy, poet, mystic, medical man and *bon viveur* all rolled into one. Alas, he was not devoid of conceit, combined with a curiously refined arrogance. His influence through the ages has been tremendous, as this collection of lectures delivered at Cambridge in his honour abundantly proves. The six speakers comprised two Arabists, two Hebraists, a scientist-philosopher, and a modern linguist—surely an appropriate team.

By them we are given an insight into Avicenna's life and work; an estimate of his place in Asiatic philosophy; an account of some aspects of his activities; an appraisal of his influence upon Jewish thought, and upon medieval scientific tradition; and finally, a description of the effect he had upon the thirteenth century, more especially, of course, upon St. Thomas Aquinas. Compact references accompany the text.

Avicenna, who contributed to metaphysics the concept of a necessary Being whose essence and existence were identical, was the same person who experimented with many drugs, and demonstrated his mastery of the inductive method. Authors and publishers have done well to pay him homage in producing this first-class book.

F. I. G. Rawlins

## Green Thoughts

By Sir Stephen Tallents. Pp. 192. (London: Faber and Faber, Ltd., 1952.) 15*s*. net.

THOSE who enjoy Sir Stephen Tallents's essays in periodicals and newspapers will be delighted to have this collection in more permanent form.

The anthology covers a wide range of country topics and pursuits around the year, and they are described with characteristic charm. One feels throughout that Sir Stephen's affection for his wood-fed fire, his crooked rake and beloved scythe, are part of the heritage of the venerable sanctuary which is now his home. The chapters on moles and nettles are particularly rewarding; but the final essay on scything is surely the most complete memoir of the art and theory of that ancient practice.

# ACCELERATION OF HEAVY IONS TO HIGH ENERGIES

By Dr. D. WALKER and Dr. J. H. FREMLIN

Physics Department, University of Birmingham

SINCE the first development of the cyclotron by Lawrence and Livingston in 1931, relatively little attention has been paid to the acceleration by its means of ions heavier than $^4$He. It was natural enough in the development of nuclear physics that attention should first have been given to the information which could be obtained by the bombardment of nuclei with the simplest possible particles; and rightly, the emphasis is still the same to-day. However, the study of fast heavy ions is of interest on its own account. Such ions occur in nuclear disintegration and recoil processes, and in the fission of heavy elements. Interest in them was stimulated by the discovery of nuclei of medium atomic number in the primary cosmic radiation by Freier *et al.*[1] in 1948. As bombarding particles for producing nuclear transformations, heavy ions accelerated in a cyclotron may prove of value in particular problems as, for example, the production of transuranic elements[2,3]. Here the product nucleus desired might differ greatly in mass and charge from the available target nucleus. Recently, Breit *et al.*[4] have pointed out that it might be possible to obtain specific information on nuclear structure, which cannot readily be obtained otherwise, by bombarding nuclei with energetic heavy ions.

## Technical Considerations

Three main differences may be noted when we compare the acceleration of heavy ions in a cyclotron with the acceleration of hydrogen or helium ions.

First, since the binding energy of the $K$-electrons in an atom varies as the square of the atomic number, it becomes increasingly difficult with the heavier atoms to produce high states of ionization directly in, or near, the ion source of the cyclotron. Indeed, this effect is already apparent if we compare hydrogen and helium, since it is well known that the beams of doubly-charged helium which can be obtained in a cyclotron are less than the corresponding beams of singly-charged deuterium. Now we are interested in producing highly-charged ions because the energy which can be imparted to an ion of a particular mass, using a given cyclotron magnet, increases with the ionic charge. This follows from the relation $p = Ber$, in which $p$ is the momentum of an ion of charge $e$ at a radius $r$ where the magnetic induction is $B$. With highly-charged ions it is possible, in a fixed-frequency cyclotron 60 in. in diameter, to produce ions energetic enough to penetrate the Coulomb barrier of even the heaviest nuclei. The Birmingham cyclotron of this diameter can produce ions with energies of about 10 $A$ MeV., where $A$ is the atomic mass number.

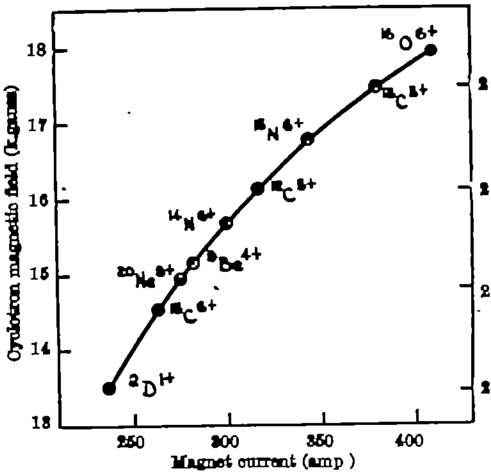
Secondly, the mass-to-charge ratios of ions of stable isotopes heavier than helium-3 are all greater than that of the deuteron (except for fully stripped nuclei which contain equal numbers of protons and neutrons). The angular frequency ($\omega$) of an ion in a cyclotron is given by $\omega = B(e/m_0)(1 + E/m_0c^2)^{-1}$, where $m_0$ is the rest mass of the ion and $E$ its kinetic energy. Consequently all the heavier ions, with the exceptions noted, have a larger ratio ($B/\omega$) for the same $E/m_0c^2$ than does the deuteron. For resonance with a given cyclotron radio-frequency, $B$ may be much larger than that required for the deuteron, as can be seen from the accompanying graph.

Thirdly, not all elements heavier than helium can be obtained in gaseous compounds suitable for the conventional gas-discharge ion-source used in cyclotrons. Thus in some cases, as for example beryllium-9, solid sources of ions must be used.

## Work in the United States on the Acceleration of Heavy Ions

The pioneering work on the acceleration of ions heavier than $^4$He, as in so many other branches of cyclotron technique, was carried out at the Radiation Laboratory of the University of California at Berkeley. The first work was reported in a brief abstract by Alvarez[5] in 1940. He used the fixed-frequency cyclotron of 37 in. diameter, the cyclotron chamber being filled with methane. A beam of $^{12}C^{6+}$ ions of about 50 MeV. was detected by means of a proportional counter and linear amplifier. Since the resonances of $^{12}C^{6+}$ and $^4He^{2+}$ ions lie close together (the mass-to-charge ratios of $^{12}C^{6+}$ and $^4He^{2+}$ differ by only one part in 1,500), care had to be taken to resolve the $^{12}C^{6+}$ beam in the presence of the helium contamination of the cyclotron. To do this clearly, it was necessary to operate with the cyclotron magnetic field below the optimum value for the acceleration of $^{12}C^{6+}$, and this led to a weak beam of only about 500 carbon ions per minute. Further work with the Berkeley 60-in. cyclotron, reported briefly by Condit[6] and by York *et al.*[7], led up to the work of Miller *et al.*[8] with the same machine. The last-named authors used a hooded capillary ion-source fed with carbon dioxide gas. They obtained external beams of $10^5$ ions per sec. of $^{12}C^{6+}$ at 115 MeV. and, using carbon dioxide enriched to 50 per cent carbon-13, of $10^4$ ions per sec. of $^{13}C^{6+}$ at 122 MeV. They estimated an internal beam of $^{12}C^{6+}$ of about $10^8$ ions per sec.

Recently, Chou *et al.*[9], using the Chicago synchrocyclotron, have accelerated carbon ions to energies as high as 1,100 MeV. They mention the acceleration



Magnetic field plotted against magnet current for the Birmingham cyclotron. Heavy-ion resonances are observed to occur at the magnet currents indicated. For the cyclotron frequency of 10·31 Mc./sec., the ionic mass-to-charge ratios calculated to give resonance with the magnetic field are shown on the right-hand scale. Mass-to-charge ratios are expressed as (atomic mass) ÷ (number of electron charges) of $^{12}C^{5+}$ ions as well as completely stripped carbon ions. Carbon dioxide gas was used in the ion-source. They have also accelerated $^{9}Be^{4+}$ ions, and assumed in this case that the beryllium ions were evaporated from an internal target which is normally subjected to intense proton bombardment when the cyclotron is accelerating protons. The authors do not mention the strengths of beam obtained, but these are apparently at least adequate for the bombardment of photographic emulsions.

## Work at Birmingham on the Acceleration of Heavy Ions

In the Nuffield Laboratory at the University of Birmingham, using the 60-in. fixed-frequency cyclotron, we have recently made a study of heavy ion resonances over a wide range of magnetic fields. Resonances due to the following ions, listed in order of increasing mass-to-charge ratio, have been studied: $^{12}C^{6+}$, $^{20}Ne^{9+}$, $^{9}Be^{4+}$, $^{14}N^{6+}$, $^{12}C^{5+}$, $^{15}N^{6+}$, $^{13}C^{5+}$ and $^{16}O^{6+}$. A scintillating crystal (potassium iodide activated with thallium[7], mounted on a 'Perspex' light guide and inserted between the 'dees' at radii varying from 24 to 27½ in., was used to detect the resonant beams of ions. The crystal was covered with 17 microns of aluminium. At a radius of 27 in. the kinetic energy of an ion, revolving about the centre of the cyclotron with a frequency equal to that of the radio-frequency accelerating voltage (10·31 Mc./sec.), is approximately 10 *A* MeV., where *A* is the atomic mass number of the ion. This maximum attainable energy therefore varies from 90 MeV. for beryllium-9 to 200 MeV. for neon-20. For producing carbon ions, the ion-source was fed with carbon dioxide gas, while the source of nitrogen ions so far has simply been the residual air in the cyclotron tank. To locate the $^{20}Ne^{9+}$ resonance, the ion-source was fed with neon gas. In order to accelerate $^{9}Be^{4+}$, the normal molybdenum tip of the ion-source was replaced by one of beryllium metal, and during some of the runs with the beryllium tip the ion-source was fed with hydrogen gas instead of carbon dioxide. When the cyclotron was running, this beryllium metal tip became heated to a bright red.

The mean magnetic field in the cyclotron is plotted against the current in the magnet coils in the accompanying graph. Superimposed on this curve, at the observed magnet currents, are the resonances due to the various ions. (The $^{2}D^{1+}$ resonance, determined by other means, is included for comparison.) These resonances correspond exactly, for the cyclotron frequency of 10·31 Mc./sec., to the mass-to-charge ratios indicated on the right-hand scale. This provides unequivocal identification of the resonances. The method has not been used to study resonances of ions for which mass-to-charge ratios are close to those of $^{2}D^{1+}$ and $^{4}He^{2+}$, for fear of damaging the crystal with intense beams of the latter ions arising from contamination of the cyclotron. It has in any event been considered an advantage to work with heavy ions the resonances of which are widely separated from those of $^{2}D^{1+}$ and $^{4}He^{2+}$. This eliminates the possibility of experiments, using the heavy ion beams, becoming complicated by the possible presence of $^{2}D^{1+}$ and $^{4}He^{2+}$ ions.

A striking feature noticed was the great prominence of the $^{12}C^{6+}$, $^{14}N^{6+}$, $^{15}N^{6+}$ and $^{16}O^{6+}$ resonances. The $^{13}C^{5+}$ resonance is much weaker than the $^{12}C^{6+}$ resonance, while $^{15}N^{7+}$ and $^{16}O^{7+}$ are not observed at all. It is to be noted that, when the cyclotron is adjusted to accelerate six-charged ions, doubly-charged ions of the same species have a frequency of revolution in the cyclotron which, in the approximation $E \ll m_0c^2$, is one-third of the cyclotron radio-frequency. Doubly-charged ions can thus be accelerated, and at a given radius will have an energy which is one-ninth of that of a six-charged ion if both ions are revolving about the centre of the cyclotron. There can be no doubt that pre-acceleration of the ions in the doubly-charged state (third harmonic acceleration) aids in an important manner in the ultimate stripping of the ions to the six-charged state through collisions with residual gas molecules. Fifth and seventh harmonic acceleration are increasingly less effective for this purpose. Of the still heavier neon ions, only the $^{20}Ne^{9+}$ ion, which fulfils the third harmonic condition, has been so far studied. The use of a scintillating crystal for the detection of the resonant beams makes possible a study of the structure of the resonance curves (the variation of counting-rate with magnetic field), and of the energy distribution of the ions by pulse-height analysis. Evidence from these studies lends support to the theory of third harmonic pre-acceleration. It is intended to publish elsewhere a more detailed account of this study of acceleration mechanisms. Condit[8] and Miller[9] have mentioned that harmonic acceleration can take place with carbon ions, but there appears to be no mention in the published literature of its possible importance for subsequent electron stripping.

In the case of $^{9}Be^{4+}$, odd harmonic pre-acceleration is not possible. However, it is felt that, owing to the comparatively low atomic number of beryllium, it is relatively easy to get the atoms fully stripped without recourse to harmonic pre-acceleration. The observed fact is certainly that beams of $^{9}Be^{4+}$ can be readily obtained which are at least as good as the beams of $^{12}C^{6+}$ obtained when carbon dioxide of normal isotopic constitution is used in the ion-source.

The Birmingham work has not so far explored the upper limits of beam-strengths obtainable. On strong resonances it is easily possible to saturate the counting system with counting-rates in excess of $10^4$ per sec. At this stage we must take the work of Miller *et al.*[9], mentioned above, as an indication of beam-strengths which have been obtained in a similar cyclotron. The beam-strengths used at Birmingham so far are more than adequate for bombarding photographic emulsions internally in the cyclotron. In the case of $^{9}Be^{4+}$, bombardment of emulsions has also been carried out with a deflected external beam. In this connexion it is worth noting that, with increasing mass-to-charge ratio, higher deflecting voltages are required to produce external beams.

Harmonic pre-acceleration might well be important in helping to obtain large beams of heavy ions. An alternative scheme, for injecting heavy ions into a synchrocyclotron or a heavy-particle synchrotron, has been put forward by Tobias[10]. A linear accelerator would pre-accelerate ions carrying a low charge. These ions would be injected into the synchrocyclotron or synchrotron, tangentially to a desired orbit, and would be fully stripped at the orbit by passing them through a thin foil.

## Experimental Studies with Heavy Ion Beams

The study of a number of problems has been made possible by the successful acceleration of heavy ions, and exploratory work on some of these problems has been reported.

Miller *et al.*[2] have reported observing the nuclear reactions $^{27}$Al($^{12}$C,$\alpha n$)$^{34}$Cl and $^{197}$Au($^{12}$C,$4n$)$^{205}$At with 115-MeV. $^{12}$C$^{6+}$ ions. The possible value of such reactions in the production of transuranic elements, where a large change of nuclear charge and mass is required when bombarding an available isotope, is obvious. Ghiorso *et al.*[3], using 120-MeV. $^{12}$C$^{6+}$ ions, have obtained small yields of californium-244 from the reaction $^{238}$U($^{12}$C,$6n$)$^{244}$Cf and report also that californium-246 is probably obtained by the reaction $^{238}$U($^{12}$C,$4n$)$^{246}$Cf with a comparable cross-section.

Miller[9] has reported a preliminary study of the nuclear interactions of 120-MeV. $^{12}$C ions and 130-MeV. $^{13}$C ions in photographic emulsions. External beams of $^{12}$C$^{6+}$ and $^{13}$C$^{6+}$ ions from the Berkeley 60-in. cyclotron were used. In exposing the emulsions, a slit system was used to eliminate contaminating particles. Using for the purpose of the calculation the full lengths of the carbon tracks in the emulsion, he finds the cross-section for inelastic nuclear events in which charged particles are emitted to be (0·40 ± 0·03) barn for $^{12}$C and (0·37 ± 0·03) barn for $^{13}$C. A feature of the nuclear explosions (stars) is the large number of α-particles emerging. The maximum number of prongs observed in a star was seven. A photograph of this star appears with his communication. It was caused by a carbon nucleus slowed down in the emulsion to 90 MeV. We have also observed, at Birmingham, stars produced in photographic emulsions by $^{9}$Be, $^{12}$C and other ions.

Giles and Barkas[11] have reported a preliminary study of the pick-up of electrons by $^{12}$C ions as they slow down in photographic emulsions. This study was carried out by counting the varying number of gaps in the tracks recorded in Ilford *D*-1 emulsions. The number of gaps is related inversely to the ionization density, which in turn is related to the mean charge carried by the ion. Such investigations should provide a check on the theories[12-15] which relate the mean charge carried by an ion passing through matter to the velocity of the ion. These theories were developed originally in a study of the range–energy relations of fission fragments and recoil nuclei. Our work in Birmingham has shown clearly the difference in appearance of tracks in photographic emulsions due to such ions as $^{4}$He, $^{9}$Be, $^{12}$C and $^{20}$Ne, which are well spaced in atomic number.

Chou *et al.*[8] have studied the density of δ-rays (recoil electrons) along the tracks of energetic carbon and beryllium ions in photographic emulsions. They find agreement with the theory of Mott[16]. This theory was first applied to the tracks of heavy ions of the primary cosmic radiation by Bradt and Peters[17]. To identify the heavy ions, these authors used the fact that the number of δ-rays with energies in a given interval is, in a certain approximation, proportional to $Z^2/\beta^2$, where $Z$ is the charge carried by the ion and β its velocity. Chou *et al.*[8] have also studied the multiple scattering of carbon ions at energies up to 1,100 MeV. by the method of Fowler[18] and find agreement with theory[19]. They have also published a photograph of a star, initiated in a photographic emulsion by a 750-MeV. carbon nucleus, in which nine charged particles were emitted.

Breit *et al.*[4], in a theoretical paper, have considered in some detail the nuclear effects which might be expected in bombardments by ions such as $^{12}$C and $^{16}$O, and have estimated the distortion effects produced in target nuclei by the incident ions. This distortion might be expected to affect the thresholds of reactions which are determined by Coulomb barriers, and also the relative probabilities of emission of the various reaction products which might be observed. One might also expect effects due to the leakage of protons and neutrons out of the two colliding heavy nuclei by wave-mechanical penetration of the regions of negative kinetic energy between the nuclei. If practicable, exploration of the latter effect would amount to a study of the halo of neutrons and protons surrounding the more compact nuclear interior. It might be helpful in determining the number of particles at the nuclear surface having a given energy.

We should like particularly to acknowledge the help of Dr. W. I. B. Smith and Mr. W. Hardy in the work carried out with the Birmingham cyclotron. We are also indebted to Mr. W. T. Link for experimental assistance, and to Profs. P. B. Moon and W. E. Burcham for their interest.

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# POLYPLOIDY IN ANIMALS

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## Origins of Polyploidy

IN all cellular organisms, so far as we know, errors in cell division can give rise to cells, tissues and individuals with a multiplied or polyploid chromosome number. Animals and plants have, in general, proved capable of adjusting themselves successfully to a wide range of numbers. In plants not only are nuclei and cells increased in size when the chromosome number is doubled but the individual also. The series haploid–diploid–triploid usually gives a steady, if not a proportionate increase in size of the whole plant, and this may even continue to the tetraploid and beyond. Such an increase is found, of course, only with a genetically uniform chromosome set, without mutations or selection. For if the increase in size is at all disadvantageous to a polyploid race of plants in Nature, selection in later generations can readily reduce it again, and evidently often has done so.

In some animals these rules still apply. In triploid *Drosophila*, nuclei and cells, organs and individuals are all larger than in the diploid. But in Amphibia, although the nuclei and cells may be proportionately larger, the individuals are scarcely increased in size at all. The larger animals, which most need to do so, regulate their size, subordinating the cell to the individual, to a degree unknown in the plant[1]. For this reason we find in animals mosaics, and even regulated combinations of diploid and polyploid tissues as successful and important as are the chimæras in plants.

There is thus no physiological difficulty about the origin of new polyploid races in either plants or animals. For both, the difficulties lie in the mechanism of meiosis, and its consequences in germ cell formation. The situation is best known in plants. A tetraploid derived from a true breeding diploid has four identical sets of chromosomes which form groups of four at meiosis. These segregate irregularly, three-to-one as well as two-to-two, and the result is the formation of unbalanced and partly inviable progeny, in other words, infertility. Only when a sterile diploid, a hybrid with two dissimilar sets of chromosomes, *AA′*, *BB′* and so on, doubles its number, do the chromosomes regularly associate in pairs *A*—*A*, *A′*—*A′* and so on, in the tetraploid. Doubling in a hybrid diploid thus restores fertility, instead of impairing it: it gives us a pure-breeding hybrid tetraploid which behaves like an ordinary diploid. New polyploid species of plants are continually arising in this way, *Raphano-Brassica* in experiment and *Spartina townsendii* in Nature, *Triticale* in agriculture and *Aesculus carnea* in the garden[2].

## Obstacles to Polyploidy

When abundant polyploids had been found in plants, the question arose of why polyploidy was rarer in animals than in plants. Muller, broaching this question, suggested that an obstacle lay in the disturbance to be expected in the sex-determination of bisexual animals[3]. Disturbance might arise, in the first place, from the failure of the pairing and segregation of *X* and *Y* chromosomes. Also, in the second place, it might arise from the unsuitable balance between the sex chromosomes and the three or four sets of autosomes. New types of balance lead to sterility of the heterozygous sex in *Drosophila* and they might be expected to do so elsewhere.

Later knowledge has largely borne out Muller's expectation. Polyploidy is infrequent in bisexual, although it is probably not infrequent in hermaphrodite, animals; and it is certainly widespread wherever parthenogenesis has been superimposed on a bisexual system. This has happened in nearly all those groups of invertebrates, the most recent being the earthworms, where the question has been studied[4]. In animals as in plants it is indeed by polyploidy that we can trace the evolutionary sequence. We can say that triploidy determined the origin of a parthenogenetic race or species, since the fertilization of a diploid egg by a haploid sperm or pollen nucleus was the first as well as the last genetic event in its history[5].

The breeding of polyploid salamanders also partly bears out Muller's view. Humphrey and Fankhauser have succeeded in raising four generations of polyploids; but they have done so only by crossing polyploid females with diploid males[6]. We have to notice, however, that it is the males, the homozygous sex in this group, which are sterile as tetraploids. How are we to account for this?

Hitherto, hybrids and polyploids have been almost too easy to make in the newts and salamanders. For the analysis of fertility, however, in their polyploid forms we need studies of the same character as those in polyploid plants. We need a comparison of fertilities of diploids and polyploids in pure forms and in hybrids; and they must be precisely first crosses and not later derivatives. These results must be compared with chromosome behaviour at meiosis at least in the male.

So far as we can tell, then, we may say that the sterility of the salamanders seems to be as much that of the non-hybrid tetraploid known in the plant as of the sexually unbalanced type expected in the animal. The limited fertility of the females may itself be helped in these salamanders by a hybrid origin.

## Sex-determining Systems

Sex determination may not, therefore, offer the obstacle to polyploidy in animals that we had thought. Nor, indeed, from what we now know of sex determination in animals does it seem likely that the balance system of determination known in *Drosophila* is universal. Rather it is at the end of an evolutionary sequence which arises from what Muller has described as a mere trigger mechanism[3]. For example, the classical animal of the cytologist, *Ascaris megalocephala*, which begins from a basic chromosome number of one, exists in diploid and tetraploid races in Europe and America. These may well be mutually convertible, and they certainly have given rise to hexaploid and octoploid forms which, I understand from Prof. Goldschmidt, exist as races infesting the horses of Mongolia. Since *Ascaris* is differentiated into male and female animals, the differentiation in these polyploids must depend on a trigger rather than a balance.

In the Amphibia such a rudimentary trigger system of sex-determination seems to be general. No differentiated sex chromosomes are to be seen; and in different groups, even in related species, the homozygous–heterozygous relationship may be reversed as between the two sexes, just as it has been in the separate evolution of birds and mammals.

Instability is now seen to be characteristic of many sex-determining mechanisms. The evidence in the mammals is both cytological and genetical. Chains of three sex chromosomes in the marsupial *Potorous tridactylus*[7], and giant sex chromosomes in the vole *Microtus agrestis*[8], both indicate an incorporation of autosomes in the segregating system which determines sex. This means elaboration. The opposite process of degradation, the replacement of a balance by a trigger, is more difficult. For this a new sex-determining segregation must be set up as a single gene-difference between a pair of *X*'s or a pair of autosomes.

A model of such a transformation has indeed been described in man himself (as also, indeed, in *Drosophila*). The Pettersson–Bonnier gene in the *X* chromosome of man converts an *X Y* individual into an apparent or spurious woman[9]. The model is imperfect, since the result is sterile and it arises in the heterozygous sex, merely producing a redundant heterozygosity. But it shows how a new trigger could be brought into action even in our own species.

It is, indeed, above all in the mammals, with their highly developed endocrine systems, that the trigger mechanism may fail to develop into a full balance of the kind realized in *Drosophila*. In this case an obstacle to polyploidy would be removed. Both triploids and tetraploids of the heterozygous sex might be fertile, as they are in the salamander.

Where sex chromosomes are differentiated as in the mammals, another possible difficulty is removed. The sex chromosomes pair only in their short pairing segments and rarely, therefore, form more than one chiasma. For them, therefore, multiple associations are more difficult than for the autosomes. In a tetraploid mammal, association at meiosis will be more regularly in pairs for the $X$ and $Y$ chromosomes than for the autosomes. This regularity will be increased, as in polyploid plants, by any hybridity of the diploid or tetraploid from which a new type arises. There will be $X$—$Y$ and $X'$—$Y'$ pairs in the heterozygous sex from which all the usual combinations can be derived.

## Polyploid Mammals

The sex-determining mechanism does not, therefore, exclude the possibility of tetraploidy in the mammals, especially tetraploidy arising from hybridization. In this regard certain new observations are of great interest. Fischberg and Beatty have found polyploids, including both triploids and tetraploids, among embryos of the mouse. They are more frequent after crossing, rising to more than 3 per cent spontaneously[10]; and they can be induced by heat treatment of the egg before implantation in as many as 20 per cent[11]. Do such embryos ever reach maturity?

For evidence we must turn to observations of chromosome numbers in wild species of mammals. Here we are faced with a different kind of problem. In all groups of vertebrates there have been doubtful indications of polyploid species. They have been doubtful owing to the sporadic distribution of chromosome studies and the uncertainty of the results. Our present knowledge of the vertebrates, it must be understood, corresponds in proportion and precision with what was known of the flowering plants thirty years ago. After that time a rapid improvement took place in plant technique which changed the face of the subject: the new treatments were easier and their results were more accurate.

The same advance is now taking place in the study of vertebrate chromosomes. Only a few years have passed since La Cour, in showing the part played by nucleic acid supply in the normal and abnormal differentiation of blood precursors in man, displayed the chromosome complement satisfactorily for the first time[12]. Now, from tissue cultures of the human embryo, Hsu has been able to obtain pictures of the chromosome complement such as have rarely been seen in the past outside the flowering plants[13].

The first important result of the new methods has been to show that polyploid species of mammals exist; the second to suggest that they are of hybrid origin. For some time chromosome numbers of 22 and 44 have been claimed for species of hamster. But the possibility of polyploidy has been mentioned by Matthey only to be rejected (doubtless for the theoretical reasons we have been discussing)[14]. Sachs, after confirming the simple doubling of number, has now given the evidence in full. He has shown that form, distribution and history all support the assumption of a recent tetraploid origin for the golden hamster. They indicate its origin as a hybrid in the Caucasian region, where two geologically older species, its presumed parents, overlap[6].

The evolution of the hamsters may be represented as follows:

*Cricetus cricetus* × *Cricetulus griseus*
(Europe eastwards) (China westwards)
22 chromosomes 22 chromosomes

*Mesocricetus auratus*
Syrian or golden hamster
44 chromosomes

Here we see the genesis and history of a species diagrammatically revealed, much as it was revealed twenty-five years ago in the now classical instances of polyploid plants of recent origin.

We can seldom expect to find the records so neatly preserved. Species often die, and chromosomes are often broken. What we shall usually find is the bald fact of an approximate two-to-one ratio of chromosome numbers. Such a ratio seems to connect the only two of the innumerable races of African and Indian gerbils which have so far been described, both of them this year[6,15]:

*Tatera brantsii draco* : $2n = 34$ (Tobias)
*Tatera indica ceylonica* : $2n = 72$ (Sachs)

How could a polyploid species arise in the way the golden hamster seems to have done? It might come about, as it commonly does in plants, through the frequent production of infertile diploid hybrids whose sole means of making effective germ cells would be through non-reduction, the failure of the first or second meiotic division. The eggs would then all have $XX$ chromosomes, the sperm $XX$, $XY$ and $YY$. If the last of these gave less fertile zygotes, the others, $XXXX$ and $XXXY$, might well be efficient enough to start a new species with sexes in equal numbers.

An alternative possibility is favoured by the mouse experiments. It is that the new tetraploids arose at fertilization in the original crossing of the two species through non-reduction in both parental species. There are, however, as the salamander experiments have shown, only too many possibilities for the origin and breeding of polyploids. When we recall that the chromosome numbers are accurately known for much less than one per cent of all the species of mammals, it becomes clear that polyploidy may have been concerned closely or remotely in the history of any or all mammalian groups.

## Origin of Man

Now, among the orders of mammals, the primates are almost the least explored in their chromosome history. At the present moment the chromosome number is known only for one or two species of monkeys apart from ourselves: and those observations, although no doubt accurate, were made nearly thirty years ago[16,17]. Where cytologists abound it seems that monkeys are scarce. Moreover, the owners of collections of living animals maintained for exhibition to the public, or for scientific purposes, are not disposed to lend their precious charges for investigation; or, at least, not until the animals are dead and their chromosomes no longer decipherable. It might well happen therefore that, after the last gorillas, chimpanzees and orang-utans had all expired in their cages, we still should not know their chromosome numbers. We should not know whether, for example, one or more of them had had half or twice our own outfit of chromosomes. Or whether we had differed only by a small amount of fragmentation and the loss or gain of a few inconvenient genes.

Great institutions have been devoted to collecting and preserving, describing and naming, the bony fragments of our ancestors and relatives, and great bodies of literature have been brought forth by their labours. Rightly so. Yet at the cost of a few hundred cells, a few drops of blood, a few moments of discomfort to the animals, and a few hours of work to a cytologist, the genetic record of human evolution could be laid bare. It would, perhaps, be worth while.

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# THE LOGIC OF EXPERIMENT

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EVERYTHING in our experience is particular; and science seeks to link it by general laws. How does the observer pass from the particular phenomena to the laws for which they are thought to provide evidence? This is the classical problem of induction, as a human habit. We are here concerned, however, only with that part of it which is formalized in scientific method.

A law, in this meaning, is a statement from which phenomena can be derived by deductive steps. The aim of induction in science is therefore to propose a system of laws from which everything in our experience will be seen to follow by strict deduction.

## The Axiomatic Model

Ideally, such a system is put in an axiomatic form. That is, there is postulated a set of primitive entities, of whatever kind—they may be reflexes, or genes, or enzymes, or mass and force (for they need not be observable). A system of axioms then lays down how these entities behave and may be combined; Mendel's rules or Newton's laws of motion are examples. With this goes a dictionary to say what conjunctions of the fundamental entities can be observed, and what these observable appearances are. The model is now ready to be set going.

The model proceeds by steps, and in a natural science these steps take place in time. Some of the axioms therefore must say how the postulated entities move or change in time. These are, broadly, the causal laws, which describe sequence or consequence.

## Experiments in Time

There can, of course, be no assurance that these sequences will follow in the future the same laws that they have followed in the past. Nature might at any instant break with herself. This remark is a valid warning against prediction and other extrapolations; but it does not, as has been thought, bear upon the process of induction which underlies them. Induction remains the process by which science seeks to trace an order in what has been experienced. At any instant (even at the instant after an experiment) this search can involve only the past record.

When an experiment repeats what was done before, it adds to this record. It does so, first, to give a narrower estimate of error. But even if experiments were free from error, the repetition would not be trivial. For it serves to scrutinize, from time to time, the way in which time has been written into the axioms. For example, we go on measuring the speed of light for both reasons, for we are by no means sure that it is not growing with time.

## 'Probability' of Laws

To assert that a law is true is to claim that, ideally, all the phenomena which can be deduced from it could be verified. Even when we confine ourselves to the past record, this is a claim that cannot be proved; it can at best be tested. For any record can only be a sample, even of the history which it records: it is the nature of experience that it only samples the universe. It is therefore pertinent to ask of a law or model: How probable is it that the configurations which it generates would have matched the universe at all points, because they match it at so many sample points?

The question is commonly put in this form; but it is not happy, for the phrase 'how probable' cannot make sense. The probability of hypotheses is a pointless inquiry. There is always an infinity of distributions from which the finite set of sample points might have been drawn; and there can always be constructed an infinity of hypotheses or models which will generate the same finite record. In any absolute sense, the probability that one hypothesis is right is therefore always zero.

This difficulty is not met by making the sample larger. Experiments are, of course, designed (this is their third function) to test the fit of the axiomatic model at new sample points. If they fail, the model is rejected; but their success, even when it is as spectacular as the discovery of Neptune, can never make the model probable in itself. It can, in fact, only make it more probable than another specified model; or, to put the matter so that it really has a defensible meaning, it can give reasons for preferring one model to another.

## Critical Evidence

Such an experiment, when it is well designed, is a challenge to Nature to opt for one of two replies. The great experiments of history are charged with this critical sense: the apocryphal experiment from the tower of Pisa which Galileo was long thought to have made, the interference of light, the work of Pasteur and that of Sherrington, the Michelson–Morley experiment, the charting of black-body radiation, the eclipse of 1919, the search for Yukawa's meson. In an absolute sense, at least some of these experimenters were mistaken, for they thought themselves to have established laws, which have since in their turn been ousted by others. But in the sense that matters, their experiments were as decisive as the discovery in a crossword that 'bezique' crosses 'syzygy' at the right point.

It has long been seen that some sciences, such as palaeontology, depend on this interlocking of evidence. By contrast, it has been thought (for example, by Collingwood) that the experimental sciences arrive at laws by a simpler accumulation of evidence. This distinction is false. Laws must be guessed by induction; they must be fitted together into an axiomatic model; and the model can only be tested by such critical devices.

The point is crucial; and it leads us to ask: How, in fact, does the scientist invent the nexus of primitive entities and their relations which make his model? The axioms of Euclid do not raise this question, because plainly they are simple experiences in geometry, and this is why they were long thought to be self-evident. But the entities which underlie an axiomatic description of Nature are not at all immediate to the senses. How does science come to isolate them?

### Experiments as Messages

Leibniz gives the clue to this when he says that the scientist must read the cryptogram in Nature. His hint has been neglected; but then, so has the whole fundamental problem.

Take some commonplace from the chemistry book, the simpler the better: say, the action of sulphuric acid on common salt. This reaction was known to Dr. Glauber in the seventeenth century. From that time, apothecaries knew what substances are involved, and more and more other reactions in which they take part. All these reactions were in a sense messages, that is, they had a systematic content; but chemists failed to read them, and chemistry remained incoherent, until their code was broken down. In effect, modern chemistry begins when Glauber's reaction could be written as

$$2\,NaCl + H_2SO_4 \rightarrow Na_2SO_4 + 2\,HCl.$$

This and the formulæ like it trace an order in the chemical actions by showing that they are all assembled from one set of code letters or elements.

The code does not stop there. It prompts the chemist to ask why S is so often coupled with $O_4$, and why the letter H moves about in so many of these messages. This is the familiar step in decoding which counts the frequencies of letters and of groups, and here it at once leads to the theory of valencies. From it we pass to physical theories, which seek a still more compact structure within the alphabet of ninety or so elements. The messages of physics can, in fact, be broken down, by these steps, first to electrons and unidentified nuclei, and then to a three-symbol Morse code of electrons, neutrons and protons.

### Code and Meaning

In this procedure, Nature is conceived as an assembly of processes (and not of objects or events). The sentences which describe these processes are thought to be a set of code messages. To trace the laws within the processes is then systematically to break down the code into its constituent symbols and their laws of arrangement. This is the most powerful form of the axiomatic method, for it recognizes that we do not analyse experiments but the sentences which record them.

This procedure, however, as yet has no criterion for preferring one axiomatic model to another. The choice between two ways of decoding the sentences, and the wish to pass from a code of ninety-odd symbols to one of three symbols, must be governed by a rational demand. This requirement is that the code shall make the content of information in the record as large as possible. In this context, information and meaning are identical; so that this is the demand that *the code shall make Nature as meaningful as possible*.

By way of example, consider two models each of which can account for the same set of experiments. The experiments are read as messages on the symbols and axioms of the two models; they therefore have in each case a content of information made up of sums

$$-\sum_i p_i \log p_i,$$

where the $p$'s are the probabilities that the symbols occur in their places by chance. The demand for the larger content of information therefore prefers the model in which the symbols have more free choices for their occurrence or behaviour. Succinctly, we are to prefer the less restrictive model; or, as Ockham put it, we are not to multiply hypotheses.

Even the messages of Nature, of course, do not reach us without noise. This background noise is provided by the experimental errors and ultimately by the coarseness of all observation. To this, Nature might have added a random process of her own, with no known law of distribution. But if so, we have not detected it. We set about the task of decoding on the assumption that nothing in the processes of Nature is meaningless.

### Direction of the Message

A message has only one dimension, and most scientific constructs have several. But since the message transcribes a process or experiment, plainly it singles out the dimension of time. Objects, events and structures are to be pictured within the code groups, where they can have their own function spaces. The direction of the message is the direction of time.

But, of course, a code message carries no mark of direction, and it might read forward or backward. Even a book of messages, or the whole record of the past, might be decoded in either direction; and its meaning would not be essentially different, with one exception. The exception is that we should not know which way time is running. This is an odd and final use of experiment: that we have to add one experiment of our own to the record, in order to fix the direction of time as we experience it.

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# OBITUARIES

## Sir William Dampier, F.R.S.

SIR WILLIAM DAMPIER was born in 1867 and named William Cecil Dampier Whetham. His early work was published under that name; but later he changed his surname to that of his mother's family. His father and grandfather were prominent citizens of London, the latter being its Lord Mayor in 1878; but his own most vital interest lay in the country rather than the town. After taking his degree in Cambridge in 1889, he went to work in the Cavendish Laboratory under the inspiration of J. J. Thomson. The best-known result of his early work is his experimental proof that when liquids flow through tubes there is no slipping at the liquid–solid interface. Later he studied the motion of ions in liquids and developed methods for measuring ionic velocity which have since been used by others. With E. H. Griffiths he made accurate measurements of the conductivity and depression of freezing points of dilute solutions and showed that their results were in agreement with the ionic theory which Arrhenius had recently put forward. As a result of these studies he published in 1902 his book "The Theory of Solution", which was for a time the standard textbook on the subject.

In 1891 Dampier was elected to the fellowship at Trinity College, Cambridge, which he retained until the end of his life. After serving for some years as a College lecturer, he accepted the heavy duties of a College tutorship. In this office he showed a capacity for human sympathy which his many pupils gratefully remember; but his duties took up so much of his time that he had to drop his laboratory work. His mind, however, was very active. During this period he published books on eugenics and was collecting material for his "History of Science" (1929).

Meanwhile, with his love of the country and country pursuits, Dampier could not be satisfied with life spent entirely in Cambridge. He and his wife bought an estate in Devonshire, and problems connected with agricultural economics soon forced themselves on his attention. In 1917 he inherited a small family estate. At that time he was working part-time with Sir Thomas Middleton at the Food Production Department of the Ministry of Agriculture. He characteristically decided to put his agricultural ideas to the test by taking two farms near his estate and operating them through a manager. The scarcity of cheese during the First World War directed his attention to this product, and he set up a small cheese factory in connexion with his farms. Here the problem of using the surplus whey led him to experiments in the production of lactose, which eventually developed into a process used on a commercial scale.

The falling prices from 1920 onwards focused Dampier's attention on the relationship between money, prices and agricultural profits. He published his opinions on these subjects in the *Economic Journal* (1925) and in a book, "Politics and the Land" (1927).

The interest aroused by these publications and the reputation for sound judgment which Dampier had acquired in several forms of public service led to his being consulted by the Government on many problems of agricultural policy. Of these none was more important than those which led to the formation of the Agricultural Research Council. After the First World War, when it became clear that the Government would have to spend large sums in supporting scientific and medical research, the Department of Scientific and Industrial Research and the Medical Research Council were set up to encourage and regulate government expenditure and activity in these fields. No such body existed for agricultural science; but a number of laboratories devoted to agricultural research were being largely supported through public funds. Since these independent bodies were in some cases absorbing increasingly large grants, it became clear to the authorities that a body analogous to the Department of Scientific and Industrial Research or the Medical Research Council would have to be set up for agriculture. Dampier's tact and experience were of great value during the delicate negotiations which were necessary to bring the existing independent bodies into a state of mind favourable for setting up an Agricultural Research Council which would regulate their grants. Dampier became the secretary to the Council, and guided it in the difficult early stages until it became firmly established. He also took great interest in rural community councils.

Dampier was elected to the Royal Society in 1901, was knighted in 1931 and awarded the Gold Medal of the Royal Agricultural Society in 1936. He married Catherine Holt in 1897 and had five daughters. His loss will be deeply felt in Trinity College, to which he was so devoted and gave such good service.

G. I. TAYLOR

## Prof. L. B. Smyth

LOUIS BOUVIER SMYTH was born in Dublin in 1883 and died there on July 11, 1952. His father was Mr. Isaac Smyth of Dublin; his mother was French. He received his school education at Wesley College, Dublin, and entered Trinity College in 1902. He graduated in 1906, obtaining senior moderatorship in natural science with a large gold medal, awarded for first place on exceptionally high marks. In those days candidates took botany, geology and zoology, equal weight being assigned to each course during the four years; but for the degree a special course also had to be taken in one subject. Smyth took botany and was appointed as assistant to Prof. H. H. Dixon during the period when the present School of Botany was being built and the department organized. This happy collaboration continued for three years. He then accepted a post as naturalist in the Fisheries Branch of the Department of Agriculture and took part in several cruises to study, in particular, the phytoplankton. After a year there he was invited by Prof. John Joly to join his staff, and from 1911 until his death he continued in the Iveagh Geological Laboratory at Trinity College, Dublin. In 1911 also he married, very happily. He is survived by his widow.

Joly sent Smyth to work in Oxford under the late Dr. Arthur Vaughan, the leading English palæontologist of that period, and, on his return to Dublin, Smyth was appointed lecturer in palæontology. Then for more than twenty years he did all the exclusively honours teaching in the Geological Department in mineralogy, petrology, palæontology and geological map-reading. Sometimes also he had to lecture as Joly's deputy, and in six consecutive years he had the Senior Engineering Class on ore deposits. From 1931 until 1934 he occupied also the newly made post of lecturer in geography.

But Smyth's influence in Trinity College, Dublin, extended far beyond the geological laboratories. He joined the O.T.C. when it was first started, and was commissioned. He was in the Territorial Forces (Unattached List) in January 1915 and was promoted lieutenant 1916; but a disabling affliction denied him his wish of going on active service. The value of his military work may be realized on looking at the T.C.D. War List (1922); the total trained by the Corps was 1,490, with some 3,000 members of the University serving, and more than 460 names on the walls of the Hall of Honour. On committees too his quiet business-like manner and precision were of much value; most notable was his service as secretary of the University Council, and on the Board of Trinity College in his last years.

His first published work (1911) was with Joly, on the radium emanation in the soil. The rest were almost all in his sole name and appeared mainly in the *Scientific Proceedings of the Royal Dublin Society*, the *Proceedings of the Royal Irish Academy*, the *Geological Magazine* and the *Quarterly Journal of the*

*Geological Society of London*. In these the patient examination of the strata and the marshalling of the palæontological evidence linked up the geology of North Wales and the Irish coast. The first of the series dealt with the faunal zones of the Rush–Skerries Carboniferous Section, Co. Dublin, and further papers considered the strata at Malahide and at Ballycastle, Co. Antrim. The fine paper on the geology of Great Orme's Head (1925) led to the award of the Sc.D. degree. The Irish Academy published a similar contribution on the Carboniferous Rocks of Hook Head, Co. Wexford (1930). His papers gave detailed descriptions of fossils, notably of corals.

In 1934 Smyth succeeded Joly in the University chair of geology, which he occupied until his death. He devoted himself, unremittingly, to his teaching, and to the improvement of the Geological Museum and Department. He was never happier than when taking his students and overseas colleagues on geological expeditions—and few university cities have more varied geological interest close at hand than has Dublin. After a gap, occasioned by his teaching duties and illnesses, came "The Carboniferous System of North County Dublin" (Geol. Soc., 1950) and "A Viséan Cephalopod Fauna in the Rush Slates" (Roy. Irish Acad., 1951). A clear lecturer, a sympathetic teacher, loyally devoted to his University, a true friend—there are many who mourn his loss.

W. R. G. ATKINS

## Mr. C. E. N. Bromehead

CYRIL EDWARD NOWILL BROMEHEAD, formerly of the Geological Survey, died on December 4. He was born at York on January 8, 1885, and was educated at Marlborough and at Merton College, Oxford. He joined the Geological Survey of Great Britain in 1909 and was assigned as his first major task the 6-inch survey of a large part of the London area. With Henry Dewey he devised the present nomenclature of the gravel-terraces of the Thames Valley, and he became an authority on the geology and early history of London and particularly on the buried tributaries of the Thames such as the Fleet and Ty Bourne.

In the First World War he served in Flanders and was severely wounded. He returned to the Geological Survey in time to take part in explorations in Derbyshire which led in 1919 to the drilling of Britain's first oil-well at Hardstoft.

In 1922 he was appointed district geologist in charge of Yorkshire. Employing techniques of stratigraphical palæontology then being devised by W. S. Bisat, Sir Arthur Trueman and W. B. Wright, he and his staff became experts on the Upper Carboniferous rocks. In fifteen years his unit made a detailed revision of most of the coalfield and its borders—an area of nearly 1,000 square miles—and sent to the press the relevant maps and memoirs as well as a new edition of the memoir on the "Concealed Coalfield of Yorkshire and Nottinghamshire". These publications have proved invaluable in subsequent developments of the coalfield.

In 1935 Bromehead took charge of geological work in Southern England, where mapping was proceeding in Kent. For much of the next ten years, however, his duties were connected with the Second World War, and throughout this time his knowledge and experience were always at his colleagues' service. He relinquished some of his responsibilities in 1945 and retired in 1949.

During this last period his interest in the origins of geology and related arts (he was a founder-member of the Society for History of Science) was revealed in two presidential addresses to the Geologists' Association on the early history of practical geology and mining in Britain, and in papers on antiquarian subjects—'eagle-stones', loadstones, 'murrhine', early water-supply and museums—in which a high order of classical scholarship was delightfully blended with geology. He also wrote on oil, reservoir-dams and fluorosis.

Profoundly influenced in his youth by what was then known as the 'Oxford Movement', Bromehead practised religion with characteristic thoroughness. He is remembered with affection by the many who experienced his kindliness and culture, his wisdom and, not least, his firmness in moments of crisis.

WILFRID EDWARDS

## Mr. R. S. Styles and Mr. F. W. Campbell

RONALD STEPHEN STYLES and Frederick William Campbell, who were attached to the Division of Radiophysics of the Commonwealth Scientific and Industrial Research Organization, Australia, were killed in an aircraft accident near Sydney on October 27 while engaged on research in cloud physics and natural rain formation.

Styles and Campbell were on a routine flight in an R.A.A.F. Dakota fitted for cloud 'probing' using microwave radar and special instruments designed in the Division of Radiophysics for observing cloud temperature, liquid-water content and cloud droplet spectra. The aircraft had been investigating clouds over the sea and reported that it was descending from 6,000 ft. to 2,000 ft. through low cloud and heavy rain preparatory to returning to base. It failed to report at the next check-point, and an intensive emergency search was immediately organized. Oil, wreckage and a half-inflated rubber dinghy were found a short distance out to sea, and some items recovered were identified as belonging to personnel on the aircraft; all on board, including an R.A.A.F. crew of four, were killed.

Mr. Styles was born in Sydney, New South Wales, in 1926. At the University of Sydney he took a course combining physics and electrical engineering. He graduated with the double degree of B.Sc. and B.E. and joined the Radiophysics Division as a research officer in March 1948. His initial work concerned radio aids to aircraft navigation, to which he made valuable contributions. He was then transferred to work on rain and cloud physics, and his obvious ability and enthusiasm soon led to his taking a major part in airborne observations of natural rain. His observations of the development of non-freezing clouds to give rain are of particular interest. He also contributed significantly to the development of instruments in this field and displayed a marked ability for organizing, implementing and analysing results in this difficult field of research. He leaves a widow and an infant son.

Mr. Campbell was born in 1915, at Norseman, Western Australia. After successfully completing a radio course at Perth Technical College in 1934, he spent the pre-war years as a radio engineer in Perth. During the Second World War he served with the Royal Air Force, rising to the rank of squadron leader. He undertook specialized radio and radar courses at Prestwick, Great Malvern and elsewhere, was mentioned in dispatches for meritorious technical services and was finally senior radar officer to No. 38 Group, R.A.F. After the War he was appointed to the Department of Civil Aviation in Sydney. He joined the staff of the Commonwealth Scientific and Industrial Research Organization in August 1947 as a technical officer, and was an active member of the team carrying out flight trials and experiments on radio aids to navigation. He had a first-class knowledge of aircraft radio equipment. He later joined the Rain and Cloud Physics team and for several years worked in partnership with Mr. Styles. Mr. Campbell was married and had two young children.

The death of these two young men is a tragic loss to Australia. Their work in the field of rain physics was just beginning to bear fruit, and their loss means a serious setback to the research in cloud physics which has progressed so well in Australia.

### Dr. E. H. Hunt

Dr. Edmund Henderson Hunt was educated at Harrow and Balliol College, Oxford, where he took a first in physiology under J. B. S. Haldane, and went on to St. Bartholomew's Hospital, London, where he added the F.R.C.S. to his M.Ch.(Oxon.). He then accepted the appointment of chief medical officer to the Nizam's State Railway, Hyderabad, more or less as a temporary measure, but he found his life's work there. Apart from the constant pressure of his medical and surgical work at the Lallaguda Hospital, he developed a large private practice, which took him into all parts of the great city. The wide first-hand knowledge of the country he so gained led him to interest himself in anthropology and archæology. He was a fellow of long standing of the Royal Anthropological Institute, and published the results of important excavations of the Hyderabad urn-burials, and other papers, including a remarkable contribution on black magic, from the clinical point of view. His incomparable photographs of Ellora and Ajanta were widely known and did much to encourage the growing interest in Indian art. He was, also, a collector of Celadon. On retirement, he became interested in scientific bee-keeping, and was chairman of the Farnham Association and a member of the National Honey Show committee. To these activities must be added the many research activities in India, from geology to archæology, which would have been impossible without his helping hand. He was a true colleague to any research worker who approached him, a real friend of India, and an unforgettable personality.

K. de B. Codrington

## NEWS and VIEWS

### Queen Elizabeth College

The granting of a Royal Charter to Queen Elizabeth College, University of London, marks the beginning of a new phase in the work of what has hitherto been known as King's College of Household and Social Science. Beginning as a department of King's College for Women in 1908, it gradually developed research and teaching in the scientific aspects of household and social work, until in 1920 there was introduced the first degree in these subjects—B.Sc. (Household and Social Science). By 1928, the department became an independent school in the University of London under the title of King's College of Household and Social Science. It played a prominent part in the development of dietetics as a specialized study, and began, in 1933, the first courses leading to a diploma in dietetics. Now, with its Royal Charter and its new name, Queen Elizabeth College (after Queen Elizabeth, the Queen Mother) is breaking new ground. From October 1953 it will be training men and women undergraduates in the science of nutrition, leading to the new degree of B.Sc. (Nutrition). So far as we know, there is no other university in Britain which gives an undergraduate course for a first degree in this subject. A brief account of this degree and of the new degree of B.Sc. (Household Science) was given in *Nature* of August 9, 1952, p. 226.

### 'Krilium'

In December 1951 publicity was given to the discovery of a new way of improving soil structure by the use of certain synthetic polyelectrolytes produced by Monsanto Chemicals, Ltd., under the trade name 'Krilium' (see *Nature*, 171, 7; 1953). Other conditioners were afterwards announced by other manufacturers. During 1952 experiments have been made with 'Krilium' by several agricultural research institutes in Britain and by the National Agricultural Advisory Service under the auspices of the Agricultural Research Council. The substance used was supplied by Monsanto Chemicals, Ltd., as 'Krilium' (*CRD*. 189) and described as a sodium salt of polyacrylic acid. This was the earliest available soil conditioner and in its original form proved somewhat difficult to incorporate in moist British soils. The results of the 1952 experiments have now been examined. They were not expected to be more than preliminary, and no definite conclusions, therefore, can be drawn at this stage of investigation. The initial findings can be summarized as follows. (1) Improvement in structure after treatment was apparent in many of the soils tested. (2) The uptake by plants of major and minor nutrients was not adversely affected. (3) The activity of soil micro-organisms was normal. (4) No conclusive evidence was obtained that the application of 'Krilium' caused any significant increases in crop yields of field or of glasshouse crops, though in certain cases increased yields were recorded. Much more experimental evidence on the best method of incorporation, degree of aggregation and persistence of structure of treated soils, and the relation of these to crop yields is required before any definite conclusion can be reached. Towards the end of the year Monsanto Chemicals, Ltd., made available a new soil conditioner, described as a calcium salt of vinyl acetate – maleic acid copolymer. This was found to be more easily incorporated in soil and is stated to have better soil aggregating properties than *CRD*. 189. Experiments will be continued in 1953 and the results, when complete, will be published in the usual reports and journals.

### Associate Directorship of the U.S. National Science Foundation

The new post of associate director of the United States National Science Foundation has been filled by Dr. Paul E. Klopsteg, at present the assistant director for mathematical, physical and engineering sciences of the Foundation, and his place is being taken by Dr. Raymond J. Seeger, the programme director for physical sciences in the Foundation. In his new appointment, Dr. Klopsteg will be responsible for assisting the director and the deputy director of the Foundation in following closely the development of relationships with universities and with other Federal agencies; he will also handle special assignments of importance to the scientific programmes of the Foundation. Dr. Klopsteg is a graduate of the University of Minnesota, and in 1916 he gained there his Ph.D. in physics. His professional career has been devoted to the administration of research, and before the Second World War he was president of the Central Scientific Co. During the War he served with the Office of Scientific Research and Development as chief of Division 17, Physics and Special Devices, of the National Defense Research Committee, which developed important equipment and devices for war-time use. Later he was assistant chief of the Office of Field Service, which organized and directed the assignment of scientific consultants to the various theatres of war, and in this capacity he served in Australia and New Guinea as chief of the Research Division, General Headquarters, Southwest Pacific. Dr. Klopsteg has been chairman of the board of governors of the Argonne National Laboratory and is chairman of the Committee on Artificial Limbs of the National Research Council. He is at present on leave of absence from his post as professor of applied science and director of research of the Northwestern Technological Institute, Evanston, Ill.

## International Association for the Exchange of Students for Technical Experience

The fifth annual report of the International Association for the Exchange of Students for Technical Experience (pp. 56; from the secretary, J. Newby, at the Imperial College of Science and Technology, London, S.W.7) records continued progress both numerically and geographically: 3,493 students were sent abroad during 1952, an increase of 1,060 over the previous year. Yugoslavia joined the Association in January 1952, and the Saar and Turkey were represented at the conference of organizers. One large company with international interests selected in 1952 twelve undergraduate students for nomination to its overseas connexions and received twelve students in Great Britain selected by its overseas counterpart. Places available abroad for students of business administration and commerce increased to 112 as compared with 35 in 1951. More students were accepted than were sent in the following countries (numbers shown in brackets): Sweden (547), Great Britain (114), United States (47), Switzerland (37) and Spain (2). Of countries sending more students than they accept, Austria (161), Germany (148), Netherlands (118), Finland (94), Denmark (93) and France (51) show the largest excesses.

Since the establishment of the Association in 1948, some 1,440 industrial and other organizations have received foreign students under the scheme; it is estimated that during the summer of 1952 international industry and commerce contributed more than £161,000 to the Association's programme. The report includes an analysis of industries participating in the exchange and also of the subjects which participating students were studying. A list of institutions and firms taking part in the scheme is included under each country, and a supplement gives further details of exchanges in which Great Britain participated in 1952, when 488 students were sent abroad and 602 foreign students were received and placed. Travelling arrangements appear to require improvement, but relations between the students and other workers were entirely satisfactory, and an interim evaluation of the reports received on British students indicates that 1952 has been the best year both in the numbers sent abroad and in the service given.

## International Trade in Agricultural Machinery

Technically there is scope for much greater use of agricultural machinery, according to a report issued by the Commonwealth Economic Committee, "A Survey of the Trade in Agricultural Machinery" (No. 36; pp. 174. London: H.M.S.O., 1952. 7*s.* 6*d.*). Rises in the prices of agricultural machinery have been considerably less than those of the principal agricultural commodities, while the urge for greater agricultural production together with widespread increases in the cost of labour should combine to increase the demand for mechanization. Figures relating to world exports of agricultural machinery show that values rose from £25 million in 1938 to £300 million in 1951. In the post-war period, the United Kingdom has become the second largest manufacturer of tractors in the world, although she is still greatly outdistanced by the United States, where the production is four and a half times as great. The report shows that recent developments have been directed towards reducing manual labour on farms, or mechanizing processes which call for seasonal peaks in labour. To reduce labour costs, balers, loaders and handling gear, electric fences and dung spreaders are being increasingly used, while to decrease the need for casual labour, root harvesters in Europe, sugar-cane harvesters in Australia and cotton harvesters in the United States are being adopted. An important aspect of development has been the adaptation of standard implements to new tasks as, for example, the application of rotary cultivators and combine harvesters to crops of irrigated rice in India.

## Scientific Methods in the National Gallery Laboratory

An article on "Scientific Method and the Art Gallery", by Mr. F. I. G. Rawlins and Dr. A. E. Werner, of the National Gallery Laboratory, London, has been published in *Science Progress* (90, No. 160), in which the authors review developments at the Laboratory since 1939 and show how the application of science has aided the care of pictures. Studies in the effects of temperature and humidity changes and the introduction of air-conditioning are recorded. Recent work in the use of X-rays, ultra-violet and infra-red rays in the examination of works of art is discussed, and some details are given of chemical and physical techniques now used in the treatment of pictures.

## *Studies in Conservation*: Journal of the International Institute for the Conservation of Museum Objects

The appearance of a new periodical is in these days an event of prime importance, and especially if that periodical may interest comparatively few members of the public, because then the venture is even more hazardous. The first number has now been published of *Studies in Conservation* (1, No. 1; October 1952. Pp. 48. London and Edinburgh: Thomas Nelson and Sons, Ltd; about 2 Nos. a year, 21*s*. net a year), which is the journal of the International Institute for the Conservation of Museum Objects, and it raises this very issue, for, although the public to which the journal is addressed is small, it is very important inasmuch as the preservation of the world's art treasures depends on the standards maintained in practice by a relatively small number of professional conservators. When "Technical Studies in the Field of the Fine Arts" discontinued publication, conservators were left without any medium of communication of a strictly comparative type; it is this gap that it is hoped the new journal will fill. The policy adopted and the scope of the work covered by the journal is well expressed in the editor's preface: "Whereas nothing less than the best—and that implies the most meticulous—in the way of scholarship will suffice, there is every reason why studio and laboratory processes should receive equal prominence. Knowledge advances by the mastery of technique . . .". This statement is fully upheld by the contents of this first number, which contains articles written by authorities in their respective subjects covering a wide field; they include an account of a detailed investigation of the Dirk Bouts altar-piece, an interesting X-ray examination of an ancient metal object, and a record of valuable data concerning the hygroscopic behaviour of wood. All the investigations have yielded results that are of great interest to those engaged in the conservation of museum objects. The number closes with reviews of books dealing with the treatment of pictures, metallurgy in antiquity, defects of paint films and the surface chemistry of solids. The editor and publishers are to be congratulated on the production of a most acceptable first number, both on account of the choice of material and the quality of the printing and the reproductions. The journal should appeal not only to those who are directly concerned with the problems of conservation but also to the far wider circle of those who take a general interest in museum objects.

## New Spectrophotometer for Visible and Near Infra-red Radiation

A NEW spectrophotometer, the '*SP*. 600', for accurate colorimetric measurements within the visible and near infra-red regions of the spectrum, has been designed by Unicam Instruments (Cambridge), Ltd., of the Arbury Works, Cambridge. With this instrument the analysis of a sample, or comparison with a reference substance, can be speedily carried out. Over the greater part of the spectral range the band-width is about 30 A., and this is sufficiently narrow to reduce to a minimum effects commonly associated with spectral impurity at the selected wave-lengths. The instrument controls are simple to operate and consist of the following: a wave-length dial, calibrated in 10-A. divisions from 3600 to 4500 A. and then in 20, 50 and 100 A. to 10,000 A.; controls for slit width, dark current, transmission or optical density; and a selector switch for a red or blue (for use below 6500 A.) photocell. The light source is a tungsten lamp, and the optical system is a simple Littrow monochromator with glass prism. The photocell output current is amplified. Bias and high-tension voltages are provided by dry batteries housed underneath the spectrophotometer, but lamp and heater supplies must be obtained from an external 12-V. source. The illustrated pamphlet describing the instrument includes a transmission/wave-length graph of Chance *O.N.* 12 didymium glass taken on a standard form of the spectrophotometer, and details of the dimensions and accessories of the instrument.

## Educational Grants for Training in Plastics

THE trustees of the Plastics Industry Education Fund have decided as an experiment to allot up to £2,000 over a period of two years for maintenance grants for students attending a new two-year full-time course in plastics at the Borough Polytechnic, London. The course, which is for a minimum of eight students of about sixteen years of age who have taken the General Certificate of Education, will follow the syllabus of the City and Guilds of London Institute, leading to the diploma of the Plastics Institute at the end of the second year. Applications to attend the course should be made to the Principal, Borough Polytechnic, London, S.E.1. The trustees have also decided to allot £2,000 for capital equipment in technical colleges in Great Britain, which will include the Acton Technical College, the College of Technology, Birmingham, the Newton Heath Technical College and the National College of Rubber Technology.

## Awards for Technical Articles on Radio

THE Radio Industry Council is continuing its practice of making awards of 25 guineas, up to an average of six a year, for technical articles on radio published during the past year in any public journal. The principal criteria in judging will be the value of an article in making known British achievement in radio and electronics, originality of subject, technical interest and presentation and clarity. Only authors whose salary is not mainly or wholly gained by writing are eligible. They should submit their work (five copies if possible) to the Secretary, Radio Industry Council, 59 Russell Square, London, W.C.1, from whom all further particulars can be obtained.

## Research Fellowships at Government Scientific Establishments

FOR several years Ministry of Supply research fellowships, tenable at Harwell and certain other Ministry of Supply establishments, have been offered annually, and now a small number of similar research fellowships is being instituted at other government scientific establishments. A considerable choice of subject will be allowed to research fellows, provided that it falls within the field of work covered by the establishment to which they are attached. The fellowships will be tenable for three years and will carry benefits under the Federated Superannuation System for Universities. Remuneration will depend on individual merit and experience and will be £800–1,000 a year inclusive for senior awards and £500–700 for junior awards. The fellowships will be advertised by the Civil Service Commission as the occasion arises, and advertisements for the first awards should appear within the next few weeks.

## Colonial Service: Recent Appointments

THE following appointments in the Colonial Service have recently been announced: B. G. Kinloch (assistant game warden, Uganda), game warden, Uganda; A. F. W. Sheffield (principal agricultural officer, Nigeria), deputy director of agriculture, Eastern Region, Nigeria; E. H. Probyn (senior assistant conservator of forests, Cyprus), conservator of forests, Tanganyika; P. E. Glover (research officer (botanist), East African Trypanosomiasis and Tsetse Research and Reclamation Organization), chief field geologist, Kenya; T. H. P. Hartley and J. A. Howarth (agricultural survey officers, Gold Coast), principal agricultural survey officers, Gold Coast; F. A. Leeds and D. Westwood (agricultural officers, Gold Coast), senior agricultural officers, Gold Coast; L. Lotringer, J. A. Makinde, S. Z. Moczarski and G. E. Okiy (agricultural superintendents, Nigeria), agricultural officers, Nigeria; K. V. W. Nicholls (meteorologist, East Africa High Commission), senior meteorologist, British Caribbean Meteorological Service, Trinidad; H. T. Shewan (agricultural survey officer, Gold Coast), principal agricultural survey officer, Gold Coast; B. D. A. Beck, plant breeder, Nigeria; S. R. Chant, plant pathologist, Nigeria; C. M. Grieve, agricultural officer, British Honduras; A. D. H. Joblin, agricultural officer, Uganda; R. G. Poultney, pasture research officer, Kenya; J. H. Proctor, entomologist, British Guiana; R. MacDonald, geologist, Uganda; R. H. Cammack, scientific officer (mycologist), Nigeria; A. G. Smyth, soil scientist, Nigeria; R. F. Coughlan, veterinary research officer, Federation of Malaya; C. J. Price, veterinary officer, Uganda; J. G. Tremlett, veterinary officer, Northern Rhodesia; E. M. McWatt, veterinary officer, British Guiana; T. R. Paton, scientific officer (soil chemist), North Borneo; J. D. Randall, statistician, East Africa High Commission; W. W. Reece, stock development officer, North Borneo; R. A. Eyre-Smith, livestock improvement officer, Kenya; R. L. Sykes, leather chemist, East Africa High Commission; Miss M. S. Timpson, computer, Uganda; R. J. Wedderburn, assistant conservator of forests, Nigeria.

## The Night Sky in February

New moon occurs on Feb. 14d. 01h. 10m. U.T., and full moon on Feb. 28d. 18h. 59m. The following conjunctions with the moon take place: Feb. 5d. 18h., Saturn 8° N.; Feb. 16d. 23h., Mars 5° S.; Feb. 17d. 09h., Venus 2° S.; Feb. 19d. 14h., Jupiter 6° S. Mercury, in superior conjunction on February 2, is not well placed for observation until later in the month. On February 14 and 28 it sets at 18h. and 19h. 15m., respectively, and can be seen in the western sky after sunset in the latter part of the month. Venus is an evening star and sets at 21h. 05m., 21h. 35m. and 21h. 50m. on February 1, 14 and 28, respectively. The visible portion of the illuminated disk varies between 0·51 and 0·34, and the stellar magnitude is about − 4·2. Mars is visible in the early evening hours, its time of setting being about 20h. 50m. during the month. Its stellar magnitude is 1·3; in the early part of the month it lies a little south of λ Piscium, and towards the end of the month a little south of ε Piscium. Jupiter sets at 1h. 15m., 0h. 25m. and 23h. 45m. on February 1, 14 and 28, respectively, its stellar magnitude varying between − 2 and − 1·8. At the end of the month the planet lies a little south of δ Arietis. Saturn rises at 23h. 40m., 22h. 45m. and 21h. 55m. at the beginning, middle and end of the month, respectively. Its stellar magnitude is 0·3, and it lies a little north-east of α Virginis during the whole of February. Occultations of stars brighter than magnitude 6 are as follows, observations being made at Greenwich: Feb. 2d. 1h. 37·6m., ρ Leon. (*R*); Feb. 4d. 2h. 58·2m., *q* Virg. (*R*). *R* refers to reappearance. A partial eclipse of the sun, invisible at Greenwich, takes place during Feb. 13–14. It begins on Feb. 13d. 23h. 12m. at lat. 21° 55′, long. − 111°, and ends on Feb. 14d. 02h. 45·6m. at lat. 68° 27′, long. 164° 08′. The magnitude of the greatest eclipse is 0·760 (sun's diameter 1·0).

## Announcements

The Third General Assembly and International Congress of the International Union of Crystallography will be held in Paris during July 21–28, 1954. These dates have been chosen in consultation with the French National Committee for Crystallography and with the national committees of all the adhering bodies. Further particulars of the meeting will be given from time to time in *Acta Crystallographica* and elsewhere, or may be obtained from the general secretary of the Union, Dr. R. C. Evans, Crystallographic Laboratory, Cavendish Laboratory, Cambridge.

The spring conference of the Geographical Association will be held in the Diocesan Training College, Lincoln, during April 7–11, under the presidency of Dr. O. J. R. Howarth. The programme mainly consists of excursions of various sorts, but, in addition to the usual social functions, there will be a number of lectures, including the presidential address for 1952 by Prof. F. Debenham, and also an exhibition of maps, plans, books, etc. Application forms, which must be returned by February 16, and further information can be obtained from the honorary conference secretary, Miss Margaret Goodrich, Training College, Lincoln.

A symposium on molecular structure and spectroscopy, on the lines of those of previous years, will be held in the Department of Physics and Astronomy, Ohio State University, during June 15–19. The interpretation of molecular spectroscopic data as well as methods for obtaining such data will be discussed, and, in addition, there will be sessions devoted to aspects of spectroscopy which are of current interest. Further details can be obtained from Prof. Robert A. Oetjen, Department of Physics and Astronomy, Ohio State University, Columbus 10, Ohio.

List No. 7 (pp. 77, December 1951) of "Scientific Papers published in the Middle East", now issued by the Middle East Science Co-operation Office, Cairo, includes the papers received by that Office during November 1, 1950–September 30, 1951, and covers Afghanistan, Cyprus, Egypt, Iran, Iraq, Israel, Lebanon, Pakistan, Sudan, Syria and Turkey. There is the usual list of periodicals, arranged by country; the papers themselves are arranged by sciences and technologies according to the decimal classification.

The Ministry of Agriculture and Fisheries is offering the following scholarships for rural workers, or the children of rural workers, of seventeen years of age or more: ten senior scholarships, tenable at universities or colleges, for degree or diploma courses in an agricultural subject or veterinary science; sixty junior scholarships and six extensions for existing holders, tenable at farm institutes, for one-year courses. Selection is by interview only. Further information and forms of application (to be completed by March 31) can be obtained from the Secretary (Room 314), 1 Cambridge Terrace, Regent's Park, London, N.W.1, or from the education offices of County Councils.

# GEOPHYSICAL PROSPECTING

THE European Association of Exploration Geophysicists held its third meeting at the Stadthalle, Hanover, during December 3–5. More than a hundred and fifty members and guests from various countries in Europe and the United States attended. At the business meeting held on the first day, the final arrangements for the publication of the Association's journal were announced and approved. The journal will be entitled *Geophysical Prospecting* and will be published quarterly, the first issue appearing, probably, in March. Twenty papers were presented at the technical sessions. They comprised ten on seismic, seven on gravity, one on magnetic and two on electric problems of prospecting.

Few people outside Germany are aware of the remarkable progress which has been made by geophysical firms in that country in the application of seismic methods underground in mines. The location of faults, metalliferous veins, and the accurate mapping of sinuous or faulted veins are problems on which considerable successful work is being done, and one of the papers presented at the meeting, by H. Linsser (Germany), described the interpretation of the seismic sub-surface records by a statistical method designed to improve accuracy. An interesting description was given by H. von Helms and H. W. Maas (Germany) of recent marine seismic observations undertaken in the Baltic Sea. By means of these observations, perhaps the first of their kind to be made off a European coast, it became possible to fill in the gaps of a seismic section observed on land between Flensburg and Kiel.

The existence of multiple reflexions sometimes causes difficulties in the interpretation of seismic reflexion records. It has been the general tendency for these multiples, when they exist, to occur in areas which, structurally, have been little disturbed, but a paper submitted by H. Richard (France) demonstrated the existence of multiples in certain areas marked by steep dips and faulting. A particularly interesting case was the simultaneous recording of multiple reflexions from horizontal beds within a graben, and other oblique multiple reflexions from the steeply inclined beds at the boundaries of the graben. In describing the possible paths traversed by the reflexions, the author made some startling suggestions and introduced conceptions which were novel. The succession of seismograms obtained along a section across the graben, when placed in sequence below each other, furnished an unusual picture of the shape of the geological structure, the vertical lines of reflexions in the early parts of the seismogram depicting the horizontal beds within the graben and the later oblique lines of reflexions, forming overall the shape of a V, depicting the two inclined boundaries of the graben.

The subject of wave-energy return by diffraction from faulted beds, already discussed at a previous meeting in London[1], was again raised through a paper presented by R. Koehler (Germany). A practical example was described which suggested that 'reflexions' caused by diffraction can almost certainly be detected if they arise from shallow beds in a faulted area with wide fracture zone; but the effect from deeper beds is negligible. Two papers, from J. Schoeffler (France) and H. J. Dürbaum (Germany), dealt with the frequently considered problem of improving seismic interpretation by taking into account the departure of the actual ray-paths from the normally assumed straight-line paths.

The Department of Geophysics of the Amt für Bodenforschung, with the co-operation of the oil companies concerned, is engaged in a compilation of the data furnished by well velocity-surveys carried out in north-west Germany, on the lines of a similar compilation undertaken in the United States which has been of considerable value to American geophysicists. The results of this German work to date, based on seventy-four well velocity-surveys carried out during a period of eighteen years, were described. The data covered depths down to nearly six thousand feet, and interesting comparisons were made with the corresponding data from the United States.

A useful electronic device for overcoming the effects of static on seismic shot signals was described in a paper submitted by A. T. Dennison and F. A. Roberts (Great Britain). Pronounced static can cause serious delays in seismic long-range refraction surveys, and a device such as this should prove invaluable in these circumstances.

The seismic session of the meeting was rounded off with two interesting papers describing methods of ascertaining the velocity of sound waves in rock samples. In a demonstration of the first method, by H. Baule (Germany), supersonic pulses were transmitted through a cylindrical core of the rock specimen by a magnetostrictive driver attached to one end. The pulses were received at any chosen distance along the core by a small crystal pick-up resting on the specimen. The transmitted pulse and the wave form of the received disturbance were displayed stationary on a cathode-ray tube, together with a time scale furnished by a quartz clock, and the travel-time could thus be measured. Observations made at different distances enabled a time-curve to be drawn from which the velocity could be accurately determined. The second method, described by E. Müller (Germany), has the advantage that only quite small specimens of the rock are required. The sample is prepared by making a single cut, so as to produce a plane face, and then it is dipped in a fluid of known sound velocity. On the plane face of the sample a minute explosion is produced by an electric spark, and the two wave-fronts produced in the fluid by the longitudinal and transverse waves propagated through the specimen are photographed by the schlieren method. The angles between each wave-front and the plane surface of the specimen are measured, and the velocities and elastic constants thereby determined.

The session on gravity prospecting opened with a paper by B. J. Hofman (Holland) describing developments in marine gravity surveying. Experience has shown that remote-control underwater instruments have many advantages, and operational costs using such instruments are lower than with other systems utilizing land instruments on tripods or in diving bells.

The uses of the first, second and even higher derivatives of gravity in the interpretation of field observations were considered in papers by V. Baranov (France), O. Rosenbach (co-authors R. Koehler and E. Wirth) and B. Kosbahn (Germany). A particularly interesting contribution by S. Saxov (Denmark) shed considerable light on the relative values of the various derivative methods in emphasizing structural anomalies at different depths.

Prof. J. Goguel (France) described certain features of the geological interpretation of the gravity map of the Paris basin, and Prof. O. Vecchia (Italy) gave a detailed account of the regional structure of northern Italy deduced from gravity measurements. The results of magnetic investigations over the palæozoic massif of Serpont, in Belgium, were described by C. Gaibar-Puertas (Spain) and E. Hoge (Belgium). The applications of conformal representation in the interpretation of the results of telluric current surveys were considered in a detailed communication by G. Kunetz and J. C. de Gery (France). The final paper at the meeting dealt with the application of geophysics in the search for further supplies of drinking-water in Western Germany, and it is interesting to learn that considerable success has attended the application of geoelectrical measurements in quite a number of the hydrological problems which are involved.

D. T. GERMAIN-JONES

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[1] *Nature*, 170, 280 (1952).

# SCIENCE MASTERS' ASSOCIATION

## ANNUAL MEETING

THE annual meeting of the Science Masters' Association was held in the Chemical Department of the Royal College of Science, London, S.W.7, during December 30, 1952–January 2, 1953. The general theme of the meeting was "Science in the Service of the Community", and, with the co-operation of the heads of the science departments of the Imperial College of Science and Technology, the Science Museum, the Metropolitan Police Forensic Laboratory, the scientific departments of the London County Council and members of the Association, the widespread use of science in the modern world was adequately and realistically displayed.

In his presidential address, Sir Graham Savage, until recently the education officer to the London County Council and previously for many years chief staff inspector to the Board of Education, made a survey of the teaching of science during the past hundred years. He illustrated his talk by quotations from many sources not usually met with in the normal educational circles, and concluded by looking forward to a possible expansion of scientific teaching, expressing the hope that greater freedom would be granted to the qualified teacher to enable him to make the most of the material at his disposal or of that which he might be allowed to acquire.

Mr. L. C. Nickolls, director of the Metropolitan Police Forensic Laboratory at New Scotland Yard, London, in a lecture enlivened by many touches of humour, described the application of scientific methods dealt with by his Department. Illustrating his lecture by examples taken from his own wide experience, he emphasized the necessity for wisdom or common sense, as well as for highly skilled technical knowledge, in the solution of practical problems. He appealed to science masters to try to instil into their students the need for wisdom. At present, he said, too many highly skilled workers are becoming technicians, and too few are becoming scientists. Forensic science demands the use of a little science but a lot of common sense as, for example, when a member of his staff identified by means of detailed analysis two specimens of paint as containing the same metallic elements and declared them identical, while omitting to observe that one was green and the other brown. Mr. Nickolls described the work of his Department as falling under four headings: to tell whether a crime has actually been committed; to say who did it; to supply corroborating evidence; and to increase the weight of the evidence when the cases are presented before the courts. These points were most adequately illustrated by photographs of activities which had been brought to the notice of the Laboratory.

The heads of the Departments of Botany, Physics and Organic Chemistry of the Imperial College of Science and Technology—Prof. W. Brown, Prof. S. Devons and Prof. R. P. Linstead, respectively—described work done recently in their Departments. Prof. Brown, in dealing with the problem of plant diseases, said that it would be possible only to skate lightly over the field of study of pathology in plants. His aim, therefore, would be to give the main lines along which one proceeds to deal with the problem. As contrasted with veterinary, and especially medical, work, the methods of plant pathology have to deal almost entirely with populations and not with individuals. Inasmuch as a plant disease almost invariably damages the plant so that it rarely recovers, the plant pathologist is more concerned to ward off disease than to deal with it once it is fully established: the adage, 'prevention is better than cure', appeals to him with particularly strong force. The lines of defence include such things as improved cultural practice, protective fungicides and bactericides, breeding of resistant types of plants and the control of the spread of infective material. In connexion with the last-named, there exists considerable legislative repercussions for the unwary. Prof. Brown's lecture was illustrated by museum specimens, cultures of pathogenic organisms and with lantern slides. Prof. Devons dealt with the electromagnetic radiation from the nuclei, discussing the factors involved and the methods used in investigating the phenomenon. Prof. R. P. Linstead discussed the oxidation-reduction systems and, in particular, the hydrogen transfer from donor to acceptor molecules, giving as the most remarkable those changes which take place in the living cell. The mechanism of some transfers of hydrogen and the energy changes involved were discussed.

Mr. F. A. Meier, of the University of London Institute of Education, gave one of his customary lecture demonstrations, this time on a theoretical and experimental approach in the teaching of the M.K.S. systems of electrical units. Mr. Meier can always be relied upon to attract and hold the attention of a large audience of physicists, and this year was no exception to the rule.

New semi-micro experiments and their application to qualitative analysis were described by Mr. H. Holness, of the South West Essex Technical College. This was followed by a visit to the College, where students demonstrated the new techniques and apparatus, and where members were given an opportunity of using some semi-micro apparatus for themselves. Dr. F. Sherwood Taylor, director of the Science Museum, South Kensington, outlined the work there, both in a lecture and by a tour of the Museum. He described his efforts to increase the co-operation between the schools and the Museum, and to display to the general and to the specialized and informed public alike how scientific achievements have and can impinge upon the life of mankind. Dr. Sherwood Taylor also indicated that were there a suitable demand he would be prepared to consider following the lead of the National Gallery and organize exhibitions of museum material outside London.

Dr. T. P. Colclough, of the British Iron and Steel Federation, showed how increased efficiency in the manufacture of steel depends upon the skilful use of the scientific worker, and that the industry, with its equipment costing millions of pounds, can only function successfully if science is applied at every stage and in every process; there is therefore a need and an opening for more, and for more highly trained, scientists.

The Departments of the Medical Officer of Health and of the County Engineer of the London County Council provided lecturers and demonstrations of the direct application of science in modern life. An informative lecture upon the drainage of London from the earliest times to the present day, with a discussion of the many problems involved, showed how life in a congested city can be maintained and also the risks to which those who are involved in the sewerage system are exposed. A colour film of this work was shown in the County Hall, London, after which the laboratories of the Chemist-in-Chief were inspected. In these laboratories more than twenty-five thousand samples are investigated annually, including samples of air from the London tunnels, water from the rivers, from the wells in the Council's institutions, from swimming pools and baths, paints and building materials, laundry materials and fabrics with their resistance to washing, and the control of all stages of sewage treatment. Time permitted only a brief inspection of the extensive display set out by the twenty-six graduate chemists and their twenty-eight assistants.

However, the most spectacular lecture of the meeting was undoubtedly that given by Dr. C. W. W. Read, director of education for West Sussex and chairman of the West Sussex Beekeepers Association, who showed how a method has been devised for inseminating instrumentally the virgin queen honey-bee while still in captivity. Hitherto mating has been done on the wing and therefore beyond human control. A special micro technique is involved, and this was demonstrated both by means of the apparatus and by a coloured film of all the processes involved. By suitable sized screens in the hives, the queen bees and the males can be separated from the 'workers'. The drones can then be marked for identification purposes, so that the males used may be those carrying known breeding characteristics. The virgin queen honey-bee and the drones are anæsthetized in carbon dioxide under suitable conditions, the semen collected from the males and, by the use of micro seekers and a micro pipette, 5 cu.mm. of semen is injected into the virgin queen bee. In this way complete control is exercised, and any type or strain can be bred. As five generations a year can be obtained, the purity of the strains produced can be recognized in a short time. The film which illustrated the lecture deserved all those adjectives that are often reserved for the commercial cinema.

As usual, one of the most useful features of the meeting was the display of apparatus and teaching devices made by the members, which extended from cotton reels and their uses in physics to "Nuclear Disintegration by Cosmic Rays". The programme for each afternoon consisted of visits to laboratories, institutions and works, all of which had a high scientific value. A reception was held in the County Hall, London, on the evening of January 1.

Nearly nine hundred signed the register of attendance, every part of the British Isles and many countries overseas being represented.

# INDUSTRIAL CHEMICAL EQUIPMENT IN THE UNITED STATES

It is an accepted fact that during the present century the chemical industry has developed at a far greater rate in the United States than it has in Europe. At the beginning of the First World War, Europe was the main centre for the production of chemicals, and the output in the United States was comparatively small; at present it is estimated that two-thirds of the world's supply of synthetic organic chemicals originates in the United States. It is to be noted, however, that Europe still excels in the making of original scientific discoveries; it is in the rapid development of these discoveries to industrial processes that the United States appear to show such marked superiority. Typical examples are detergents, penicillin, streptomycin, many plastics, silicones and chemicals made from petroleum, all of which could be bought in the United States before being made on the eastern side of the Atlantic. The main reason for this is usually ascribed to the very large number of chemical engineers available in the United States for development work, and the very small number trained elsewhere, the ratio being of the order 20 to 1 so far as Great Britain is concerned. During the past few years numerous reports and discussions have emphasized this state of affairs, and many recommendations have been made for training chemical engineers in much larger numbers.

The latest approach to the subject is wider in scope and is a report* entitled "Chemical Apparatus in the U.S.A." made to the Office of European Economic Co-operation by a group of experts who visited a number of American firms. The title is not a happy one, as it fails to convey the expressed object of the mission, which was to investigate so far as possible the reasons for the great development of the American chemical industry. It is obvious that such a task would be beyond the powers of any small body of men in a reasonable time, and consequently the mission has been forced merely to mention some of the causes of development and, after contact with some twenty manufacturing firms, to write more detailed accounts of a few selected operations. The result is bound to be unbalanced, but it is, none the less, very readable. Another difficulty with which the mission had to contend was the use of the term 'Europe' as the antithesis of 'United States'. Europe is still far from being one country, especially where chemical engineering is concerned, so that to state that a process or machine is not commonly used in Europe may be quite accurate where some of the component countries are concerned, but incorrect in other cases. This is particularly noticeable in the case of chemical engineering training, the description of which in Europe can scarcely be taken to apply to Great Britain.

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* Chemical Apparatus in the U.S.A. Technical Assistance Mission No. 23. Report by a Group of European Experts. Pp. 224. (Paris: O.E.E.C.; London: H.M.S.O., 1952.) 20s. net.

In Part 1 the authors discuss the factors which tend to give American manufacturers an advantage over corresponding firms in Europe. Some of these are as follows: more chemical engineers; superior natural resources; larger home market; stronger internal competition; more vigorous sales methods; greater interest in new processes, products and materials; breaking down of development projects into simple units each dealt with by specialists; greater use of sub-contractors; more standardization, internal and external; greater readiness of firms to publish process details; availability of much empirical information; superior methods of transport and storage; and more instrumentation and automatic control.

It seems probable that the rise of the chemical engineer in the United States was originally due to the requirements of the oil industry. His success in this department led naturally to a call for chemical engineers in other branches of the chemical industries, and the cumulative effect was to produce the present large numbers, many of whom are employed successfully in industries not directly connected with chemistry. It is interesting to note, however, a serious decline in the number of new graduates in the subject, the 1953 figure being estimated at only 36 per cent of that for 1950. This decline is common to other branches of engineering, and a similar trend may be observed in Great Britain.

Many of the advantages listed above are directly dependent on size; thus the larger the connexions of a specialist firm of equipment makers, the more designs can they hold from which to suit a customer and the more can they spend on research. The report emphasizes the attitude of American manufacturers towards new projects, but fails to mention the deterrents which exist, particularly in Great Britain, in the shape of restrictive regulations, insufficient obsolescence allowance, the risk of loss and, in the event of success, the confiscation by taxation of a large percentage or sometimes nearly the whole of any gains. It is surprising that, in these circumstances, development proceeds at all.

Part 2 contains articles on process instrumentation, catalytic processes, distillation and extraction, heat exchange, special equipment, materials of construction, and transport and storage. With the exception of the first, these savour somewhat of the text-book, although an attempt is made to direct attention to plant and methods which are more commonly used in the United States than in Europe. The twenty-six pages devoted to instrumentation give a clear picture of the extent to which automatic control is used in the United States, and thirty-five diagrams indicate the variety of ways in which it can be applied, as well as showing some of the most modern instruments. It is emphasized that automatic control is not merely a device for saving labour, but that the operation of many modern plants would be impossible without it.

The report itself is highly condensed and it is difficult in a brief notice to give an adequate idea of its contents. Few chemical or plant manufacturers, however, bearing in mind the limitations already referred to and reading the subject-matter in an inquiring rather than in a critical manner, will fail to find ideas or suggestions for which they may be grateful.

H. E. WATSON

# ATOMIC ENERGY RESEARCH AT HARWELL

THE main research programmes of the Atomic Energy Research Establishment at Harwell since its inception in 1946 to the end of 1951 are described in a fascinating and connected story of the work and problems of the Establishment, which is the first of its kind to be published*. Some of the information has already appeared in scientific journals, but this new account is presented in a fashion which it is hoped will appeal to the more general reader. The subject, however, is far too technical to be appreciated and understood by any but those who have at least a background knowledge of the physics and chemistry of the atom.

Harwell is only a part, but an important central part, of the British atomic energy project. It has been given two main tasks: to conduct research into all aspects of atomic energy, and to advise the production organization and furnish it with the scientific and technical information that it needs. The atomic pile or nuclear reactor is obviously the primary requirement, and the two Harwell piles—'Gleep', the Graphite Low Energy Experimental Pile, which has been in almost continuous operation since August 15, 1947, and 'Bepo', the British Experimental Pile 0, which was started up on July 3, 1948—have proved invaluable research tools. Full descriptions of these reactors have been published previously, but, for convenience, these are reproduced in an appendix to the volume. Gleep operates at 100 kW., and Bepo, roughly of the same size, operates at 6,000 kW. with air cooling and is mainly concerned with the production of isotopes. These piles have been used to help solve problems in the design of the Windscale production piles, the main function of which is to produce plutonium. This branch of the work is briefly considered in the third of the nine sections into which the volume is divided. Other sections deal with the production and distribution of radioisotopes, perhaps the most widely publicized aspect of the work at Harwell; nuclear reactors and the production of useful power; particle accelerators, their purpose and the various forms in use at Harwell; methods of detection of radiation and of protection of atomic energy workers against damage to their health by exposure to radiation; the fundamental research programme involving chemical, physical and metallurgical investigations (engineering, biological and chemical-engineering work will be described in subsequent publications); and Harwell's extra-mural relations in the two important categories: collaboration through research and development contracts placed with academic, industrial or government laboratories, and exchange of scientific and technological ideas and information through published work, lectures, training schools and conferences.

To the general reader the sections on radioisotopes and on radiation protection will make most appeal. Present deliveries of isotopes, including those of long life which two years ago could be obtained only from the United States, now number eight hundred a month, and an increasing proportion is now made by air transport to many overseas customers. Various applications of radioisotopes in biological, medical and industrial fields are described. The use of cobalt-60 in place of radium is not so well known as

* Harwell: the British Atomic Energy Research Establishment, 1946–1951. Pp. 128+32 plates. (London: H.M.S.O., 1952.) 6s. net.

it should be, and the recent introduction of radioactive sodium for skin-graft operations is an important advance in plastic surgery. The protective measures taken at Harwell give some indication as to how much protection the general public may be able to get in atomic warfare. The instruments devised for the detection of radiation are sensitive and accurate. The frog-suit and helmet that are worn by those who have to come into contact with highly contaminated areas are somewhat frightening, as shown in the illustration given; but nevertheless it is reassuring in that these workers can be thus protected.

In the sections dealing with fundamental aspects, the research and technical worker will find some interesting information. Among the topics discussed are the study of the unusual crystal structure of uranium, which is orthorhombic at room temperature (some more details have recently been published in an article by Dr. H. M. Finniston in *Times Sci. Rev.*, No. 6; winter 1952); the effects of irradiation on the physical properties of crystals and glasses; neutron diffraction; the splitting of carbon into three, and oxygen into four, helium nuclei by high energy X-rays; powder metallurgy, principally of beryllium, zirconium and niobium; and research on ceramics.

It would appear that the compilers of this excellent volume intend to encourage the average student of science to extend his knowledge of nuclear physics, and to assist him in this commendable purpose they provide, in an appendix, a list of books suitable for the non-scientist, another list for students up to honours degree standard, and in addition a list of papers on the generation of useful power from nuclear energy. Perhaps further accounts, similar to "Harwell", to bring the story up to date will aim at particular sets of readers, possibly one account for the general public and another more technical one for the student of nuclear energy in its various aspects.

# THE WORK OF G. F. FITZGERALD

A SPECIAL meeting of the Royal Dublin Society was held on October 30, 1951, to commemorate the centenary of the birth of George Francis FitzGerald (see *Nature*, 168, 930; 1951). A message of greeting was read from the president of the Institution of Electrical Engineers, of the Irish branch of which Prof. FitzGerald was the first chairman. The Physical Society, London, was represented by Prof. K. G. Emeléus, and personal messages of congratulation, received from Sir Edmund Whittaker and from Dr. G. F. C. Searle who remembered FitzGerald personally, were conveyed to the meeting by Prof. F. E. Hackett. Slides and exhibits of some of FitzGerald's models, letters and experiments were shown.

The major part of the meeting was devoted to the reading of five papers dealing with FitzGerald as a man and a scientific worker and with the FitzGerald–Lorentz contraction and its relation to the theory of relativity. The text of these papers, together with two illustrations of FitzGerald as he was in 1878 and 1897, is included in the FitzGerald Memorial Number of the *Scientific Proceedings of the Royal Dublin Society*[*]. In the first paper, Prof. Hackett discusses the character of FitzGerald as revealed by his letters to Heaviside and gives examples of the several brilliant suggestions proposed but not actively pursued by FitzGerald. This is followed by a paper by Prof. H. E. Ives, who, after a brief historical survey of the FitzGerald contraction, derives, using the method of approach of Poincaré's principle of relativity instead of the more usual invariance of the Michelson–Morley experiment, the exact value of the FitzGerald contraction together with the accompanying change of clock frequency perceived by Larmor. Prof. Ives concludes with a brief discussion of the experimental evidence for the contraction and adds some interesting remarks concerning the ether.

Prof. W. H. McCrea discusses some paradoxes of the FitzGerald contraction and their resolution, and Dr. G. J. Whitrow the theories of relativity of Galilean frames with particular reference to E. A. Milne's work. Finally, Prof. J. L. Synge, in a paper entitled "Effects of Acceleration in the Michelson and Morley Experiment", offers an explanation, which he admits may appear fantastic but which is capable of direct experimental test, of D. C. Miller's observations in his 1933 repetition of the Michelson–Morley experiment. The explanation is based on G. H. F. Gardner's theory of the behaviour of a rigid body in accelerated motion. Because of the horizontal position of the interferometer, the original Michelson–Morley experiment is extremely poor as a check on Gardner's theory. An interferometer firmly integrated with the earth and with at least one of the two arms of the interferometer inclined at 45° to the horizontal is required, and such an instrument, Prof. Synge estimates, even with an arm-length of only 20 cm., compared with Miller's 3,000 cm., would give a fringe shift of a full fringe on rotation about a vertical axis. Reference may be added here to an experiment on these lines made by Prof. R. W. Ditchburn and O. S. Heavens (see *Nature*, 170, 705; 1952).

# AMERICAN–ASIAN FLORISTIC RELATIONSHIPS

THE floristic relationship between eastern Asia and eastern North America is the subject of a considerable memoir by Hui-Lin Li (*Trans. Amer. Phil. Soc.*, New Ser., 42, 2, 371; 1952), the subject being one which has interested plant geographers ever since Asa Gray's important paper on the subject in 1840.

While the present work broadly confirms the basic ideas established one hundred years ago, it reviews and revises the data in the light of modern concepts of taxonomy, nomenclature, plant geography and genetics. There is, in fact, a close floristic relationship between eastern Asia and North America, this being particularly marked in the east. Many genera which are common to, and dominant elements in, the two floristic regions have also a wide, general distribution and are therefore less useful in establishing relationships between the two continental regions. But there are many other less widespread genera which are of particular value in this study. Those genera, common to both continents, which are better developed in western than in eastern North America are considered as primary genera of western North America, whence they have spread eastwards into eastern North America and westwards into adjacent parts of north-eastern Asia. Their range is thus more or less continuous.

Leaving aside the many pan-tropical genera, a number of tropical and subtropical genera are known to occur in eastern Asia and in Central America and Mexico, these exemplifying a discontinuous distribution. Temperate and tropical genera which are especially confined to eastern Asia and eastern North America are enumerated. These include trees, shrubs, herbs and vines, some 38 genera being recorded for temperate regions and 19 for tropical regions. These genera are not necessarily of the same geological age and origin, but the evidence indicates that the majority have formed associations with each other and some of them may have been the dominant elements of past floras.

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[*] *Scientific Proceedings of the Royal Dublin Society*, 26 (N.S.), No. 1: Fitzgerald Memorial Number. Pp. 54+8 plates. (Dublin: Royal Dublin Society, 1952.) 12*s*.

An interesting point is that many of the genera under consideration are of relative antiquity in the phylogenetic scale; they include, for example, ancient genera like *Liriodendron*, *Magnolia* and *Sassafras*, of which reliable fossil records have been obtained. The species of the genera of the two disjunct areas are in most cases sharply defined and, in practically all cases, are different in the two continents, such differentiation being attributed to, or affording evidence of, the long isolation of the two floras. It is in this connexion that later workers have been able to correct the work of Gray and others; for many of the species from the two regions originally considered to be identical have now been demonstrated to be distinct. The truly identical species are found in the colder northern regions and have typically a continuous distribution. Many of these species are very widely distributed, some being typically circumpolar or circumboreal. They comprise plants which are characteristic of the glaciated regions of North America and Europe and are apparently of more recent origin than the disjunctive genera of the temperate region. These are but a few of the points brought out in this unusually interesting survey.

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# EXTRA-CELLULAR PHOTOSYNTHETIC REACTIONS IN ENTIRE LEAF MACERATES

By DR. F. C. GERRETSEN

Department of Microbiology, University of Groningen

IN a recent article in *Nature*, Prof. D. Arnon[1] discusses the possibility of extra-cellular photosynthesis. His view that a rather straightforward experimental approach to this problem by using entire leaf macerates does not seem promising, because the stability of the photolytic system in isolated chloroplasts undergoes rapid deterioration, is not shared by me. Though in many cases leaf macerates are indeed useless for the purpose, at least in one case this is not so, namely, in the case of macerized *Avena* leaves. (In more recent studies macerates of young leaves of *Beta vulgaris* also gave satisfactory potential changes on illumination.) Studying the role of manganese in photosynthesis[2], it was proved that filtered cell-free suspensions of crushed *Avena* leaves show a pronounced photo-reactivity for several hours and that an illuminated suspension even retains its reducing power during a dark period of 1–2 hr. following illumination.

Illumination of crude *Avena* chloroplast suspensions generally brings about large and rapid changes of the redox potential as measured with a bright platinum electrode. As the potential of such a complicated and heterogeneous system depends on a number of unknown factors, one has to be very cautious in drawing any definite conclusions from the observed changes; in a number of cases, however, valuable information was acquired concerning the nature of the oxidation-reduction processes occurring during illumination in these suspensions.

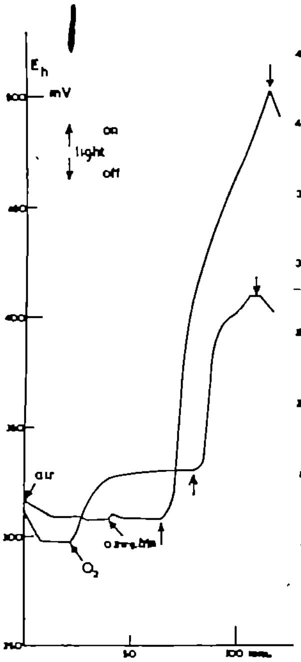

Fig. 1

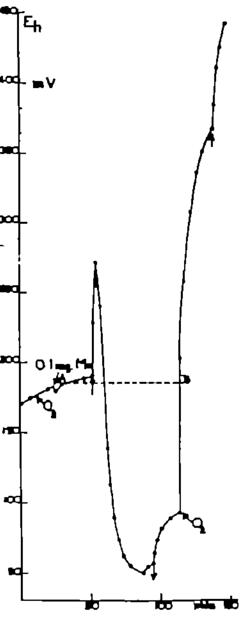

Fig. 2

Fig. 1. Redox potential curves of entire leaf-macerate of two identical leaves of the same oat plant, with and without manganese ions. The addition of manganese has no effect in the dark (↓); on illumination (↑) the potential rapidly rises to 500 mV., indicative of the formation of peroxide. pH 6

Fig. 2. Redox potential curves of leaf macerates. Note (1) that the entire leaf suspension retains its capacity to hydrogenate oxygen in the dark, 45 min. after illumination has been stopped (↓); (2) difference in behaviour at the equipotential points *A* and *B*, which refer to the same macerates in the dark, the only difference being that *B* had been illuminated previously

As may be seen from the accompanying graph (Fig. 1, lower curve) the addition of oxygen to an entire chloroplast suspension in the dark causes the potential to increase insignificantly by about 25 mV., after which it remains constant for about 50 min. When the suspension is illuminated, there is a sudden rise of the potential of more than 150 mV. up to 410 mV.

In the second curve, 0·2 mgm. manganese as manganese sulphate is added in the dark to an analogous suspension, which does not influence the potential. Illuminating this suspension, the potential increases much more and even reaches a maximum of 500 mV. (calculated on the basis of the normal hydrogen electrode).

This experiment, which is representative for a series of experiments of the same nature, shows, in the first place, that the crude chloroplast suspension has retained its photosensitivity for nearly two hours; illumination causes a rapid shift towards a more oxidized state. After the addition of manganese ions the potential rises to a much greater height and reaches 500 mV., which might be indicative of the formation of a peroxide.

The mean maximum value of a series of ten different determinations after the addition of 0·1–0·2 mgm. manganese ions as manganese sulphate to 8 ml. suspension and during illumination was

505 mV., which is 153 mV. higher than in the absence of manganese.

The most plausible explanation of the occurrence of such high potentials in the crude chloroplast suspensions is that during illumination oxygen is photochemically hydrogenated to hydrogen peroxide, which process is accelerated by the manganese ions added to the suspension[2]. Gaffron[3], supporting this view, remarks, "Such an interpretation seems likely, for Mehler[4] in this laboratory has shown that manganese ion has a strong catalytic effect on oxygen uptake by a system, in which $H_2O_2$ is known to be formed in this manner".

The course of another very instructive experiment is shown by Fig. 2. After some oxygen had been introduced into the suspension, manganese sulphate was added in the dark; this did not change the potential appreciably. On illumination, the potential rises very quickly until the oxygen is exhausted; at this moment the potential decreases very rapidly and ultimately reaches a minimum of 52 mV. When the light is turned off, there is generally a slight increase of the potential. Introducing oxygen in the dark into the suspension 20 min. later causes the potential to rise 260 mV. in a few minutes, reaching a height of 365 mV., which increases still further on illumination.

Comparing the equipotential points *A* and *B*, we notice that in both cases oxygen had been recently introduced, manganese ions are present at both points and both are in the dark; the only difference is that *B* had been illuminated 40 min. previously. In this case also these high potentials are indicative of the formation of peroxide, and the capacity of the dark suspension at *B* to hydrogenate oxygen can only be explained by the presence of some strongly reducing compound, which had been formed during illumination and persisted during the dark period. In another case a rise of 180 mV. was observed on the addition of 0·1 mgm. manganese in the dark to a suspension, 115 min. after illumination had been stopped, whereas the addition of the same amount of manganese to a similar unilluminated suspension had no effect.

These experiments are further strong evidence for the existence of a relatively stable intermediary reduction compound, persisting during a dark period following illumination, which has been postulated by van Niel[5] and others[6] and the existence of which had been made plausible by Calvin and Benson[7] with the aid of carbon-14.

In a paper read at the annual meeting of the Society for Experimental Biology at Oxford in April 1949, I showed that when entire *Avena* leaf macerates are illuminated under anaerobic conditions and in absence of carbon dioxide, changes of the redox potential are small, whereas the *p*H remains constant or slowly becomes more acid. After the addition of a small amount of carbon dioxide there is first a small increase of the $E_h$ due to acidification of the suspension, which now on illumination shows rapid decrease of potential of more than 150 mV. within 25 min. (see Fig. 3). At the same time the *p*H becomes more alkaline, whereas in the previous period without carbon dioxide the *p*H became more acid and the macerate did not react on illumination. When the light is turned off, the reverse is observed.

Though it is not suggested that this is an indisputable proof of photosynthesis *in vitro*, it seems likely that the rapid change of the $E_h$ and the alkalinization during illumination after the introduction of carbon dioxide both point to participation of the carbon dioxide in the oxido-reduction reactions of the chloroplast suspension. The amount of carbon dioxide which disappeared during illumination, calculated from the change of the *p*H, is equal to 2–4 per cent of the amount of carbon dioxide used by the same area of intact leaf-surface during normal photosynthesis.

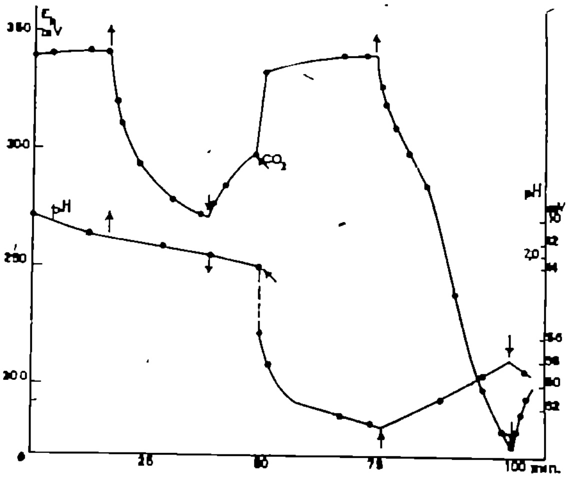

Fig. 3. Influence of the addition of carbon dioxide to an entire leaf macerate on the redox potential and *p*H. Before the addition of carbon dioxide, the $E_h$ soon tends to reach a minimum of about 260 mV. at illumination. The *p*H slowly becomes more acid and does not react on illumination. After the addition of carbon dioxide, the $E_h$ rapidly reaches a much lower value and the *p*H becomes more alkaline on illumination, most probably indicating that carbon dioxide partakes in the photosynthetic reactions

These few examples will serve to show that experiments with entire leaf macerates can procure valuable information on extracellular photosynthetic reactions. This does not, of course, imply that experiments with isolated chloroplasts will not be indispensable to disentangle the complicated photosynthetic apparatus.

[May 28.

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# SEPARATION OF NEUTRAL PROTEINS ON ION-EXCHANGE RESINS

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ION-EXCHANGE resins have been used to purify basic proteins of low molecular weight such as lysozyme[1], ribonuclease[2] and cytochrome *c*[3], and a separation of the active substances in a preparation of adrenotropic hormone has recently been reported[4]. We have recently endeavoured to extend the range to neutral proteins such as the hæmoglobins. As in previous work in this field, the resin adopted for these experiments was the monofunctional carboxylic acid cation exchanger 'Amberlite *IRC* 50'.

Paleus and Neilands found that cytochrome *c* could not be eluted from a column of '*IRC* 50' with 0·1 *M* ammonium hydroxide – ammonium acetate buffer below a *p*H of 9·9. Our own experiments, however, have shown that the elution of cytochrome *c* from a column of '*IRC* 50' is very dependent on the cation concentration in the eluting buffer as well as the *p*H. If the cation concentration is greater than 0·22 gm. ions/l., the cytochrome may be eluted at *p*H 7·0. In the work described here, the effect of sodium ion concentration and *p*H of buffer on the adsorption of cytochrome *c* has been studied in detail, and the information gained has been used to predict conditions for the separation of neutral proteins.

Cytochrome *c* was prepared from horse heart muscle by the method of Keilin and Hartree[5], and a chromatographically pure fraction was obtained by adsorbing the preparation on a column of '*IRC* 50' and eluting with sodium phosphate buffer of *p*H 7·0 and sodium ion concentration 0·34 gm. ion/l. This fraction contained 75 per cent of the material put on the column as measured photometrically at 548 mμ but only 55 per cent as measured by the ninhydrin reaction[6]. As impurities in the crude cytochrome preparation, we observed a pale yellow substance[5] which was eluted ahead of the cytochrome band and a red band which remained stationary at the top of the column. This latter band was eluted when the concentration of the buffer was increased and gave the same spectral curve as the main fraction, namely, that for oxidized cytochrome *c*. The main fraction behaved as a single substance when applied to a fresh column of the same resin and could be eluted from it quantitatively. Cytochrome *c* used in subsequent experiments was purified in this manner.

Figs. 1*a* and 1*b* show the effect of *p*H and cation concentration on the elution of cytochrome *c*. The elution volume is unaltered by substituting ammonium for sodium ions and appears to be independent of the nature of the anion. The behaviour of the protein on the resin column, as shown by the continuous line in Fig. 1*a*, is markedly different from that of ampholytes of low molecular weight such as the basic amino-acids. The amino-acid lysine shows a marked maximum adsorption at *p*H 7·3. As the *p*H rises towards its isoelectric point (*p*H 9·7), the lysine is desorbed; and similarly, as the *p*H falls, desorption again takes place due to suppression of the ionization of the resin carboxyl groups. Cytochrome *c* (isoelectric point 10·1) is desorbed in a similar manner to lysine as the *p*H rises from 8 to 10, but is not desorbed under acidic conditions. On the contrary, at *p*H 6–6·5 its elution volume rapidly rises, and under still more acidic conditions the cytochrome band remains stationary at the top of the column.

The broken lines in Fig. 1*a* are plotted from the data of Hale and Reichenberg[7] and Topp and Pepper[8], and show the relationship between the amount of sodium ion taken up by the resin and the *p*H. It will be observed that the rapid rise in the elution volume of cytochrome *c* in sodium buffers occurs over the same *p*H range as the rapid fall in the amount of sodium ion retained by the resin from buffers of comparable concentration. This suggests that the irreversible adsorption of cytochrome *c* that occurs at low *p*H is due to uncharged carboxyl groups on the resin, and that the mechanism of desorption at higher *p*H is concerned with the conversion of the resin to its sodium form. Thus, although electrostatic forces diminish as the *p*H decreases, due to suppression of negative charges on the resin, these forces are replaced by a large increase in the contribution of secondary short-range forces. The increase in short-range forces is most probably due to the concomitant removal of a layer of electrostatically bound water. With substances of high molecular weight, such as the proteins, the contribution of short-range forces towards the net adsorption affinity may be very large, and may be sufficient to account for the apparent irreversibility of adsorption at low *p*H. With amino-acids this contribution will be small, and thus the observed desorption of lysine at low *p*H would be expected.

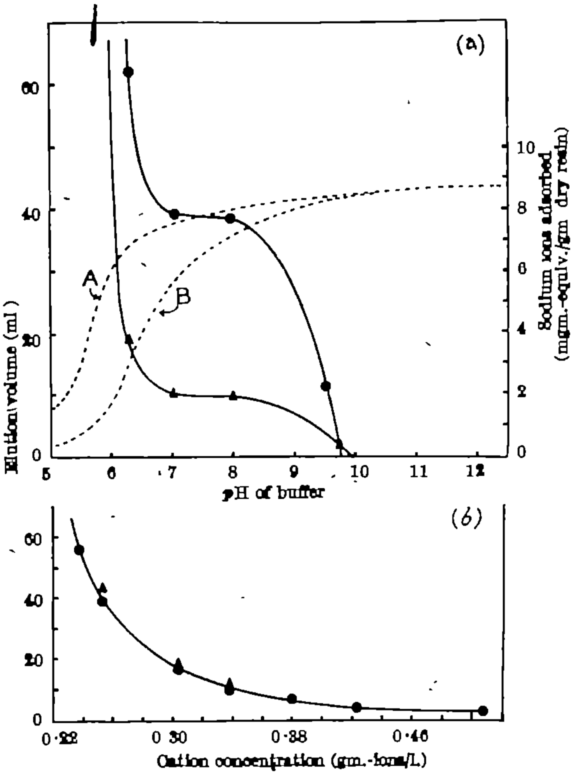

Fig. 1

(*a*) Effect of *p*H on the elution of cytochrome *c* by sodium phosphate buffer. 6·0-mgm. samples chromatographed on columns of 'Amberlite *IRC* 50', 16·0 cm. × 0·9 cm. Rate of flow, 1·0–1·5 ml./hr.; temperature, 25° C. ○, Sodium ions, 0·17 gm. ions/l. △, Sodium ions, 0·34 gm. ions/l. The broken lines show the amount of sodium ion taken up by the resin: *A*, from 1·0 *M* sodium chloride; *B*, from 0·1 sodium chloride

(*b*) Effect of cation concentration on the elution of cytochrome *c*, *p*H 7·0. ○, sodium ions; △, ammonium ions

The interaction of protein and resin may be represented by the following reactions:

$$R^{-}\text{Na}^{+} + \text{H}^{+} \rightleftharpoons R\text{H} + \text{Na}^{+} \quad (1)$$

$$R\text{H} + P^{+} \rightarrow R\text{H} \ldots P^{+} \quad (2)$$

$$R\text{H} \ldots P^{+} + \text{Na}^{+} \rightleftharpoons R^{-}\text{Na}^{+} + P^{+} + \text{H}^{+} \quad (3)$$

$$R^{-}\text{Na}^{+} + P^{+} \rightleftharpoons R^{-}P^{+} + \text{Na}^{+} \quad (4)$$

In these reactions short-range secondary forces are represented by $R\text{H} \ldots P^{+}$ and electrostatic adsorption by $R^{-}P^{+}$. Reaction (2) represents the mechanism due to secondary forces and lies wholly to the right; (3) shows the desorption of the protein in the presence of sodium ions; and (4) shows the reversible adsorption of the protein due to electrostatic forces.

The electrostatic attraction between protein and resin will depend on the net charge on the protein molecule and, to a lesser extent, on the distribution of that charge. The secondary forces will be influenced by the chain-length of the protein molecule, its configuration, and also on the nature of the side-chains. It should thus be possible to separate proteins of the same net charge but with different molecular configurations, or proteins of the same molecular weight but with different net charges. An example of the first type of separation is that of lysozyme and cytochrome *c*, which are proteins with approximately the same isoelectric point (10·5, 10·1) and molecular weight (15,000): the elution volumes are very different, and with a column of 5 cm. × 0·9 cm., cytochrome is eluted with sodium phosphate buffer in 3·3 ml. and lysozyme in 26 ml. As an example of the second type, a successful separation has been obtained with bovine carboxyhæmoglobin and sheep fœtal carboxyhæmoglobin, samples of which were kindly prepared by Dr. G. S. Adair.

Separation of the hæmoglobins presents two major difficulties. First, the proteins are readily denatured and at their isoelectric points slowly form precipitates even at 0° C. Secondly, the proteins are isoelectric near neutrality and thus the flat section of the adsorption – *p*H curve between *p*H 7 and *p*H 9 found with cytochrome *c* is absent. The isoelectric points of bovine carboxyhæmoglobin and sheep fœtal carboxyhæmoglobin are respectively 7·3 and 6·7 at 0° C. in phosphate buffer of ionic strength 0·02 [9]; but in the *M* citrate buffer used for the chromatographic experiments, their isoelectric points lie between 4 and 5 [10]. Thus in citrate buffer at *p*H 6, both proteins have a net negative charge, and neither is adsorbed by the resin. On the other hand, as is shown in Fig. 1*a*, at *p*H 5 the carboxylic groups of the resin are almost wholly undissociated, and adsorption of the hæmoglobins is complete and irreversible. The elution volume – *p*H data of the hæmoglobins may thus be represented by a family of steep curves falling rapidly from very high values to zero in the narrow range *p*H 5–6, the curves for the more acidic proteins being displaced to the left of those for proteins with higher isoelectric points.

Owing to the extreme steepness of the curves, chromatographic behaviour is sharply dependent upon the *p*H and cation concentration of the buffers, and these must be accurately controlled. The best separation of the two hæmoglobins investigated here was obtained at *p*H 5·81 (sodium ion concentration 0·34), and under these conditions sheep fœtal carboxyhæmoglobin was unabsorbed ($R_F = 1$) and the bovine carboxyhæmoglobin had a value for $R_F$ of 0·7.

Fig. 2*b* shows the chromatogram obtained from sheep fœtal hæmoglobin in citrate buffer of *p*H 5·8 at 25° C., using a column of finely ground '*IRC* 50', 5·0 cm. × 0·9 cm. The effluent from the column was collected in 0·2-ml. fractions and the hæmoglobin content of each fraction determined photometrically at 550 mμ. It was observed that as the hæmoglobin band progressed down the column it left behind a light deposit of coloured protein which appeared to be uniformly spread over the whole column. The carboxyhæmoglobin in the band was nevertheless eluted as a symmetrical peak without tailing. It was concluded that the material remaining on the column was probably denatured hæmoglobin (or represented some stage in the denaturation of the protein). It was found that the denatured protein could be eluted with concentrated sodium citrate buffer of *p*H 6·5 (sodium ion concentration 3·2), and peak *C* in Fig. 2*b* is the elution curve formed by this material.

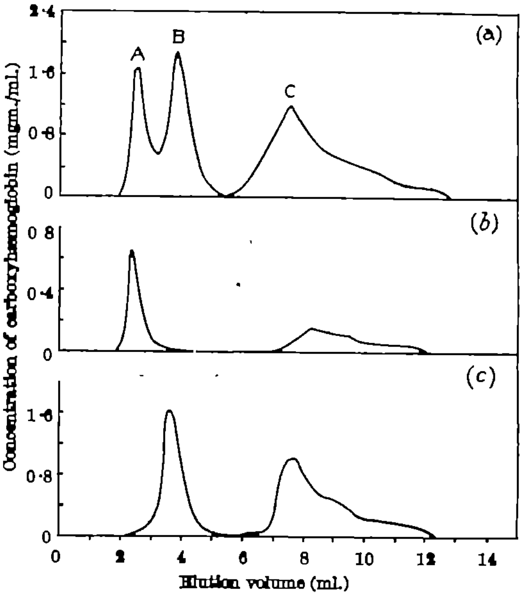

Fig. 2. Chromatograms of carboxyhæmoglobin using a column of '*IRC* 50', 5·0 cm. × 0·9 cm. Rate of flow, 0·5 ml./hr.; temperature, 25° C. Buffer: citrate *p*H 5·81, sodium ion concentration 0·34, changed to citrate *p*H 6·5, sodium concentration 3·2 after 1·2 ml.
(*a*) 5·7 mgm. of a mixture containing sheep fœtal carboxyhæmoglobin and bovine carboxyhæmoglobin. (*b*) 2·5 mgm. sheep fœtal carboxyhæmoglobin. (*c*) 3·1 mgm. bovine carboxyhæmoglobin.

The chromatogram of bovine carboxyhæmoglobin is shown in Fig. 2*c*, and it will be observed that this protein also shows a second peak on changing the buffer to one of higher concentration and *p*H. The two carboxyhæmoglobins were then mixed and the elution carried out under the same conditions. Fig. 2*a* shows that the two proteins separated as symmetrical peaks (labelled *A* and *B*) and that the denatured material from both appeared as a third peak (*C*). Samples of pure protein obtained from peaks *A* and *B* appeared to contain no denatured material.

While the separation of the two hæmoglobins described above is satisfactory for some purposes, and could no doubt be improved somewhat by the use of a rather longer column, the yields of the pure components were low. It appears probable that, if the material in peak *C* has indeed been denatured by passage down the column, yields could be improved by working at lower temperatures. A study of the nature of the processes leading to changes in the protein on the surface of the resin is in progress, in the hope that extension of the procedure to the separation of other protein systems will be possible.

We wish to thank Dr. G. S. Adair for many helpful discussions during the course of this work. One of us (N. K. B.) is the holder of a Dafydd Lewis Trust Scholarship. The work forms part of the programme of the Food Investigation Organization of the Department of Scientific and Industrial Research.

[July 3.

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# LETTERS TO THE EDITORS

*The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications*

## Action of Antibiotics on Avian Tubercle Bacilli studied with the Electron Microscope

THE method described by Brieger and Cosslett[1] of growing tubercle bacilli on the 'Formvar' film of a stainless steel electron microscope grid has been modified for use with liquid media. In this form the method has been found suitable for a study of the action of antibiotics upon growing tubercle bacilli. In order to prevent the fluid medium contaminating the inoculated surfaces, the grids are placed in contact with filter paper which rests on a cotton-wool support in a small dish 5 cm. in diameter and 2 cm. deep. The cotton-wool is kept moist by being thoroughly soaked in the medium. One dish can take up to twenty grids. The grids are inoculated with a drop of bacillary suspension using a fine platinum loop. If the drop does not stay on the surface of the grid, it is assumed that the holes in the 'Formvar' film are too large and the grid is discarded. The grids on which the drops remain are considered to be inoculated with similar numbers of bacilli. The dishes are incubated at 37·5° C. and grids removed at various intervals for inspection. Each grid is floated on sterile distilled water to remove any medium adhering to the lower surface, fixed by floating on 5 per cent formalin for 30 min., and washed again to remove any excess fixative. Throughout the procedure care is taken that the inoculated surface of the grid remains undisturbed. This is an essential condition for the study of variations in growth-rate.

A preliminary experiment was carried out to compare growth on the grids with growth directly on the medium. Grids inoculated with avian bacilli were placed on a Löwenstein plate and examined daily. At the same time, uninoculated grids were laid face downwards on the growth on a Lowenstein plate and impression prints taken on the 'Formvar' film. The comparison showed that the diffusion of the medium through the 'Formvar' film does not impair growth to any large extent. In fact, if inoculated grids are placed in dishes with Dubos medium, growth is usually so rapid that the squares of the grid are overgrown in two to three days even if the inoculation is made with a dilute suspension. With Dubos medium it is advisable to use small inocula and to examine the grids with a dry phase-contrast objective (× 40) before investigation in the electron microscope. Phase-contrast observation of grids can also be applied to the study of problems such as viability and growth-rate, especially the growth-rate in small inocula. Unfortunately, photographic recordings do not give very satisfactory results because the presence of the grid bars makes good phase-contrast difficult. However, some comparison can be made of the morphology and internal structure of the bacilli located in one square with phase-contrast and electron microscopy. Grids can also be stained in the normal way by carbol-fuchsin, after the examination by electron microscopy is completed. It is remarkable that the bacilli retain acid-fastness after exposure to the electron beam.

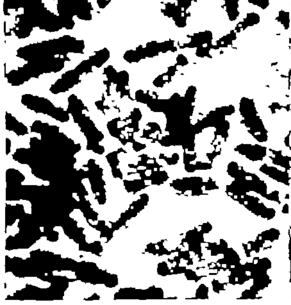

Fig. 1

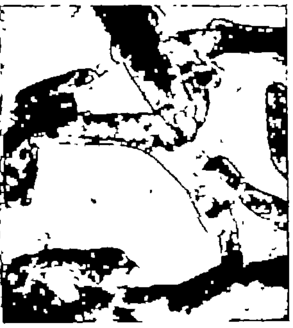

Fig. 2

Fig. 1. Growth on normal Dubos medium. 3 days. Shadowed. × 6,200

Fig. 2. Growth on Dubos medium containing 100 μgm. of streptomycin per ml. 3 days. Shadowed. × 6,200

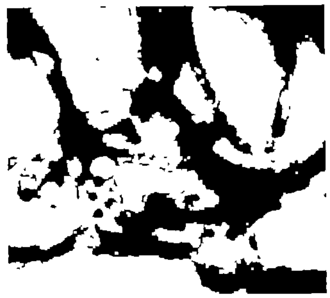

Fig. 3. Growth on Dubos medium containing 10 μgm. of streptomycin per ml. Mycelial strain. 5 days. Unshadowed. × 6,200

To study the action of streptomycin and *iso*nicotinic acid hydrazide ('Ditubin', Schering) two sets of dishes were prepared in which the Dubos medium contained 0, 10, 20 and 100 μgm. of antibiotic per ml.

Under normal conditions, the short bipolar rods of the inoculum elongate up to seven times their original length in 24 hr. During this time, internal structure becomes apparent and shows that the filaments consist of a row of intracellular units and have two dense polar bodies. After three days the uniform bipolar filaments have broken down into individual rods (Fig. 1). The cultures containing streptomycin grow more slowly; the filaments initially formed differ from the normal ones in being much broader and showing less definite internal structure (Fig. 2). The bipolar densities which are still present in most filaments often increase in size and become distorted.

The mycelial tendencies present in some strains are encouraged by small doses of streptomycin, which also cause a broadening of the branches and an irregular arrangement of the dense bodies (Fig. 3). Higher concentrations of streptomycin (100 μgm. per ml.) arrest growth in the mycelial stage, and after seven days of incubation the filaments become very broad and some disintegrated mycelial branches are regularly seen.

In comparison, *iso*nicotinic acid hydrazide produces very different results. A dose of 10 μgm. per ml. has very little visible effect on the growth pattern. With doses of 20 μgm. per ml. and more, the rods of the inoculum do not elongate at first and seem to shrivel, lose their transparency, and appear as dense oval bodies with tapering ends. The further development depends upon the dose. With a dose of 20 μgm. per ml. normal filaments develop within three days side by side with the tapering rods (Fig. 4*a*). After

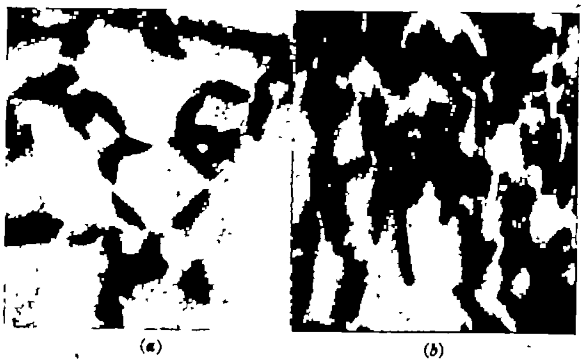

Fig. 4. Growth on Dubos medium containing 20 μgm. of *iso*nicotinic acid hydrazide per ml. (*a*) 3 days. Shadowed. × 6,200; (*b*) 7 days. Shadowed. × 6,400

seven days the cultures seem to recover partially and a mass of filaments covers some squares of the grid (Fig. 4*b*). At higher concentrations of *iso*nicotinic acid hydrazide (100 μgm. per ml.) recovery does not begin until the seventh day of incubation and growth is greatly retarded.

Our observations only refer to the action of antibiotics on an avian strain which had lost much of its virulence during subculture. The results suggest that the technique described may be of value in assessing the action of antibiotics at a very early stage of development. They also show that streptomycin and *iso*nicotinic acid hydrazide attack the bacillus in different ways and cause different morphological changes. The initial inhibition by *iso*nicotinic acid hydrazide and the more delayed action of streptomycin suggest that a combination of the two antibiotics should give promising results. Clinicians have already used combined treatment with good effect. The method should also be useful in studying the genetical aspects of resistance to these substances.

We wish to thank Mr. H. Pearson for invaluable assistance in taking the electron micrographs.

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Audrey M. Glauert*
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Strangeways and Cavendish Laboratories,
Cambridge. Oct. 30.

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* Sir Halley Stewart Research Fellow.

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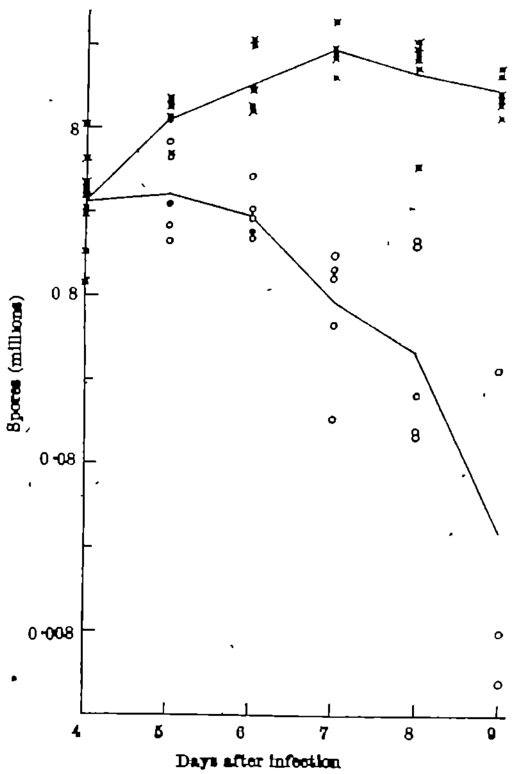
## Effect of Fumagillin upon *Nosema apis* (Zander)

A preliminary report by Katznelson and Jamieson[1] on the effect of the antibiotic fumagillin (derived from an *Aspergillus* culture designated *H*–3 [2]) upon the infection of the adult honey bee by the microsporidian *Nosema apis* indicated promising results. They suggested that the action of the drug was prophylactic in nature, killing the infective amœboid phase which is released from the spore into the ventricular lumen prior to its entry into the epithelial cells. This view was probably suggested by the results of McCowen *et al.*[3], which showed a depressant action of the drug upon the growth of bacteria-free cultures of *Endamœba hystolytica*.

I have fed measured numbers of spores of *Nosema apis* to individual bees and watched the progress of infection under various conditions of treatment by sampling bees daily and counting the ventricular content of spores by means of a hæmocytometer.



Group of individually infected bees (fed 1,000,000 spores each) divided four days after infection. One group (O—O—) fed freely on 6 mgm. fumagillin per 100 ml. of syrup; the other group (×—×—) continued on plain syrup.
6 mgm./100 ml. is a heavy dosage of drug. The effect becomes significantly less when about 1 mgm./100 ml. or less is fed

This technique has shown that the infection is most probably arrested or destroyed during its intracellular phase. If, for example, the infection was allowed to become well advanced and then the drug was fed in syrup, a practically instantaneous decline in infection took place (see graph). Also, bees fed with the drug during and after infection showed no greater decline in infection than those bees which were put on the drug two days after infection, by which time the intracellular phase of infection is well established and no amœboid forms remain within the ventricular lumen.

Sections of the ventriculus from recovering bees showed that spores became more restricted to those cells farthest away from the regenerative crypts or nidi. This suggests that the early vegetative forms of the parasite have been killed, or arrested in their development and re-infection of adjacent cells. The natural regeneration of cells from the crypts replaces those cells containing the later developed forms of the parasite.

Examination of sections and fresh material shows no histological difference between the renewed epithelium of the recovering bee and the epithelium of the healthy bee. The death-rate of treated bees was no different from that of healthy bees. Thus an intracellular protozoan parasite was destroyed in a striking fashion without any apparent damage to the structure and physiology of the host. However, relapses occurred even after the cessation of seventeen-day treatments; infection persists at the anterior end of the ventriculus, where the œsophageal invagination shields the epithelium.

Further experiments of this nature and with colonies of infected bees are in progress and the results will be published later. Thanks are due to the Upjohn Company of New York for supplies of fumagillin.

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July 27.

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## Heat Exchanges of a Muscle Model

TENDONS immersed in a solution of mercury – potassium iodide contract; if held at constant length they exert tension, there being a reversible relation between tension and concentration of the reagent[1]. This system has been proposed as a model of the molecular mechanism of muscular contraction[2], and may be taken as typical of such models[3]. The reagent appears to act as a 'plasticizer', weakening attractions between protein molecules, and leaving them free to curl up under the influence of thermal agitation.

To demonstrate the energy relations of the system, a continuously acting machine was constructed, based on one described by Wiegand[4]. This consisted of a wheel with a heavy brass rim and twenty-four spokes made from tendons. The wheel was suspended in a narrow trough which was filled to the level of the axle with a concentrated (2 *M*) solution of mercury – potassium iodide, and above that with a very dilute solution. The lower spokes, which are immersed in the concentrated solution, contract, stretching the upper spokes and bringing the wheel out of balance so that it rotates half a turn. This brings the contracted spokes up into the dilute layer, in which they give up reagent and are extended in their turn by the contraction of the lower spokes. A light ratchet ensures that rotation is always in the same sense. The time for a complete rotation was about twenty minutes.

Over a complete cycle, the condition of the working substance, the spokes, is unchanged, and energy can only be derived from mixing of the solution. The heat of dilution of the mercury – potassium iodide solution was found to be negative, the addition of 50 ml. of a 2 *M* solution to an equal volume of water absorbing about 117 calories. This comparatively large absorption of heat indicates that dilution is accompanied by a net increase in potential energy, so that the only possible source of energy for mechanical work is the increase in the entropy of the solution on mixing.

The energy exchanges were followed in more detail by using shredded collagen (standard hide powder) instead of whole tendons; this permitted the use of large quantities, so that changes in temperature could be followed with a Beckmann thermometer. The heat of reaction of a molar solution of mercury – potassium iodide with swollen hide powder was found to be 1 cal./gm. dry weight, a low value which agrees with the observation that the reaction can be reversed by tension. By comparing natural hide powder with gelatin and with hide powder 'melted' by previous heating, a figure of 4 cal./gm. was obtained for the 'latent heat of fusion'. Both these values are the means of six determinations and are probably reliable to within about 1·5 cal./gm. The value for the latent heat of fusion is a minimum, but is perhaps nearer the mark than the figure of 16·8 cal./gm. found for tendon by Wöhlisch and de Rochement[5], which is based on a false estimate of the water content. Energy available from changes in crystalline arrangement thus seems to be small. The quantity of reagent absorbed was estimated by measuring the density of an *M*/4 solution of mercury – potassium iodide before and after allowing it to react with natural hide powder. From these measurements it appeared that, under the conditions used, about 3 gm. of mercury – potassium iodide are absorbed by 1 gm. dry weight of hide powder. This corresponds to 1 molecule of mercury – potassium iodide to 170 units of protein, or about 1 mol. per amino-acid.

We may now compare the model with Nature. It has been suggested that muscle operates on a similar cycle, with actomyosin as working substance and adenosine triphosphate as plasticizer, removal of plasticizer during the extension phase being by chemical decomposition rather than by elution. The first objection to this simple view concerns concentrations of reagent and amounts adsorbed. Adenosine triphosphate will cause contraction of extruded actomyosin filaments at concentrations[6] of the order of $10^{-6}$ *M*, and the amount adsorbed during contraction is of the order of 1 mol. per 100,000 units[7]. The least concentration of mercury – potassium iodide required to bring tendons to their 'fibre melting point' is about 0·2 *M*, at which the uptake is about 1 mol. per 170 units. No simple plasticizer could function at such dilutions as adenosine triphosphate does, but the mechanism in muscle is presumably an indirect one, involving some critical change of shape in the myosin by which it is rendered incapable of fitting on to the actin. A second difficulty is that, according to Weber[6], adenosine triphosphate does not bring about contraction of actomyosin filaments unless it is broken down at the same time; a filament of which the enzymatic activity has been abolished merely becomes plastic. Weber contrasts the activity of adenosine triphosphate in causing contraction with its effect as a plasticizer, but it appears from the model that the two differ only in degree, as tendon can be brought to a plastic state by the action of a concentration of mercury – potassium iodide just too low to cause contraction. The effect of the small amount of adenosine triphosphate adsorbed at any one time may be intensified by repeating the cycle, successive segments of the same molecule extending one another in the same way that one spoke extends another in the model. The rate of production of energy would then depend on the frequency of repetition of the cycle and on the amount of adsorbed plasticizer, which is in turn a function of the load.

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## A Coagulase-destroying Factor produced by Variants of *Staphylococcus aureus*

It has recently been shown[1] that rough variants of *Staphylococcus aureus* give high, and smooth variants low, yields of coagulase. The present communication shows that certain smooth variants produce a factor capable of destroying coagulase.

It was noticed that some colonies of the smooth variants were surrounded, on 'chocolate' agar, by a zone of discoloration and transparency. Cultures made from such colonies were more proteolytic (speed of liquefaction of gelatin, peptonization of milk), and yielded less coagulase than smooth variants with no action on chocolate agar. Some, in fact, did not clot plasma in 24–48 hr.; it is important, however, to mention that these were unstable and sooner or later gave rise to coagulase-positive cultures. From both the weakly positive and the apparently coagulase-negative, proteolytic variants a coagulase-destroying factor was isolated.

Many colonies showing a maximum zone of discoloration on chocolate agar were selected; each colony was suspended in 2 ml. of saline and inoculated on to a large agar slope in an 8-oz. flat bottle. After 18 hr. incubation at 37° C. each slope was washed with 4 ml. of meat-extract broth (*p*H 7·2); the suspensions were spun, the sediments discarded and the supernatants tested for plasma-clotting power. Those failing to cause clot in 24 hr. or with long clotting times (more than 6 hr.) generally contained the coagulase-destroying factor.

The coagulase-destroying activity of the supernatants was estimated in the following manner: mixtures of cell-free, heated coagulase were made with: (*a*) the supernatant, (*b*) the autoclaved supernatant and (*c*) meat-extract broth of a *p*H identical with that of the supernatant. All reagents contained 0·1 per cent merthiolate. Destruction of coagulase was revealed by a progressive increase of clotting time and decrease of titre of the mixture of coagulase with non-autoclaved supernatant (*a*); no destruction of coagulase was observed in the controls (*b*) and (*c*).

Variants showing the presence of the coagulase-destroying factor were found in all of ten strains examined, five strains giving extremely active variants. Thus the clotting power of a coagulase of a titre of 1 : 8,000 and a clotting time of 2 min. was completely abolished by incubation for 24 hr. with an equal volume of a very active supernatant. With potent preparations of the coagulase-destroying factor the destruction of coagulase at 37° C. became apparent 15–30 min. after mixing and progressed for 24–40 hr. The activity of the coagulase-destroying factor was most marked at a *p*H of 6·8–7·2; the activity was not strain specific. Cell-free coagulase-destroying factor was obtained by filtration through sintered glass and could be concentrated by cold (4° C.) precipitation with ten volumes of ethanol. The activity of the crude preparation was partly lost on heating for 10 min. at 70° C. and abolished by boiling for 30 min.; the ethanol-precipitated preparation was more heat-sensitive. The coagulase-destroying factor was inhibited by whole serum (man and horse), by serum globulins and by egg white.

Purely as a working hypothesis, it is assumed that the coagulase-destroying factor is a proteolytic enzyme. It is thought that along with the rough ⟷ smooth variation in *Staphylococcus aureus* the occurrence of this factor may explain the irregularity of coagulase production *in vitro* observed by many workers. It seems also logical to believe that the coagulase-destroying factor is at least partly responsible for the low coagulase yields of smooth variants of this organism.

We are indebted to the Rankin Research Fund for a grant towards the expenses of this work.

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## Noise from Aircraft at Supersonic Speeds

T. GOLD, in *Nature* of November 8[1], has directed attention to the need for an explanation of the bangs that have been heard when aircraft in the vicinity have exceeded the speed of sound.

Gold develops his argument sufficiently far as to indicate when bangs may be expected. Briefly, an observer will experience a bang from every occasion on which the aircraft is travelling towards him at the speed of sound. This happens whenever $-\mathrm{d}r/\mathrm{d}t = c$, where $r$ is the scalar distance of the aircraft from the observer, and $c$ is the speed of sound. We see at once that triple and quadruple bangs will occur if there are three or four occasions respectively on which the aircraft is travelling towards the observer at sonic speed. Moreover, the aircraft itself does not have to pass through sonic speed more than twice to cause such multiple bangs: they can be caused by changes of course.

The occurrence of bangs having been explained, one must next consider their intensity. This will depend primarily upon $\mathrm{d}^2r/\mathrm{d}t^2$, varying inversely as the square root of this quantity if $\mathrm{d}^3r/\mathrm{d}t^3$ and higher derivatives can be neglected. It should be noted that $\mathrm{d}^2r/\mathrm{d}t^2$ is not the acceleration of the aircraft away from the observer, which is $\mathrm{d}^2r/\mathrm{d}t^2 - r(\mathrm{d}\theta/\mathrm{d}t)^2$. For $\mathrm{d}^2r/\mathrm{d}t^2$ small, the intensity will depend also upon $\mathrm{d}^3r/\mathrm{d}t^3$. A flight path such that $\mathrm{d}r/\mathrm{d}t$ is constant and equal to $-c$ is of interest, as $\mathrm{d}^2r/\mathrm{d}t^2$, $\mathrm{d}^3r/\mathrm{d}t^3$ and all higher derivatives are zero, and a bang of enhanced intensity would be expected. Such a flight path is the equiangular spiral of angle equal to the Mach angle, $r = r_0 \exp\{-\theta/\sqrt{(M^2 - 1)}\}$, where $M$ is the Mach number. It degenerates for a Mach number of unity into a straight line, and for a Mach number of infinity into a circle. The former is of interest in indicating that disturbances of enhanced intensity are to be expected from periods of steady flight at a Mach number of unity, although they will be localized, and will be experienced only by observers in the direct line of flight.

The final point that needs clarification is the cause of the bangs. Three possible sources of the disturbances can be put forward, the disturbances in all cases being propagated in the same manner, as outlined by Gold. First, there are the aerodynamic disturbances that would result from flight through an inviscid fluid: these will depend upon the size and shape of the aircraft. Secondly, there are the aerodynamic disturbances due to the turbulence created by the boundary layers, by regions of flow separation and by the wake. Finally, there are the acoustic disturbances which arise from the fact that the aircraft, through the medium of its engines, is a source of noise. Simple estimates show that the enhancement of the noise of the aircraft in a typical case falls very far short of the intensity of the pressure disturbance associated with the bang (about 1 lb./ft.$^2$). Equally, although it is more difficult to show, it is not expected that the enhancement of the disturbances due to turbulence could be sufficient to explain the intensity of the bangs. On the other hand, calculations have been made of the disturbances to be expected from flight through an inviscid fluid, and these yield pressure disturbances that are of the same order as those that have been experienced.

Thus far we have explained the occurrence of the bangs, and the intensity of the peak pressure disturbance to be expected. What still needs clarification is the acoustic 'character' of the bang. In particular, do the disturbances due to engine noise and due to turbulence make a significant contribution to what one actually hears ?

I am indebted to the Chief Scientist, Ministry of Supply, for permission to publish this communication, but the views expressed are my own.

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Nov. 19.

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[1] *Nature*, 170, 808 (1952).

THE impression exists that the double bang made by supersonic flight is mysterious. It would be well if those who support this view would bring forward the arguments that show that the exact and straightforward account of the bangs given by T. Gold[1] is wrong. The following circumstances have made the subject seem mysterious ; but, in fact, none of them is a real objection to the straightforward account.

(*a*) At the recent Farnborough display, the black *D.H.* 110 aircraft gave a triple bang on at least one occasion. But we should in general expect multiple bangs if an aircraft were to change course slightly in its supersonic flight, for then there would be two solutions of the equation $-dr/dt = c$, for each straight portion of the aircraft's path, where $r$ is the scalar distance between aircraft and observer. When three bangs are heard, it is likely that there are really four, of which two happen to coincide. It must be remembered that these bangs are so close as scarcely to be heard separately.

(*b*) The bangs are often said to be produced as the aircraft 'pierces the sound barrier' at either end of its supersonic flight. This is inconsistent with Gold's account, according to which at every given supersonic speed there is a direction making a definite angle with the direction of flight along which the bang will be propagated. Now the first account cannot be correct, because it means that the very loud bang heard at all points on the ground will have been produced at one point in the track of the aircraft. Such a dissipation of energy would be of an altogether greater order of magnitude than that at other points, and the aircraft could not accelerate to greater speeds.

(*c*) The objection that shock waves and sound waves are different in nature is not relevant to this discussion, because we need consider only regions outside a certain closed surface surrounding the aircraft, at all points of which the particle displacement due to sound or shock waves is small compared with their wave-length. Yet this closed surface can be effectively at a point as far as listeners on the ground are concerned.

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[1] *Nature*, 170, 808 (1952).

THE acoustic phenomena accompanying the dive of an aircraft to attain supersonic speed appear to be adequately explained by the Huyghens wavelet construction. The case of a body moving at a uniform supersonic speed $V$ in a straight path, in a uniform atmosphere, is well known. Circular wavelets, expanding with the velocity of sound $c$, are centred on successive positions of the body at chosen time intervals. The envelope of the wavelets representing a shock wave front is a cone with the line of flight as axis and half-angle $\alpha$ given by

$$\sin \alpha = c/V = 1/M,$$

where $M$ is the Mach number.

In the case of a body moving in a uniform atmosphere, in a straight path, at a speed which increases and then decreases through the speed of sound, the shock wave departs radically from the single conical surface and becomes a meniscus symmetrical about the line of flight, with two surfaces. In the example shown in Fig. 1, the duration of supersonic flight is 16 sec. and the Mach numbers are shown at the positions of the body at second intervals.

In the case of a body moving in a uniform atmosphere, at a uniform speed, in a curved path, the shock wave becomes a distorted meniscus. The section in the plane of the flight path is similar in general outline to that shown in Fig. 2.

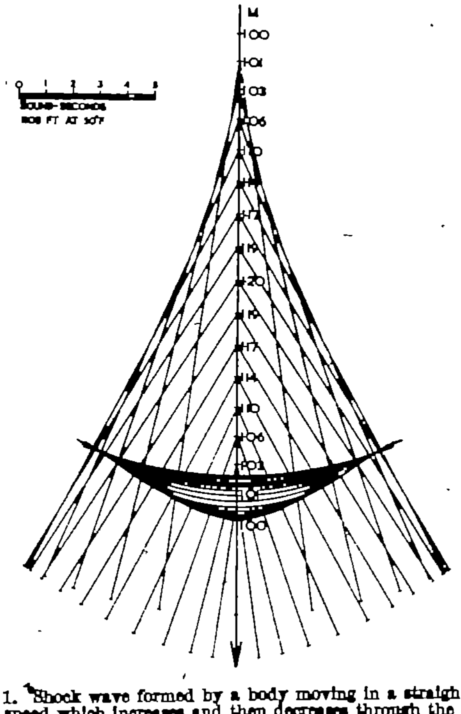

Fig. 1. Shock wave formed by a body moving in a straight line at a speed which increases and then decreases through the speed of sound

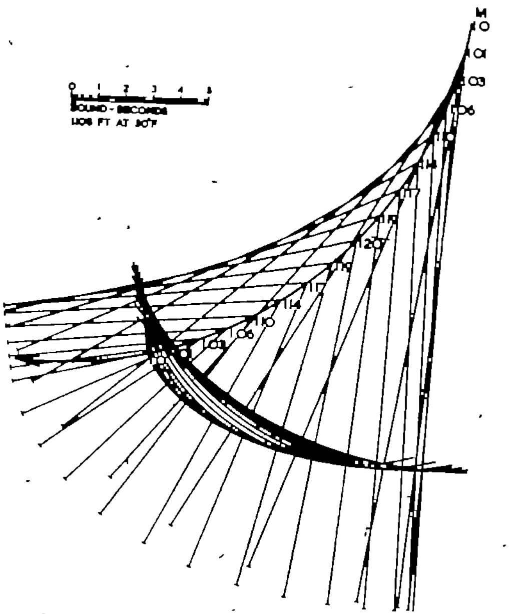

Fig. 2. Shock wave formed by a body moving in a circular path at a speed which increases and then decreases through the speed of sound

In the case of a body moving in a uniform atmosphere, in a curved path, at a speed which increases and then decreases through the speed of sound, the shock wave is again a distorted meniscus. The section in the plane of the flight path is represented in Fig. 2 for the particular case in which the flight path is the arc of a vertical circle with radius 15 sound-seconds and the duration of supersonic flight is 16 sec., the assumed Mach numbers at second intervals during this period being shown against the positions of the body. Sound rays are drawn from the point of origin of each wavelet perpendicular to the shock wave front. To do this the ray is drawn at an angle $\alpha$ given by $\sin \alpha = 1/M$, to the tangent to the circular flight path at the point of origin of the particular wavelet, $M$ being the Mach number at that point. The separation of the rays is a measure of the intensity of the shock wave; the closer the rays for a given length of flight path the greater the intensity.

The outstanding features of the shock wave are as follows. (1) The shock wave has two surfaces, the forward one being due to the lower part of the flight path and the rear one to the upper part of the path. The time interval between the two surfaces varies from zero at the outer edge of the shock wave to a maximum at or near the middle of it. The maximum interval and also the extent of the shock wave are greater the greater the maximum Mach number attained, the smaller the acceleration to that Mach number from $M = 1$, and the flatter the curve of the flight path. Uniform supersonic speed in a straight path is a particular case in which acceleration is zero and the interval is infinite. In the example of Fig. 2, for which the radius of curvature of the flight path is 15 sound-seconds, the duration of supersonic flight is 16 sec. and maximum Mach number is 1·2, the maximum interval is about 1·2 sec.

(2) The shock wave is most intense near its outer edge. The intensity on the inside of the curve of the dive, near the plane of the curve, is greater than on the outside of the curve and is maintained to greater distances after the Mach number has fallen below 1 because the divergence of the rays is comparatively small. Intensity is increased by increasing the acceleration to maximum Mach number from $M = 1$ and by diving in a path of smaller radius of curvature.

The assumptions of a uniform atmosphere and a dive in a vertical circular arc are simplifications of the actual case of an aircraft diving to attain supersonic speed, but the features listed above should be fairly representative of the acoustic effects to be expected.

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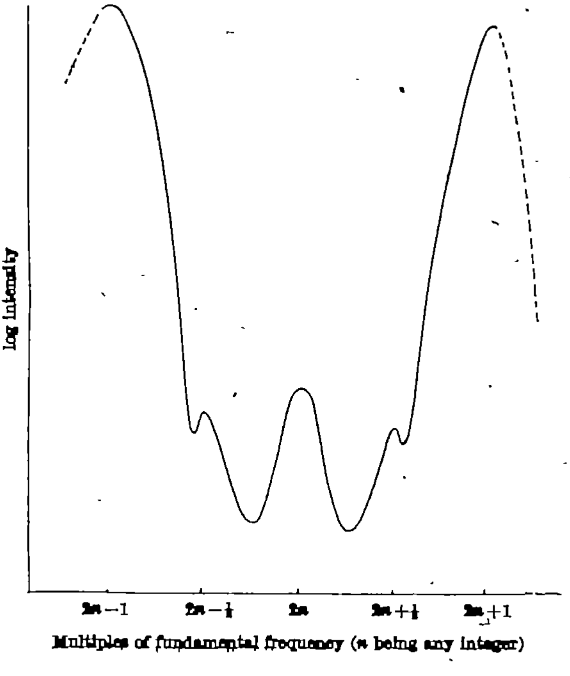
Dec. 19.

## Piezo-electric Oscillations of Quartz Plates at Even and Half-odd Harmonics

It is well known that a piezo-electric quartz plate can be excited into strong oscillations at its fundamental frequency, mainly determined by its thickness, or at any of its odd multiples, the even multiples being ruled out on theoretical considerations[1]. Parthasarathy[2] first observed that a quartz plate can vibrate at its 5/2 and 7/2 harmonics. Afterwards, Parthasarathy, Pande and Pancholy[3] showed that an X-cut quartz plate could also be made to oscillate, though with a lower intensity, at its even harmonics and such frequencies as ½, 3/2, 5/2, etc., of its fundamentals. This observation was later confirmed by Tsien and Chu[4] and Özdogan[5]. The former also reported that, besides the even and half of odd multiples of the fundamental frequency, the plate would oscillate continuously, though with less intensity, at any intermediate frequency.

It has been suggested[1,4] that this effect might be due to one or more of the following causes: (*a*) twinning or other defect in the quartz plate; (*b*) inhomogeneous electric field; (*c*) uneven plating; (*d*) feed-back to the oscillator. Experiments were



recently undertaken with the view of eliminating these possibilities. A number of quartz plates of different dimensions, obtained from well-known American manufacturers of frequency-control crystals, were plated fairly uniformly with silver, aluminium and copper by different methods such as electrochemical deposition, metal evaporation in vacuum, electroplating, etc. These plates were excited by the output of a master-oscillator power-amplifier with a buffer amplifier in between the oscillator and the crystal. The crystal was put in a liquid medium and the diffraction pattern obtained by the usual Debye–Sears method. It was noticed that the crystal could be made to oscillate at any frequency, though the intensities varied at different frequencies. The relative intensities of the diffraction lines revealed that, for the same radio-frequency feed, the crystals oscillated vigorously at their odd harmonics and less vigorously at the even and half of odd multiples. The intensities of the diffraction lines showed peaks in these regions. In going from one odd harmonic to another, the amplitude of oscillations as indicated by the diffraction lines undergoes variations as shown in the accompanying graph.

The results confirm the earlier observations that a piezo-electric quartz plate has preferred modes of oscillation at the even and half of odd multiples of its fundamental frequency in addition to the odd harmonics.

A detailed paper is being published elsewhere.

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## Damping of Turbulence by a Magnetic Field

IN experiments which I carried out in the summer of 1951, mercury flowing in a long narrow rectangular channel at a Reynolds number $R$ entered a region of constant transverse magnetic field $H$. The pressure gradient was measured downstream of any entrance effects.

For a given fluid, the pressure gradient can be shown to be a function of the dimensionless quantities $R$ and $M$, where $M = \mu Ha\sqrt{\sigma/\eta}$, and $\eta$ is the coefficient of viscosity. Hartmann[1] gives the theoretical form of this function for the case of laminar flow. Lundquist[2] gives theoretical reasons for expecting the critical value of $R$ to vary linearly with $M$.

My experiments covered the range $0 < M < 130$, $10^4 < R < 1{\cdot}2 \times 10^5$. With $M > 1{,}000\ R$, the pressure gradient agreed with Hartmann's laminar flow solution. With $M/R < 1{,}000$, the pressure gradient was larger than that predicted by the laminar flow solution. This suggests that turbulence is present, and confirms Lundquist's predictions.

The action of the magnetic field in damping turbulence has been studied. It appears that this damping is progressive with increasing field, as surmised by Lundquist. There was no evidence for the creation of turbulence near the walls due to the high rates of shear produced by the 'Hartmann effect', as suggested by Lehnert[3].

I wish to thank the Director of the Atomic Energy Research Establishment, Harwell, for permission to publish this letter.

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July 31.

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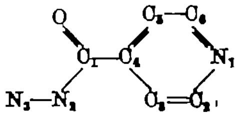
## Crystal Structure of *iso*Nicotinic Acid Hydrazide

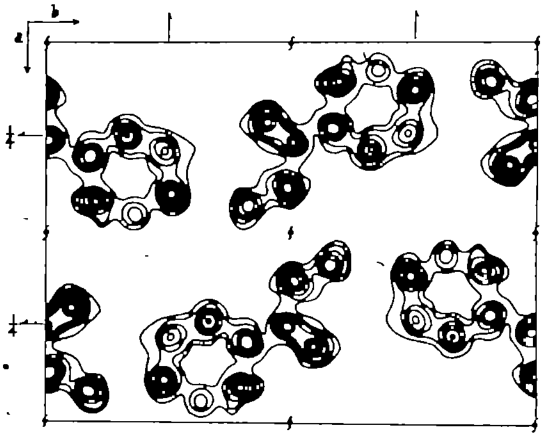
As part of a programme of X-ray diffraction studies of biologically important compounds, the crystal structure of *iso*nicotinic acid hydrazide ('Nydrazid') is being determined.

The lattice parameters and space group were determined from Weissenberg photographs about the $a$- and $c$-axes. The unit cell is orthorhombic, space group $P2_12_12_1$, with $a = 11{\cdot}33$ A.; $b = 14{\cdot}74$ A.; $c = 3{\cdot}84$ A. There are four molecules in the unit cell; calculated density $1{\cdot}42$ gm.cm.$^{-3}$; observed, $1{\cdot}41$ gm.cm.$^{-3}$.



Structural formula for *iso*nicotinic acid hydrazide

The intensities for $\{hk0\}$ were put on an 'absolute' basis[1], and an unsuccessful attempt was made to determine a set of signs for the larger $F$'s[2]. A Patterson projection on (001) showed the orientation of the ring, and the approximate position of the molecule was obvious from the magnitudes of $F_{110}$, $F_{120}$, $F_{200}$ and $F_{210}$. It was, however, immediately apparent from $F_{200}$ and $F_{210}$ that the 'absolute' intensities were high by a factor of $c.$ 3. Thus the expected root-mean-square unitary structure factor is 0·16; neglecting a relatively small temperature factor, observed value is 0·04. Furthermore, calculation of the ratio $(\overline{|F|})^2/\bar{I}$ for various intervals $0{\cdot}256 < \sin\theta < 0{\cdot}745$ showed a marked decrease in value for $0{\cdot}50 < \sin\theta$, the weighted average value being



Projection on (001) for *iso*nicotinic acid hydrazide. Contours are drawn at intervals of 1 $e$ A.$^{-2}$, contours below 2 $e$ A.$^{-2}$ omitted

0·50[3]. This is to be compared with a value of 0·637 to be expected for a projection which is centrosymmetrical[4].

Electron densities were calculated at units of $a/30$ and $b/60$, using Patterson–Tunell strips. Successive $F$ syntheses refined slowly. The seventh synthesis with seventy terms based on intensities estimated by eye is shown in the accompanying diagram.

The approximate $x$- and $y$-co-ordinates based on this synthesis are given in the table.

APPROXIMATE $x$- AND $y$-CO-ORDINATES

| | $x$ | $y$ |
|---|---|---|
| $C_1$ | 0·256 | 0·605 |
| $C_2$ | 0·224 | 0·742 |
| $C_3$ | 0·271 | 0·666 |
| $C_4$ | 0·212 | 0·583 |
| $C_5$ | 0·091 | 0·601 |
| $C_6$ | 0·045 | 0·680 |
| $N_1$ | 0·107 | 0·752 |
| $N_2$ | 0·377 | 0·490 |
| $N_3$ | 0·422 | 0·410 |
| O | 0·200 | 0·445 |

Integrated intensity data are being used in refinement of the (001) projection and the determination of the $z$-co-ordinates. A full account of this work will appear at a later date.

I wish to thank E. K. Squibb and Sons for the sample of crystalline 'Nydrazid' used in this study, and Dr. Wayne Chen, who performed most of the numerical work.

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## A Dislocation Model for the Study of Boundary Phenomena and Deformation in Metals

IN an earlier communication[1], an account was given of an experimental examination of the behaviour of the crystal boundaries in aluminium and its alloys at temperatures near the melting point. In an extension of this work, some consideration was given to the results obtained by Achter and Smoluchowski[2] in their studies of the structure and properties of grain boundaries, and it was thought desirable to construct a dislocation model for a study of grain-boundary phenomena. It was hoped that this model would also prove of use in a related investigation of the mode of deformation of the crystals of a polycrystalline mass under a rapidly applied force.

The bubble model devised by Bragg[3], in which the atoms in a metal are represented by bubbles, is somewhat fragile and unsuited to withstand the rapid application of a force of any magnitude. In a search for a more robust method of construction of an atomic model, it was found that, if several hundred steel rods of suitable diameter ($\frac{1}{16}$–$\frac{1}{8}$ in.) and length are piled together longitudinally in a container, with the cut ends of the rods at one end of the container in the same vertical plane, the resulting pattern of the cut ends of the rods is similar to that of the bubbles in the bubble model. Fig. 1 shows that the rod model provides a useful schematic illustration of the atomic arrangement in a polycrystalline metal. The regions of atomic disorder at a crystal boundary are well defined. Single dislocations and lines of dislocation within the crystals are also apparent, one such line being shown on a larger scale in Fig. 2.

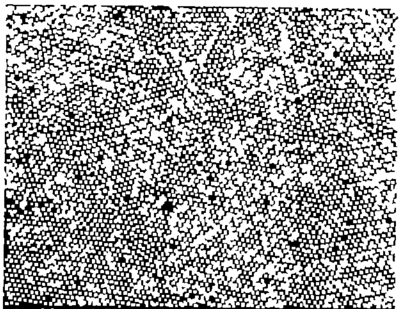
Fig. 1

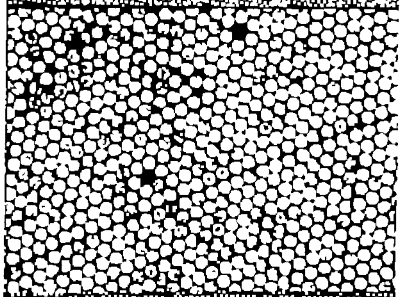
Fig. 2

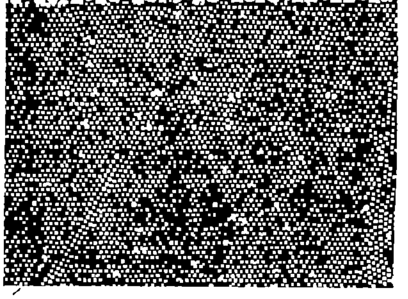
Fig. 3

Fig. 1. Atomic arrangement in a polycrystalline metal as represented by the rod model

Fig. 2. Single dislocations and line of dislocation in a crystal illustrated by the rod model (magnification greater than that of Fig. 1)

Fig. 3. Effect of introduction of atoms of larger size than average (white spots) into an atomic structure as represented by rod model

The rod model is robust and well suited for demonstration purposes. The effect of introducing atoms of large diameter into an atomic structure may be simulated by introducing rods of larger diameter than the average into the container (Fig. 3). If the container is made suitably flexible by hinging the sides or making them of more flexible material, the rod model may be used for observing the effect on a polycrystalline structure of the rapid application of loads of appreciable magnitude.

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## Height of the Potential Barrier in Barrier Layer Cells

Measurements of the zero resistance of a number of barrier-layer cells[1] over a wide range of temperatures have shown that the theoretical expression:

$$R_0 = AT \exp(\varphi/T), \tag{1}$$

where $A$ and $\varphi$ are regarded as constants, is not obeyed over the whole range of temperatures. The power of $T$ appearing outside the exponential in equation (1) depends on the assumptions made in the theoretical treatment; values ranging from $+ 3/2$ to $- 1/4$ [2-4] have been obtained, but these do not significantly alter the shape of the curve. Accordingly, the value of unity has been used in this work. It is the purpose of this communication to put forward a possible explanation of the observed departure from equation (1).

In the case of selenium rectifiers, the existence of weak spots has been postulated to explain breakdown phenomena[5], and in germanium the multicontact theory[4] has been proposed to explain the forward characteristics of point-contact diodes. By a simple mathematical analysis of these postulates, it is possible to account for the zero resistance measurements. The barrier layer is considered as being made up of a number of elements in parallel, to each of which equation (1) applies. The parameter $\varphi$ is assumed to have a normal distribution among the elements about a mean value $\bar{\varphi}$ with standard deviation $S$. Then it is easy to show that, for the whole cell,

$$\frac{R_0}{T} = \frac{2A}{N(1 + \operatorname{erf} x)} \exp\left[\frac{\bar{\varphi}}{T} - \frac{S^2}{2T^2}\right], \tag{2}$$

where $N$ is the number of elements, and

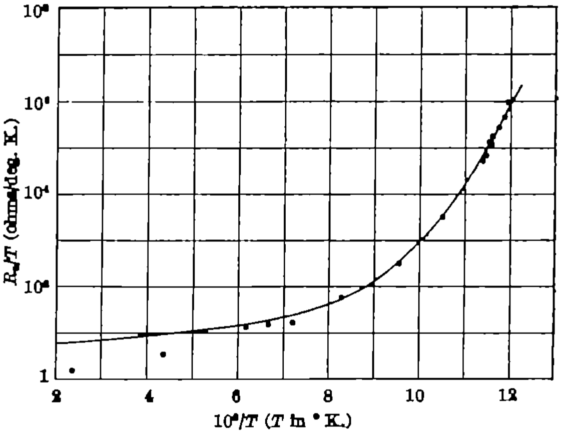
$$x = \frac{1}{S\sqrt{2}}\left(\bar{\varphi} - \frac{S^2}{T}\right).$$

Equation (2) has been fitted to the results for a selenium rectifier, and the theoretical curve and experimental points are shown in the accompanying graph. A similar fit has been obtained with a commercial selenium photocell and germanium and silicon point diodes. Values of $\bar{\varphi}$ and $S$ obtained by fitting equation (2) to the experimental results are shown in the table.

| | $\bar{\varphi}$ (eV.) | $S$ (eV.) |
|---|---|---|
| Selenium rectifier | 0·69 | 0·09 |
| Selenium photocell | 0·86 | 0·12 |
| Germanium rectifier | 1·18 | 0·13 |
| Silicon rectifier | 0·47 | 0·07 |

It is clear from the experimental results that equation (1) cannot be used as a reliable method for the determination of $\varphi$, but $\bar{\varphi}$ and $S$ obtained from equation (2) will give some indication of the uniformity of the barrier layer.

The above calculations can be modified by allowing for an upper and lower limit for the distribution of $\varphi$; the shape of the curve is found to be sensitive to the lower, but very insensitive to the upper, limit. This is in agreement with the multicontact theory, where it is shown that it is the low-value tail of the distribution which is of primary importance. The upper limit may be less than $\bar{\varphi}$, so that the occurrence of $\bar{\varphi}$ greater than the width of the energy gap in the semiconductor need not imply that the individual barrier heights exceed this value ($\bar{\varphi}$ for germanium, 1·13 eV.; width of energy gap, 0·72 eV.). Detailed calculations of this sort were not considered worth while, as the data so far available do not justify the inclusion of yet another parameter.



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## Molecular Weight Determination by Thermistors

A THERMISTOR is a resistance body which has a high negative temperature coefficient of resistance, and is a valuable circuit element with a large variety of applications. Thermistors can be used as sensitive thermometers in cryoscopic measurements[1] and also in place of thermocouples for measuring the lowering of vapour pressure of aqueous colloidal solutions[2]. At a condition of steady state, the droplets of solution and solvent deposited on the tips of the thermistors have a constant difference in temperature which can be measured as a difference of resistance in an A.C. bridge circuit. The construction and operation of a simple A.C. thermistor bridge, used for measuring the osmotic activities of aqueous solutions, has been described by McGee and Iyengar (submitted for publication elsewhere).

A pair of matched thermistors can also serve as a sensitive element for determination of molecular weights of compounds in organic solvents. The resistance differential $\Delta R$ set up per unit molal difference in concentration between the drops of solvent and solution ($k = \Delta R/m$) is generally much higher for organic solvents than for water; for example, $k = 12{\cdot}1$ ohms/mol. for water and $40{\cdot}1$ ohms/mol. for toluene in the case of a pair of Western Electric thermistors (Type 14$B$, resistance about 2,000 ohms at 25°). Thus, organic solvents increase the sensitivity of measuring the small difference of vapour pressure between the drops of solution and solvents.

Benzil was used as a standard substance for determining the calibration constant $k$ of the thermistors. The molecular weights of camphor, naphthalene, phenanthrene, and the two detergents 'BRIJ 30' and '35' were checked in two organic solvents, benzene and toluene, at 25° C. The results are summarized in the accompanying table.

| Substance | Molecular weight obs. | Molecular weight calc. | Substance | Molecular weight obs. | Molecular weight calc. |
|---|---|---|---|---|---|
| Naphthalene | 128·0 | 128·2 | | | |
| Camphor | 151·9 | 152·2 | 'BRIJ 30' | 435 | — |
| Phenanthrene | 177·6 | 178·2 | 'BRIJ 35' | 747 | — |

The range of concentration was 0·5–7 gm. of solute per 100 gm. of solvent. The mean average deviation of the readings is ± 0·25 per cent.

The results shown in the table were reproducible and independent of the concentrations and solvent used, within the limits of experimental error. The thermistor has been found to be extremely sensitive, and has the further advantages of being rapid in its operation and free from the spurious electrical effects that might be encountered within the D.C. thermocouple method of Hill-Baldes[3]. It is also seen to be far more accurate than the chemical boiling-point and vapour-pressure methods, thus permitting the study of very dilute solutions.

The Beckmann freezing-point method is limited to low temperatures, where the solubility of many substances is inadequate. However, the most important advantage of the thermistor technique over the usual Beckmann freezing-point method is the wide range of temperatures and solvents which can be employed in the measurements. Besides being far more accurate than the Beckmann methods, only a few drops of solution are required for the measurement.

With the present set of thermistors, the limit of molecular weight measurement is roughly 2,000 in water and 5,000 in benzene. As soon as more-sensitive thermistors become available, the method can be extended to compounds of higher molecular weight.

I wish to express my thanks to Prof. J. W. McBain, Dr. S. S. Marsden and Dr. B. R. Y. Iyengar for their suggestions and interest in the work.

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## The Laws of Friction

The laws of static friction are usually described as: (1) $F = \mu R$, which governs the relation between limiting frictional force $F$ and normal reaction $R$; and (2) the coefficient of friction $\mu$ is independent of the apparent area of contact.

Exceptions to law (1) are now well established, and in the field of fibre friction have been known for some time. In these cases the friction is governed by an expression of the form $F = aR^n$, where $n$ has values for different materials ranging from 0·67 to 1·0, the value for metals. Thus Bowden and Young[1] obtain $n = 0·8$ for diamond, Lincoln[2] 0·67 for nylon and Howell and Mazur[3] 0·96 for cellulose acetate, 0·91 for viscose rayon, 0·90 and 0·80 for undrawn and drawn nylon respectively. This form of the frictional relation is more general than law (1), and it is the purpose of this note to point out certain consequences which arise from it.

(1) Amontons's law $F = \mu R$ represents the special case of $n = 1$.

(2) The frictional force $F$ now depends upon the apparent area, and only in the particular case of $n = 1$ is it independent. Consequently, the two laws as such are not independent, but law (2) is a natural consequence of law (1).

(3) If the effect of roughening a surface is to produce valleys large compared with the distance between surface asperities, then the area available for real contact is reduced with a consequent reduction in the frictional force.

(4) In the important case of friction of a string around a pin or cylinder, the tension relation $T = T_0 \exp \mu\theta$ is derived on the assumption $F = \mu R$. If the general expression $F = aR^n$ is used in the analysis, the relation becomes

$$\left(\frac{T}{T_0}\right)^{(1-n)} = 1 + (1-n) \,.\, a \left(\frac{\rho}{T_0}\right)^{(1-n)} \theta \,;$$

or, in the limit as $n$ approaches unity,

$$T = T_0 \exp a \left(\frac{\rho}{T_0}\right)^{(1-n)} \theta,$$

where $\rho$ is the radius of the cylinder, which is not involved in the usual treatment. The data on the tensions of wool fibres given by Martin and Mittelman[4] have been examined and found to conform to this expression.

(5) The coefficient $a$ in $F = aR^n$ is not dimensionless except when $n = 1$, but normally has dimensions $[\text{force}]^{1-n}$.

Again, in the case of the cylinder, since $F$ and $R$ in the analysis refer to unit length, the dimensions are $[\text{force/length}]^{1-n}$.

A full account of this work, which forms part of a programme of fundamental research of the British Rayon Research Association, will be given elsewhere.

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## A Method of determining the Electrical Resistance of Fibre Bundles

Some years ago, one of us[1] showed that the quantity of static electricity developed on textiles during, for example, the carding operation, could be explained in terms of the electrical leak through the fibre; but the resistance measurements made at that time were limited to the order of $10^{11}$ ohms by the electric leak of the supporting frame.

We have recently devised a method which enables such resistance measurements to be made up to the order of $10^{17}$ ohms, and which avoids this leak by eliminating the supporting frame. In this method the bundle of fibres or sliver is hung vertically from a metal support to which is applied a voltage of the order of 5 kV., and the total charge resident on the fibre after a known period of application of voltage is measured by transferring the bundle to a Faraday cylinder.

SPECIMEN : COTTON

Applied voltage ($V$) = 5 kV. Final charge ($Q_\infty$) = 0·0285 μC.

| $t$ (hr.) | 0 | 0·4 | 0·6 | 0·75 | 0·9 | 1·0 | 1·2 | 1·5 | 1·8 | 2·85 | 3·1 | 3·5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $Q$ (μC.) | 0 | 0·014 | $0·016_5$ | 0·019 | 0·020 | 0·021 | 0·023 | $0·02_7$ | $0·025_5$ | $0·028_4$ | $0·028_5$ | $0·028_5$ |
| $Q/Q_\infty$ | 0 | 0·49 | 0·58 | $0·66_5$ | $0·70_5$ | $0·73_5$ | 0·81 | 0·88 | 0·89 | | | |
| $t/CRL^2$ | 0 | 0·19 | 0·27 | $0·36_5$ | 0·42 | 0·46 | 0·59 | $0·75_5$ | 0·82 | | | - |
| $CRL^2$(hr.) | | 2·1 | 2·2 | 2·1 | 2·1 | 2·2 | 2·2 | 2·0 | 2·2 | | | |

Average $CRL^2$(hr.) = 2·1 $CL = \frac{Q_\infty}{V} = 5·7$ μμF.

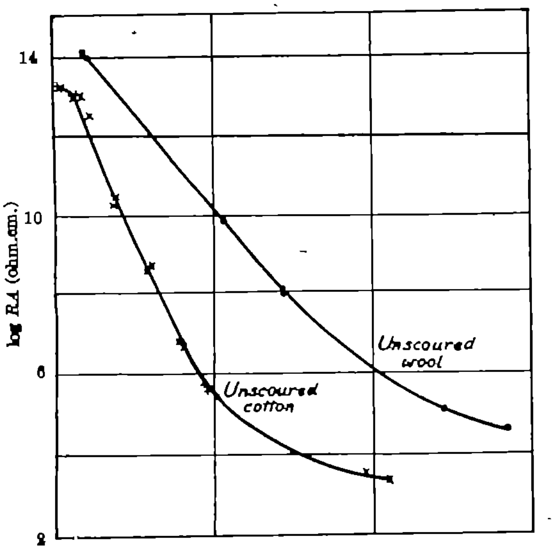
$$RL = \frac{2·1 \times 36 \times 10^{14}}{5·7} = 1·3 \times 10^{15} \text{ ohms.}$$

The equation for the voltage at any point in the bundle is identical with that describing the flow of heat in a conducting rod, and a convenient solution is given by Carslaw and Jaeger[2]. Integrating their expression, a graph is obtained between the ratio of total charge to the equilibrium charge and the product $t/CRL^2$ (where $t$ is time in sec., $R$ is resistance per unit length in ohms, $C$ is capacitance per unit length in farads and $L$ is length of the sample). $CL$ is, of course, equal to the final charge on the sample divided by the applied voltage. A set of experimental results using this method is shown in the table.

In our experiments the samples are suspended axially in a metal pot 45 cm. in diameter, and this vessel has passed through it a current of air at controlled relative humidity. Some typical curves connecting moisture regain and electrical resistance are shown in the accompanying graph.

At resistances of the order of $10^{12}$ ohms, the times involved become too small for convenient measurement; but at this level the normal condenser-discharge method, using a capacitance of the order of 200 pF., can be used if the lower end of the fibre bundle is also bound with a fine wire. The new method gives results consistent with those by the conventional condenser-discharge method at this level.

The rate of charge method can be applied to single textile fibres. The method we have found most convenient is to secure a $\frac{1}{16}$-in. bearing ball to the lower end of the fibre, which is then charged by applying voltage to the other end. The relevant mathematical formula is again provided by Carslaw and Jaeger[3].



Resistance regain for card slivers

Preliminary experiments show that the resistance of single fibres is of the same order as, but lower than, that calculated from the experiments made with fibre bundles or slivers. It is hoped that these differences will enable the effect of lateral contact resistance in a sliver of staple fibre to be evaluated.

It is hoped to publish a detailed account of these experiments in the near future.

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## Molecular Configuration of Dextrans in Aqueous Solution

Ingelman and Halling[1] have made measurements of sedimentation, diffusion and viscosity of fractions of dextran subjected to partial hydrolysis. On the basis of sedimentation and diffusion alone, and neglecting solvation, they concluded that the dextran particles are considerably elongated (length/thickness varying between 17 and 110).

Fessler and Ogston[2] and Ogston and Stanier[3] have shown that both the asymmetry and the solvation (effective volume) can be deduced from measurement of the sedimentation constant and any pair of: diffusion, intrinsic viscosity and the variation of sedimentation constant with concentration. It is of interest to examine Ingelman and Halling's data from this point of view.

The procedure chosen is as follows: from the sedimentation constant at zero concentration and the intrinsic viscosity (using Perrin's[4] and Mehl, Oncley and Simha's[5] relationships) sets of values of the axial ratio $p$, the effective volume $V'$ ml. per gm. of unsolvated solid, and the unsolvated molecular weight $M$ are obtained. From these quantities, values of $d(1/s)/dc$ are predicted. The values of $M$ obtained from $S_0$, $D_0$ and $\overline{V}$ (partial specific volume), and the observed values of $d(1/s)/dc$ are then compared with the predicted values.

The values of $M$ in every case are close to those predicted for an axial ratio of 1 and, where the data are sufficient to give reliable estimates of $d(1/s)/dc$, these indicate values of the axial ratio of less than 10.

The corresponding values of $V'$ vary between 3 ml./gm. for $M = 14{,}000$ and 30 for $M = 3 \cdot 3 \times 10^6$, indicating considerable degrees of solvation. Kuhn and Kuhn[6] have shown that the effect of branching of a flexible chain is to reduce the volume which it occupies in solution compared with that occupied by an unbranched chain of the same total length (that is, the same molecular weight). The volumes deduced above lie between 0·17 and 0·09 of the volumes predicted by the theory of Kuhn and Kuhn for unbranched flexible chains of glucose units, and this agrees with the chemical evidence[7] in suggesting a high degree of branching.

We conclude that the data available indicate that dextran particles in solution are highly solvated and not very asymmetric, and that this view is consistent with what is known of their chemical structure.

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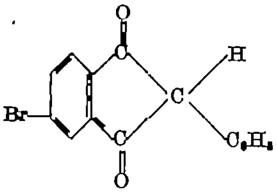
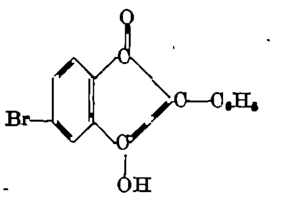
## Thermochromism and Keto-Enol Tautomerism of Solutions of 1 : 3-Diketo-2-phenyl-5-bromoindan

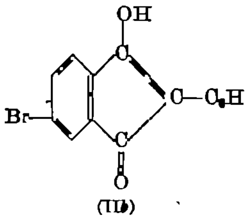
In connexion with the growing interest in the phenomenon of thermochromism[1], we should like to describe some experiments with 1 : 3-diketo-2-phenyl-5-bromoindan (I). In contrast to 1 : 3-diketo-2-phenylindan, which exists only in a colourless, solid form, (I) exists in a deep violet, solid form (IIa or IIb) and an almost colourless, solid, ketonic form (I). Koelsch[2], who discovered these forms, stated that by crystallization from non-polar solvents the white modification is obtained, and from polar solvents the violet-black modification is formed; he mentioned only acetic acid and benzene as solvents. According to our observations, dilute solutions of the violet-black form in ethyl benzoate are orange at − 10°, whereas at the boiling point of the solutions they are light-yellowish. The process is reversible and may be explained by assuming that, at high temperatures, the keto form is predominant, whereas in the cold the enol form (IIa or IIb) is present in greater concentration. This opens a route for the investigation of the position of the equilibrium between the keto and the enol forms in relation to temperature by the investigation of the visible spectrum.



(I)



(IIa)



(IIb)

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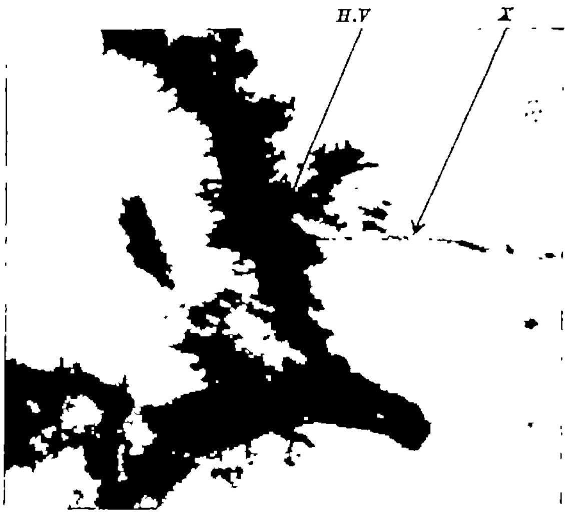
## Anatomical and Physiological Evidence of Anastomosis of the Hepatic Artery and Hepatic Vein within the Mammalian Liver

That the hepatic artery sends direct branches to the hepatic vein in the livers of Amphibia has been established[1]. Several workers have reported translobular branches in mammalian livers; but the evidence is frequently indirect. Chronszczewsky[2], Braus[3] and Loeffler claim to have seen such a vessel; Elias[4] is a protagonist of the view of Chronszczewsky, whose work he has repeated; he also reports that the arterial blood gains the centre of the lobule via thin-walled capillaries which run in close apposition to the parenchyma. Seneviratne[5], using a trans-illumination technique, also supports the existence of translobular arterial vessels. Owing to technical difficulties these arterial vessels have not been shown convincingly, and their presence is not yet generally accepted.

The vessels can, however, be demonstrated by the following technique. Immediately after death the liver is washed with a slightly alkaline solution[6]. When the organ is free from blood, the portal venous system is blocked by perfusion of the portal vein with a suspension of kieselguhr in saline. 'Hycar' latex is then put into the arterial system at a pressure of about 200 mm. mercury and, afterwards, coloured neoprene is run into the hepatic vein in a retrograde direction at a pressure of 30 mm. mercury. The organ is then fixed in acid formalin, and a cast of the vascular system obtained by digestion with commercial hydrochloric acid.

The completeness of the injection varies somewhat from liver to liver. In successful preparations the arterial and hepatic venous trees are well injected, and only isolated segments of the portal venous tree appear; the sinusoids are frequently not filled, except for localized areas. On occasion, the hepatic tree has been almost fully filled from the arterial side without injection of sinusoids. This filling is achieved by means of direct arterio-venous anastomoses, one of which is shown in the accompanying photograph.



Arterio-venous anastomosis *H.V.*, hepatic vein. *X*, anastomosing branch of the artery

In these specimens it is impossible to retain the normal relationships of the vessels, and one cannot determine the angle at which the vessels run before joining. There is no constant pattern, but the majority of the arterial vessels run into the base of small sublobular veins; they appear to be more frequent in the deeper parts of the parenchyma. Owing to distortion of the vessels by the injection technique, their size cannot be estimated with certainty, but they appear to be arterioles. Occasionally they split into a few short sinusoids before joining the hepatic venous tree. From the unbranching path taken by most of these vessels they appear to be shunts, and not concerned with the maintenance of parenchyma. They have so far been demonstrated in rats, rabbits and guinea pigs.

Supporting physiological evidence has been elicited from perfusion of isolated canine livers. Acetylcholine produces an increase in hepatic volume and a diminution of outflow when injected into the hepatic artery in amounts of 0·25–1·0 μgm.: ten to twenty times the amount is required to give a similar response if introduced into the portal vein[7]. Also, on occasion, adrenaline may give rise to swelling of the liver when put into the hepatic artery, and invariably produces a diminution of volume when put into the portal vein. The variation of the action of these drugs according to the vessel of administration is strong evidence in favour of different intrahepatic pathways of arterial and portal venous blood, especially as in each case increase of liver volume is due to reduction of outflow and not to increase of inflow, suggesting that the site of action is on the hepatic veins.

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[2] Chronszczewsky, N., *Virchows Arch.*, **35**, 153 (1866).

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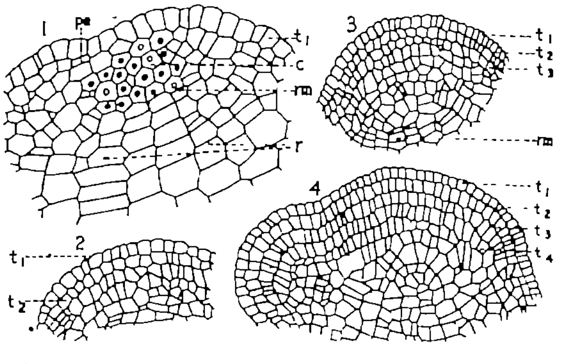
## Organization of Shoot Apex during the Ontogeny of *Brassica campestris* L.

OUR knowledge of the organization of shoot apices is confined mostly to mature plants, and there has been very little work on the ontogenetic changes occurring in them[1]. Certain interesting observations on the above topic came to light during a comparative anatomical study of vernalized and control plants[2] of mustard. Microtome sections of: (1) seeds soaked for six hours in water; (2) seedlings collected at intervals of twenty-four hours up to seven days and then on the ninth day; and (3) vegetative and reproductive apices formed fifteen and twenty-nine days after sowing were cut 13 μ thick and stained with hæmatoxylin and safranin.

The apical meristem of the resting embryo is a dome-shaped structure with a uniseriate tunica (Fig. 1) surmounting the corpus, the central cells (*c*) of which are polygonal, more or less isodiametric and deeper stained. The cells of the rib-meristem (*rm*) and the rib (*r*) converge above to this group of central cells and appear to be originating from them. These central cells could not be distinguished in seedlings more than twenty-four hours old. This type of zonation in the apical meristem is quite different from any so far observed[1,3-5]. The periclines (*pe*) present in the second layer of the apical meristem of the embryo become rarer with an advance in age, and in seedlings nine days old the tunica is biseriate (Fig. 2). The cells of the next layer now begin to show a stratified form. Occasional periclinal divisions, however, continue to occur here and shoot apices of fifteen-days-old plants show two or three layers of tunica (Fig. 3). In a reproductive shoot the tunica layers, composed of more-or-less columnar cells, increase further to three or four (Fig. 4) and the corpus appears to be replaced by vacuolating cells. One or more layers of cells below the central part of the tunica are also stratified.

There is scarcely any activity of the rib meristem for the first five days, and the growth of the epicotyl is due to a progressive elongation of rib cells. At an age of six days, however, the rib meristem becomes suddenly active and gives rise to several layers of transversely elongated cells. In seven- and nine-day-old seedlings no fresh similar cells are formed and the pre-existing ones enlarge longitudinally. Normally, it is expected that the rib meristem, once active after germination, would continue to be so, and thus its behaviour in the present case is rather interesting. In the shoot apices of fifteen-day-old plants, the



Figs. 1–4. Median longitudinal section through the shoot apices of mustard: *c*, central group of cells; *pe*, periclines; *r*, rib; *rm*, rib meristem; $t_1$–$t_4$, different layers of tunica. Fig. 1, from seeds soaked for 6 hr. Fig. 2, from seedlings 9 days old; Figs. 3 and 4, from plants 15 and 29 days old, respectively. All × 200

rib meristem assumes a semi-circular form extending from almost one flank of the apex to the other (Fig. 3, *rm*).

Procambial strands differentiate acropetally in the apex before the leaves, which they are going to supply, arise. Similar cases have been recorded by several workers[1,4,6,10].

Variation in the number of tunica layers within the same species has been accounted for in *Garrya* by the stages of development of leaf primordia by Reeve[8,9]. I, however, failed to observe this in my materials, and so did Millington and Gunckel[6]. In mustard, the variation in the number of tunica layers appears to be related to the growth conditions of the shoot. During the vegetative phase there is scarcely any appreciable elongation of it. At the onset of the reproductive phase, the main axis grows in length very rapidly and its apex shows the maximum number of stratified layers (5–6). Majumdar[5] observes that, in shoot apices of *Heracleum*, there are 5–6 stratified layers on the flanks in contrast to only three at the apex. Here, too, the increased number on the flanks is related to the growth conditions of the plant, which possesses a "rapidly widening axis just below the apical cone without any vertical expansion". Similar positive correlation is observed in (1) *Liriodendron*[6], where there are more tunica layers in the active stage, and (2) *Tropaeolum*[11], the young axillary shoot apices of which have only a uniseriate tunica in contrast to 2–3 in the main shoot.

I am grateful to Prof. B. Singh and Prof. G. P. Majumdar for their kind criticisms and suggestions.

S. C. CHAKRAVARTI

Department of Botany,
Balwant Rajput College,
Agra. Oct. 30.

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[1] Philipson, W. R., *Biol. Rev.*, 24, 21 (1949).
[2] Chakravarti, S. C., *Curr. Sci.*, 19, 319 (1950).
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[11] Ball, E., *Amer. J. Bot.*, 31, 316 (1944).

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## Regeneration of the Potato Shoot Apex

MR. I. M. SUSSEX[1] propounds a problem of great importance and interest, but the main conclusion which he draws from his skilful experiments appears open to question. He has found that in shoots of potato lateral portions of the apical meristem which are separated by longitudinal cuts from the main part are often prevented from regenerating by the growing-point of that meristem, or if they do regenerate are soon inhibited by it in their growth. He concludes that since the inhibiting influence has travelled down to a level below the cut and up again to the separated piece of meristem, it must be based not on a transport of hormones but on a competition for nutriment. He supports this conclusion by mentioning some unpublished experiments which, he states, have shown that there is in these apices a transmission of some other kind of hormone-like stimulus which, after travelling in the morphologically downward direction, cannot travel up again.

These other results will be awaited eagerly; but it remains quite possible that the transmission of inhibition from the growing-points of these apices is based on a transport of hormones, since one kind of stimulus or influence may follow different rules of transmission from another, even if both are based on hormones. Thus in shoot systems the stimulus for cambial growth, which comes from developing buds and leaves, travels strictly in the morphologically downward direction only[2]. But correlative inhibition, coming from the same source, can travel down one shoot and up another orthotropic shoot, even when the transpiration stream in the latter has been artificially reversed[3]. Also, in many plants an influence coming from the main apical bud keeps the branches plagiotropic, and this must travel down the main stem and out along the branches to their tips. Yet all these transmissions are based on transport of hormone; and, indeed, the first stage is the same in all of them, being the formation of auxin by developing leaves near the apex and its transport down the stem[4–8]. If an explanation of the difference in further transmission be sought, it may be suggested that the cambium is stimulated to grow by the descending auxin itself, whereas the other two effects depend on other substances which can be transported upwards as well as downwards and are formed either from the descending auxin, by modification of its molecule, or as a result of its action[9]. Similarly, there may be different transmissions within the apical bud also.

It may also be remarked that although Mr. Sussex emphasizes the fact that the lateral pieces of meristem which he isolated by vertical cuts were either prevented by the growing-point from regenerating at all, or else were afterwards inhibited by it, it seems of equal interest that some of them did regenerate to form buds with two or three leaves, so that these pieces must have been partially released from inhibition. In this respect his results are rather similar to those of experiments on *Lupinus albus* in which, for another purpose, we isolated the youngest leaf or the presumptive area of the next leaf due to arise, or of the next but one, by similar vertical cuts[10]. For in many of these experiments, in which enough apical tissue was left on the isolated piece axillary to the isolated leaf, a bud was formed from this tissue, although neighbouring leaves of the same seedlings had no axillary buds. These buds grew quite strongly, so that they must have been released from inhibition nearly completely.

R. SNOW

Magdalen College, Oxford.

MARY SNOW

Somerville College, Oxford.

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[1] Sussex, I. M., *Nature*, 170, 755 (1952).
[2] Jost, L., *Bot. Z.*, 49, 485 (1891); 51, 89 (1893).
[3] Snow, R., *New Phytol.*, 36, 283 (1937).
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WHILE I agree that there is much justice in the comments on my communication[1], the main fact which needs emphasis at this stage is that we are still very much in the dark concerning the roles of hormones and general nutrients in growth and morphogenesis at the shoot apex.

Fig. 1 of my communication showed in plan a potato shoot apex in which a small lateral panel *a* had been isolated from the remainder of the apical meristem *A* by a single vertical incision which penetrated all the meristematic cell layers and just into the differentiating sub-apical region. On further growth of such shoots the panel *a* usually failed to regenerate, remaining totally inhibited, although its cells retained their embryonic appearance. The incision was considered to prevent direct hormonal inhibition of the panel *a* by the larger part of the apical meristem; but the two separated parts of the apical meristem would still be able to compete with one another for a share of the available nutrients in the sub-apical region. The further growth of each would be a measure of its ability to grow under such conditions of competition. The results have been described (*loc. cit.*).

In support of this hypothesis, further experiments in which the incision was 4–5 mm. deep were carried out. Such incisions penetrated deeply into the maturing zone of the shoot, where nutrients may be expected to be localized in the vascular tissue. In such shoots the sub-apical nutritional competition between the separated parts of the apical meristem is eliminated, but it is still possible for substances to pass downwards in the stem from *A*, below the incision, and upwards into the panel *a*, that is, hormonal correlative inhibition of the panel *a* would still be possible.

Three types of deep incisions were made: (1) vertical, (2) undercutting the panel *a*, (3) undercutting the remainder of the apical meristem *A*. By such sloping incisions it was possible to provide either of the separated parts of the meristem with increased amounts of nutrients derived from a greater relative area of the mature shoot.

In each treatment eight shoots were used, and the cut surfaces were prevented from regrafting by placing a fragment of mica in each incision. The average number of leaves on the lateral panel *a* and the main apex *A* in each treatment after six days is presented in summary form in the accompanying table.

| (1) Incision vertical | | (2) Incision undercutting *a* | | (3) Incision undercutting *A* | |
|---|---|---|---|---|---|
| *a* | *A* | *a* | *A* | *a* | *A* |
| 2·9 | 4·3 | 0·4 | 3·9 | 2·9 | 1·5 |

In treatment 1, all eight of the lateral panels *a* regenerated completely, and the results obtained with a deep incision thus differ sharply from those following a shallow incision when regeneration is infrequent. In treatment 2, the strongly growing main apex *A* of several shoots was excised after six days, leaving only the inhibited panel *a*, which then usually began to grow and formed two to three leaves in the following six days. In treatment 3 it is noteworthy that the growth of the larger meristematic region *A* has been 'inhibited' by the smaller panel *a*.

In these treatments the more rapidly growing meristem became considerably enlarged, even if it was initially very small, and gave rise to leaves which were much larger than those on the slow-growing shoot. As a result of these experiments it is felt that the inhibition of growth in lateral parts of the apical meristem is achieved in large part by a depletion of nutrients in the immediate vicinity of the inhibited meristems. Growth hormones may well be of importance in such inhibition but would appear to have an indirect effect, perhaps acting in the mobilization of nutrients towards the more actively growing regions of the meristem.

I. M. Sussex

Department of Cryptogamic Botany,
University, Manchester 13.

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[1] Sussex, I. M., *Nature*, 170, 755 (1952).

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## *Amœba discoides* recorded for Milngavie, Dunbartonshire

The inoculation material for our stock cultures of *Amœba* at Notre Dame was procured either from Killarney or Milngavie. From the outset each culture was numbered and its subsequent history entered in a field-book, so that we know the origin and history of any material given to the various universities and schools which have asked for it during the past thirty years. Early on, it was suspected that culture 14 was different from the other cultures, but many researches were pressing, and I had not time to look into the matter. The culture accumulated and sub-cultures were made. In 1949 and 1950 I devoted time to the examination of the cytoplasmic movements of the individual amœbæ and concluded that they were not those characteristic of *A. proteus*. In 1952 I completed the investigation. The creatures in culture 14 are *Amœba discoides*, the life-history of which has been worked out by Sister Carmela Hayes[1]. Up to date, the species has been recorded from the neighbourhood of Oxford and Grimsby.

Monica Taylor

Notre Dame,
Dowanhill,
Glasgow.
July 12.

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[1] *Quart. J. Micr. Sci.*, 80, 459 (1946).

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## Flight-tone and Wing-stroke Frequency of Insects

In his interesting article, Dr. O. Sotavalta[1] discusses the estimation of the wing-stroke frequency of insects by their audible note. This method is older than he suggests. ". . . and I took coach, having first discoursed with Mr. Hooke a little, whom we met in the streete, about the nature of sounds, and he did make me understand the nature of musicall sounds made by strings, mighty prettily; and told me that having come to a certain number of vibrations proper to make any tone, he is able to tell how many strokes a fly makes with her wings (those flies that hum in their flying) by the note that it answers to in musique during their flying. That, I suppose, is a little too refined; but his discourse in general of sound was mighty fine." (Samuel Pepys, August 8, 1666.)

Doubtless Pepys would have been pleased to know that his criticism had been met.

C. F. A. Pantin

Trinity College,
Cambridge.
Dec. 22.

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[1] Sotavalta, O., *Nature*, 170, 1057 (1952).

# FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

## Saturday, January 31

Nutrition Society, Scottish Group (in the Anatomy Lecture Theatre, Marischal College, Aberdeen), at 1.20 p.m.—Conference on "The Psychology of Eating".

## Monday, February 2

University of London (at the London School of Economics and Political Science, Houghton Street, Aldwych, London, W.C.2), at 5 p.m.—Prof. H. Lauterpacht: "The Revision of the Laws of War".*

Society of Engineers (at the Geological Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Mr. G. N. Swayne Presidential Address.

Society of Chemical Industry, London Section (joint meeting with the Plastics and Polymer Group, at the Chemical Society, Burlington House, Piccadilly, London, W.1), at 6.30 p.m.—Dr. D. Traill: "The New Wool-like Fibres".

Royal Institute of Chemistry, London Section (joint meeting with the Alembic Club, in the Physical Chemical Laboratory, The University, Oxford), at 8 p.m.—Symposium on "Research in Industry compared with Research in Universities".

## Tuesday, February 3

University of London (in the Anatomy Theatre, University College, Gower Street, London, W.C.1), at 1.15 p.m.—Dr. H. Wiesenberg: "The Dead Sea Scrolls".*

## Wednesday, February 4

British Psychological Society, Industrial Section (in Room 105, London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 1 p.m.—Mr. R. Marriott: "Some Problems in Attitude Survey Methods".

Royal Society of Arts (at John Adam Street, Adelphi, London, W.C.2), at 2.30 p.m.—Mr. I. D. Wratten: "A Century of Photography" (Peter Le Neve Foster Lecture).

Geological Society of London (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Scientific Papers.

University of London (at Bedford College, Regent's Park, London, N.W.1), at 5.15 p.m.—Mr. G. de Q. Robin: "The Recent Antarctic Expedition" ("Recent Exploration and Discovery", 1).* (Further Lectures on February 11 and 17.)

University of London (at King's College, Strand, London, W.C.2), at 5.30 p.m.—Dr. W. J. Gibbs: "High Frequency Machines—Inductor Generators and Couplings".* (Further Lectures on February 18 and March 4.)

## Thursday, February 5

University of London (in the Anatomy Theatre, University College, Gower Street, London, W.C.1), at 1.15 p.m.—Dr. K. A Kermack: "The Origin of Mammals".*

Chemical Society (at Burlington House, Piccadilly, London, W.1), at 2.30 p.m. and 7.30 p.m.—Symposium on "Acetylene Chemistry".

Society of Chemical Industry, Corrosion Group (joint meeting with the Nottingham Section of the S.C.I., at the Gas Showrooms, Parliament Street, Nottingham), at 7.15 p.m.—Dr. J. C. Hudson and Mr. J. F. Stanners. "Atmospheric Corrosion and Atmospheric Pollution".

## Friday, February 6

Physical Society (in the Department of Meteorology, Imperial College of Science and Technology, Exhibition Road, London, S.W.7), at 2.15 p.m.—Discussion on "Physics of the Upper Atmosphere".*

Royal Institute of Philosophy (at University Hall, 14 Gordon Square, London, W.C.1), at 5.30 p.m.—Prof. J. N. Findlay: "Wittgenstein's Philosophical Studies". (Further Lecture on February 12.)

Society of Dyers and Colourists, London Section (at the Royal Society, Burlington House, Piccadilly, London, W.1), at 6 p.m.—Mr. F Ward: "Methods and Principles of Textile Fireproofing".

Society of Chemical Industry, Plastics and Polymer Group (joint meeting with the Manchester Section, in the Chemistry Lecture Theatre, The University, Manchester), at 6.30 p.m.—Mr. J. R. Whinfield: "Textile Fibres—Variations on some Familiar Themes" (Jubilee Memorial Lecture).

Society of Cosmetic Chemists of Great Britain (in the Conference Room, British Colour Council, 13 Portman Square, London, W.1), at 7 p.m.—Dr. J. G. Fife: "Patents".*

Royal Institution (at 21 Albemarle Street, London, W.1), at 9 p.m.—Dr. Henry Seligman. "Production and Uses of Radio-isotopes".

## Saturday, February 7

London County Council (at the Horniman Museum, London Road, Forest Hill, London, S.E.23), at 3.30 p.m.—Dr. Hurustiati Subandrio: "The Toradja—Peoples of Central Celebes".*

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# APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Assistant Director (with a good degree, preferably with first-class honours, in natural science, including chemistry or physics) of Examinations in Science—The Secretary, Civil Service Commission, 6 Burlington Gardens, London, W.1, quoting No. 4183/53 (February 7).

Physicist or Electronic Engineer to assist in research and clinical work on the applications of physics to diagnostic radiology, and a Physicist to assist in work on the medical applications of radioactive isotopes—The Secretary, Institute of Cancer Research, Royal Cancer Hospital, Fulham Road, London, S.W.3 (February 7).

Physiologist (with a good honours degree in physiology, or equivalent qualification, and research experience preferably involving the perfusion of isolated organs) for research on the bovine udder—The Secretary, National Institute for Research in Dairying, Shinfield, Reading, quoting Ref. 53/8 (February 7).

Biochemist (principal or senior grade)—The Secretary, South Worcestershire Hospital Management Committee, Royal Infirmary, Worcester (February 9).

Lecturer in Physiology—The Registrar, King's College, Strand, London, W.C.2 (February 14).

Principal of the East Riding Institute of Agriculture, Bishop Burton—The Chief Education Officer, County Hall, Beverley, Yorks (February 14).

Superintending Scientist at the Long Range Weapons Establishment, Salisbury, Australia, for the direction of research and development work concerned mainly with methods of investigating the behaviour and performance of guided missiles and with flight research on guided missiles—The Senior Representative, Department of Supply, Canberra House, 87 Jermyn Street, London, S.W.1 (February 14).

Senior Research Fellow in the Departments of Economics and Pacific History, Australian National University, Canberra—The Secretary, London Office of the Australian National University, 27 Russell Square, London, W.C.1 (February 15).

Assistant Instructor in Physics and Applied Mathematics at the Ethiopian Air Force Training School—The Educational Adviser, Imperial Ethiopian Embassy, 17 Princes Gate, London, S.W.7 (February 16).

Assistant Lecturer or Lecturer in the Department of Civil Engineering—The Registrar, The University, Liverpool (February 23).

Senior Lecturer or Lecturer in Mathematical Statistics, and Lecturers in Psychology, Veterinary Anatomy, Veterinary Physiology and Veterinary Farm Clinic, at the University of Sydney—The Secretary, Association of Universities of the Commonwealth, 5 Gordon Square, London, W.C.1 (March 7).

Educational Psychologist for Child Guidance Department—The Medical Officer of Health, Civic Centre, Southampton.

Engineers and Physicists (particularly with electronics) in (a) Senior Scientific Officer and Scientific Officer grades (Ref. A.246/52A) and (b) Senior Experimental Officer, Experimental Officer and Assistant Experimental Officer grades (Ref. A.247/52A) in Admiralty Experimental Establishments in London, Portsmouth, Weymouth areas, and Scotland—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting the appropriate Ref. No.

Experimental Officers in the Guided Weapons Department, Royal Aircraft Establishment, Farnborough, for work on design, development and performance of new weapons and associated guidance and control systems; instrumentation of flight trials and investigations of trials results—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting D.508/52A.

Graduate (with honours degree in chemistry or metallurgy) to undertake research in the methods of preventing corrosion of iron and steel—The Personnel Officer, British Iron and Steel Research Association, 11 Park Lane, London, W.1, endorsed 'Corrosion'.

Graduate (with good honours degree in chemistry or metallurgy) to carry out research into chemical reactions of interest in iron and steel making—The Personnel Officer, British Iron and Steel Research Association, 11 Park Lane, London, W.1, endorsed 'Slags'.

Head Statistician—The Director, British Boot, Shoe and Allied Trades Research Association, Satra House, Kettering.

Lecturer or Assistant Lecturer in Inorganic Chemistry—The Registrar, The University, Nottingham.

Mining Geologist (with a first- or second-class honours degree in geology, or higher qualification) in the Local Civil Service of the Gold Coast, to undertake geological mapping in the field and underground—The Director of Recruitment (Colonial Service), Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting CDE 105/13/53.

Physical Metallurgist (university degree or equivalent essential) to carry out research on the ageing of mild steel (location: Sheffield)—The Personnel Officer, British Iron and Steel Research Association, 11 Park Lane, London, W.1, endorsed 'Ageing of Steel'.

Physicist interested in mechanics (with an honours degree or equivalent) for study and instrumentation of felting machines—The Director, British Hat and Allied Feltmakers Research Association, Stanley House, Manchester Road, Fairfield, Droylsden, Manchester.

Scientific Officer (Grade II) in the Operational Research Division at Euston Square, to undertake research on a wide variety of railway subjects—The Director of Research, Railway Executive, 222 Marylebone Road, London, N.W.1.

Scientific Officer or Senior Scientific Officer (with an honours degree or its equivalent) for the determination of solidification sequences in cast iron by temperature gradient measurements, as part of an investigation on the soundness of iron castings—The British Cast Iron Research Association, Alvechurch, Birmingham.

Senior Scientific Officers (with at least a second-class honours degree in chemistry or metallurgy, or equivalent, and three years postgraduate research experience) at Sellafield: (Ref. 404) for research in physical and inorganic chemistry (experience in fluorine chemistry, ion exchange, and radiochemical techniques desirable), and (Ref. 405) for research in metallurgy of radioactive materials—The Ministry of Supply, Division of Atomic Energy (Production), Risley, Warrington, Lancs, quoting the appropriate Ref. No.

Tutorial Assistant (with a good honours degree in mathematics, including statistics) in the Department of Economics, to assist in the first year in statistical research, with a view to appointment as Assistant Lecturer in the field of Statistics and Mathematical Economics—The Registrar, The University, Nottingham.

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# THE PROPOSED SCIENCE CENTRE FOR LONDON

IT is now approaching ten years since Sir Henry Dale in his presidential address to the Royal Society raised the question of the need for a national centre of science capable of progressive adjustment to changing needs. Referring to the missed opportunities of the past, largely through Government procrastination, and the congested and unsuitable conditions in which not only the Royal Society but also the Chemical Society and other scientific societies were then housed, Sir Henry claimed that the progressive needs of our scientific societies should be given early consideration in any new allotment which plans for reconstruction might allow. He thus recognized that expansion would of necessity be linked with the reconstruction which the destruction and changes due to the War had necessitated in London as a whole; but he also added that we ought nevertheless to have a scientific centre permitting scientific societies in Britain to co-ordinate their activities with economy and giving room for change, expansion and organic growth. "We have the further right," he concluded, "to expect that the home of science, in this capital city, will have a dignity symbolizing its value to the nation and the empire, and enabling us to hold up our heads in the company of other countries, whose scientific academies, not more famous than ours, have so long been housed more worthily, and with a more generous recognition of their due place in an enlightened people's scale of cultural values."

That claim for adequate and dignified accommodation for science in the Metropolis has been frankly acknowledged, but it is clear that the nature of the claim is still but imperfectly appreciated, not only by the Government but also by the ordinary citizen. Somewhat more tangible support has indeed been accorded than was received by the earlier schemes which were put forward in 1930 by the late Sir Arnold Wilson, and by Prof. J. F. Thorpe in his presidential address to the Chemical Society. The scheme then proposed contemplated what was described at the time as a certain amount of rationalization of the scientific societies concerned. These included, besides the Chemical Society, the Institution of Mining and Metallurgy, the Institution of Mining Engineers, the Society of Chemical Industry, the Institution of Chemical Engineers, the Institution of the Rubber Industry, the Institution of Petroleum Technologists, the Institute of Fuel, the Institute of Metals, the Iron and Steel Institute, the Faraday Society and the Physical Society. All these societies were to be housed under one roof, and their libraries were to be pooled for the common use of their members.

The need for such a scheme had been even then realized, so far as chemistry was concerned, for at least ten if not twenty years, and the central library was one of the chief features of the scheme for the chemical societies, which would have shared two-fifths of the space. Nevertheless, an approach to the

Treasury at the time resulted in a refusal of financial assistance, although the Government expressed sympathy with the scheme. An Association was formed to collect funds and erect and administer a building; but the raising of the necessary £140,000 proved too much for the chemical societies concerned, in the difficult circumstances of the financial depression then prevailing, and the only tangible result has been a larger measure of co-operation between some of the chemical societies themselves.

As a result of Sir Henry Dale's address, however, on October 13, 1944, Mr. C. R. Attlee (Lord President of the Council), Sir John Anderson (Chancellor of the Exchequer) and Lord Portal (Minister of Works) received a very representative deputation from learned societies regarding the needs and claims for accommodation of the societies which aim at promoting the independent advance of the fundamental sciences. The deputation was assured of the interest of the Government, and Sir Henry Dale was asked to submit a quantitative statement of needs. In 1947 the Scientific Societies Accommodation Committee was set up to review the alternative schemes and facilitate a close estimate of the needs of the societies. The idea of extending facilities in Burlington House or its vicinity was abandoned in favour of the conception of a Science Centre; and when on July 7, 1948, a second deputation was received by the Lord President of the Council, the Chancellor of the Exchequer and the Minister of Works, the agreed list of participants included the Biochemical Society, the British Association, the Chemical Society, the Faraday Society, the Geological Society, the Linnean Society, the London Mathematical Society, the Physical Society, the Physiological Society, the Royal Anthropological Institute, the Royal Astronomical Society, the Royal Meteorological Society, the Royal Society, the Royal Statistical Society and the Society of Chemical Industry. It was also understood that many of the smaller scientific clubs and societies would receive hospitality under the new arrangements.

The deputation was much encouraged by its sympathetic reception and was given to understand that the Government was prepared to acquire a site and contribute to the cost of building, but that the building must be the societies' own responsibility. The deputation pointed out that this would involve indefinite postponement, except perhaps for societies having close association with industry, and expressed the hope that the Government would reconsider this attitude and provide the site, the buildings and rent-free accommodation in them. Nevertheless, detailed arrangements were made to carry the project to a further stage, although a particular scheme discussed in negotiations with the Ministry of Works in April 1949 was eventually abandoned.

In the early autumn of 1950 the Royal Society was informed that the scheme for a Science Centre had made great progress. An adequate, central site had been selected and the Treasury had offered to provide the cost of building. On November 21, 1950, Mr. Herbert Morrison, then Lord President of the Council, in reply to questions in the House of Commons by Mr. M. Phillips Price and Sir Wavell Wakefield, stated that since the matter had last been raised on May 5, 1950, the remaining obstacles to the adoption of the Royal Society's long-term proposals had been overcome. Mr. Morrison emphasized that it would be some years before such a centre could be built, but that a start would be made on it as soon as resources could be found, having regard to other urgent claims. Provision would be made for accommodating also within the area the Patent Office and its Library, which would be modernized and extended as a first-rate central reference library on science and technology.

The Lord President added that suitable new quarters would be built for the Royal Society and for other leading scientific societies with their important special libraries, and new offices for the Department of Scientific and Industrial Research and for other Government scientific organizations would also be provided, thus releasing buildings elsewhere and achieving some economies in building requirements. The Centre would be designed to improve facilities and contacts between scientists and users of science, both nationally and internationally. Much detailed planning was still required, but Mr. Morrison said that he hoped to announce the selection of a site early in 1951, although it would be some time before a final scheme could be developed.

The decision that the proposed Science Centre should include provision for a first-class central reference library on science and technology was obviously prompted by the specific recommendation of the Royal Society Scientific Information Conference of June–July 1948, which urged increased support by the United Kingdom Government of central scientific libraries and information services, particularly of the Science Museum Library and the Patent Office Library. In spite of the association of these Government libraries and of the Department of Scientific and Industrial Research with the proposed centre, Sir Robert Robinson, in commending the scheme to the Royal Society in his presidential address on November 30, 1950, was emphatic that there was no evidence of any attempt or desire to undermine the independence of the Royal Society or to make it subservient to any material or political interest. The Lord President of the Council had indicated his full concurrence in the importance of maintaining the prestige and independence of the Royal Society, and in certain conditions for securing this in a Science Centre which had been put before him. The great national value of the Society as a focus of the scientific activity of the Commonwealth was recognized.

No further statement was made by the Government until, in response to a motion by Lord Samuel in the House of Lords on June 11, 1952, asking how the matter stood, the Lord President of the Council, Lord Woolton, gave the assurance that the present Government was in agreement with the statement made by its predecessor on November 21, 1950. No final decision had been made; but Lord Woolton confirmed that a site on the South Bank immediately below Waterloo Bridge and facing Somerset House had been reserved for a Science Centre by the London County Council, which is the planning authority, and was so reserved in the County of London Plan. Lord Woolton could give no assurance as to when the Science Centre would come into existence; but he pledged himself to use his own influence to ensure that it would eventually be constructed on that site.

Strong support for these proposals has been forthcoming from the Advisory Council on Scientific Policy. In its third report, in July 1950, the Advisory Council noted the finding of the Panel on Technical Information Services of the Committee on Industrial Productivity that the development of technical library facilities in Britain had failed to keep pace with the growth of scientific research, and that in consequence scientific and technical libraries were no longer capable of maintaining full collections of technical literature, and of providing reasonable facilities for readers. The Panel, in its report on Technical Information Services, urged the development of a central reference library in London, if possible in close association with specialized libraries of the learned societies, as well as of a national lending library of science and technology, not necessarily in London.

The Panel itself suggested that the Patent Office Library might form the basis of the proposed central reference library; and, agreeing with the broad objectives stated by the Panel, the Advisory Council constituted a Standing Scientific Library and Technical Information Committee charged, *inter alia*, with co-ordinating the development of scientific libraries as a whole, and considering in greater detail the parts to be played by individual libraries. This Committee eventually reported on the needs of the national library of science and invention which is to form part of the new Science Centre, and in its fourth report, in July 1951, the Advisory Council referred to the action which had been taken in consequence of the Government's announcement of November 21, 1950. It was indicated that the President of the Board of Trade had agreed that the Patent Office Library should be expanded to form the national reference library of science and invention, and that it would continue to serve the needs of the Patent Office. It would cover the whole field of science and would be supported by the specialized libraries of the learned societies. The areas of its responsibility had been agreed with the Research Councils and with the Government Departments principally concerned. Moreover, in conformity with the proposal that the Library should not contain any scientific literature more than about fifty years old, material no longer of value for current work was to be pruned in consultation with the British Museum.

The advisory Council further emphasized that the Library would serve industrial scientists and all those concerned with research and technical development, and would be adjacent to the Department of Scientific and Industrial Research, so that more detailed information services would be available for users. The Advisory Council stated that the Lord President of the Council, Viscount Addison, had approved the report, which had been forwarded to the Ministry of Works for preliminary planning in connexion with the Science Centre.

It is therefore clear that the planning and discussion of the proposed Science Centre had made considerable progress. Yet on December 17 last in the House of Commons, the Minister of Works stated that the scheme has been postponed. Sir Wavell Wakefield had inquired as to the present position with regard to the Science Centre, and whether it was intended that the necessary buildings should be erected on the South Bank site. Mr. Eccles replied that the planning of the Science Centre had had to be deferred in view of the need for economies, and that when the economic situation improved it was hoped to lease a site on the South Bank immediately below Waterloo Bridge.

That this bland reply was received in the House of Commons apparently without protest demonstrates how far not merely the Government but also the House of Commons is from any real appreciation of the importance of science and technology in the national economy, or of the conditions in which both science and technology are nurtured. It is disheartening enough that once again the plans and hopes of a decade should be jettisoned without result; nor can that jettisoning be regarded as other than waste and false economy. For it must be noted that Mr. Eccles stated expressly that the planning itself—not the actual construction—had been deferred.

That in itself is discouraging enough, for no one who has been associated with what has been done, ever since the Royal Society Scientific Information Conference in 1948, can fail to realize the far-reaching repercussions of such a decision and the frustration which must result in many different fields. The record of disappointments which have attended the efforts of the Royal Society over the past century to obtain a worthy home and adequate accommodation, and which Sir Henry Dale recapitulated more than ten years ago, is well calculated to prejudice any fresh effort. It makes it hard to believe in the sincerity of any fresh government approach "when the economic situation improves".

That, however, is not all. The project for a Science Centre was intended not merely to provide a dignified home for the Royal Society and other scientific societies: it was also intended to further their more efficient and economic functioning. Thus the financial difficulties which threaten the continuation of the Bureau of Chemical Abstracts might have been considerably less acute, and the call for Government assistance much slighter, if indeed made at all. Furthermore, even so far as already elaborated under the Advisory Council for Scientific Policy, the project appears to offer some advantages and savings in the operation of the Department of Scientific and Industrial Research without detriment to its efficiency.

The real objection to the postponement of the scheme is its adverse effect on the advance of science and technology upon which the economic recovery and survival of Great Britain so largely depend. That dependence has been admitted by Government spokesmen and others, who have insisted that the first need is to secure the effective utilization of existing knowledge, and have recognized, too, the dependence of such utilization upon the effective dissemination of scientific and technical information. The proposal for a national reference library of science and technology, which forms an essential part of the scheme, and which was intended to relieve the congested conditions which at present hinder the efficient use of the library of the Chemical Society and others, was a step to that end long overdue.

The Department of Scientific and Industrial Research has already re-orientated its policy so as to encourage the more effective dissemination of both scientific and technical information, and thus made the need for such a central library more urgent. Moreover, while Governments have procrastinated, the outflow of scientific and technical literature throughout the world does not stop but rather increases. Libraries which were overtaxed ten years ago are still more overstrained to-day: conditions and expedients, which could be accepted for a short period while plans for adequate accommodation were being formulated, become intolerable when delay is indefinite.

Now the whole scheme is in abeyance. It may be that economic conditions, on a short-term view, are so serious that immediate action on the scheme is impossible, in spite of its importance for the future of science and technology in Britain. Having proceeded thus far, however, every opportunity must be taken to remind the government of the day of its existence—and of its vital importance.

# A BOTANIST'S QUO VADIS: INTEGRATION OR SPECIALIZATION

## Phylogeny and Morphogenesis

Contemporary Aspects of Botanical Science. By Prof. C. W. Wardlaw. Pp. viii + 536. (London: Macmillan and Co., Ltd., 1952.) 42s. net.

Many of those who belong to the older generation of biologists may recognize in biology at the present time something of the welter of confusion in aims and ideas that marked the similar period after the First World War. It is therefore an appropriate moment to ask whether we are going to witness another transformation in the climate of biological thought similar to that which overtook the biological subjects after 1920. Revolution in techniques is obviously taking place. Will this produce a generation of botanical specialists, or is it possible to offer an idea which will serve to integrate further advances? At such a time it is stimulating to receive a book by an eminent botanist which looks at the present position and attempts to resolve it.

Prof. Wardlaw's central position is that of a morphologist and, as his title indicates, he sees in phylogeny and morphogenesis twin aspects of a unified treatment of plant form which may serve as a focal point for further botanical developments. His detailed consideration of these matters, ranging over a wide field, starts with the comparative study of the phylogeny of ferns and other pteridophytes (as suggestive examples). This leads to a consideration of the morphology and origin of leafy shoots and the questions associated with the origin of a land flora. The antithesis of this comparative treatment is next developed—the idea of causal morphology leading to the developmental study of morphogenesis. Three chapters deal with the influence of genes on the development of form; then come three more chapters devoted to biochemical aspects of this problem. There follows an inquiry into the physical and mathematical considerations involved, and this leads to a survey of experimental studies on morphogenesis in which the author's own work on ferns figures prominently.

The point of view adopted is thus that morphogenetic processes have necessarily a genetical basis. The primary action of genetical factors upon growing cells is held to be biochemical in nature; but simultaneously, and often as a direct consequence, physical factors become operative and are largely involved in the detailed determination of form and structure in the tissues. But because form is regarded as a product of evolution, it follows that the findings of phylogeny and of the comparative method will be of advantage to the morphogenetist, just as enhanced knowledge of morphogenesis must lead to a better understanding of phylogeny.

Prof. Wardlaw thus suggests that, while contemporary botanical science is feeling boldly in a number of directions, this does not mean that its students must necessarily become more specialized and its study more dispersed. He clearly sees the possibility of integrating these diverse lines of advance around the twin subjects of phylogeny and morphogenesis. This is not very far away from the late-Victorian doctrine that the study of evolution should be the main motive underlying biological research, although no doubt the emphasis is now placed differently. In particular, the morphological consequences of this doctrine are restated in modern terminology and in the light of modern work. It is clearly impossible to say how this point of view may represent the future of botany. A majority of present-day students of this subject appear to have a greater interest in the *processes* by which the living organism functions than in its form. For this reason the dynamic aspects of morphogenesis are likely to prove more popular than the comparative. Thus growth and organization, which are essentially dynamic and which we can study as existing processes, are beginning to attract more attention than evolution as the fundamental properties of living organisms. If so, it is around these that it may prove possible to integrate the future of botany, whatever an individual's special field of interest may be. This, at least, might well be an alternative statement of the note on which this book ends.

It would be unusual in a work of this type if the specialist in any section of the vast and diversified field surveyed could not find some point of criticism. It would be unjust to direct attention to these in a short review without being able to survey in much greater detail the wealth of information the book contains. It must suffice to say that such a book has been greatly needed. Its publication will stimulate thought and inquiry in a fundamental field.

W. H. Pearsall

# PREHISTORY IN AFRICA

**Proceedings of the Pan-African Congress on Prehistory, 1947**

Edited by L. S. B. Leakey, assisted by Sonia Cole. Pp. viii+239. (Oxford: Basil Blackwell, 1952.) 35*s*. net.

UNTIL about the second decade of the present century the study of early prehistory was mainly confined to Europe, more particularly to the western regions. Later, as a result of the brilliant researches of a number of prehistorians, the importance of Africa to the subject has been more and more realized. Investigators in all parts of the continent have made discoveries of great interest, and these cannot always be fitted into the narrow framework of the scheme of development created by the prehistorians in western Europe.

Dr. L. S. B. Leakey, a former pupil of the Cambridge school of archæology, fully realized this situation; but the outbreak of the Second World War delayed any action, and it was not until its conclusion that he determined to call a Congress, held in Nairobi in 1947, to discuss the various early archæological problems in the African continent. Maybe it was a pity the Congress was called so soon after the War; if it had been summoned a year, or even two years, later many more prehistorians from many more countries would have been able to attend. When important decisions are to be taken, it is well to have more delegates present than were able to be at Nairobi so soon after the close of hostilities; only now has it been possible to produce the proceedings, and most of the papers appear in a very attenuated form. Shortage of paper and expense were, of course, the reasons.

Roughly speaking, the work of the Congress came under three headings: papers dealing with aspects of geology, general palæontology and climatology; papers on human palæontology; and papers on prehistoric archæology. Obviously, before a stone-age culture can be properly understood, the conditions under which it flourished must be known, and this involves questions of Quaternary geology and palæontology. Prof. C. Arambourg contributes two papers on "African Pleistocene Mammals" and "The Red Beds of the Mediterranean"; and there is a paper, with many diagrams, on "Pleistocene Climate Changes in East Africa" by Dr. E. Nilsson. There are also papers by Abbé H. Breuil, Prof. F. Zeuner and Dr. A. Ruhlmann. The section of the Congress on human palæontology is nowadays perhaps a little out of date, as the study of early man himself and his precursors in Africa has been going ahead by leaps and bounds. But the facts as known at the time are duly set out in a number of papers by the late Dr. R. Broom, Prof. W. E. le Gros Clark, Prof. R. Dart and others. The final section contains papers on various industries and cultures. Dr. Desmond Clark writes on Somaliland; but shortly his book on this interesting region will be published, and we shall have his work there set before us in detail. The problem of the so-called Tumbian culture in the Congo is discussed by Dr. F. Cabu and Dr. Leakey, and there are also, among many other contributions, papers from Dr. B. D. Malan on "The Final Stages of the Middle Stone Age in South Africa" and by Dr. S. A. Huzayyin on the "Upper Palæolithic of Egypt".

The volume is, of course, of first-class importance to any prehistorian interested in Africa. It is only such a pity that factors outside the control of the editors have so delayed its publication. It is to be hoped that the proceedings of the Second Congress, held recently in Algiers, will see the light of day rather more speedily.

MILES BURKITT

# PSYCHOSURGICAL STUDIES AT THE GREYSTONE HOSPITAL

**Psychosurgical Problems**

By the Columbia Greystone Associates, Second Group. Dr. Fred A. Mettler, Editor. Pp. xii+357. (London: Routledge and Kegan Paul, Ltd., 1952.) 42*s*. net.

THIS book is a second report of the work carried out by a research team known as the Columbia Greystone Associates. The first report by this group, called "Selective Partial Ablation of the Frontal Lobes", dealt with various biological, psychiatric and psychological effects of psychosurgery (particularly topectomy) as applied to psychiatric subjects. The present volume reports a similar study into the after-effects of various less commonly employed psychosurgical procedures (notably cortical, venous, ligation and thermocoagulation).

The seventeen chapters of "Psychosurgical Problems" are written by psychiatrists, psychologists, neurologists, physiologists and other experts in various medical fields, whose names are well known within their specialties. Starting with a general survey of the project and a consideration of the special setting within the Greystone Hospital, the writers take up in turn the surgical procedures employed, general medical findings, neurological findings, vestibular functions and, for the remaining two-thirds of the book, psychological studies. All these contributions are clearly written, scholarly and well presented. Nevertheless, the reader is likely to lay down the book with a feeling of disappointment. In the first place, the number of cases included is rather small; including control subjects, we are dealing only with about thirty patients in all. It may be doubted whether such a small number which, it should be remembered, has to be sub-divided again because of the different operations carried out, really justifies such detailed reporting. In the nature of the case, only very gross changes could be expected to exceed reasonable criteria of statistical significance, and such gross changes would scarcely have required the setting-up of such tremendous experimental apparatus.

In the second place, the reader will find that in this study, as in the one preceding it, conclusions are mainly negative; that is to say, the research workers failed to find changes after the operation in the various areas investigated. It is, of course, possible that surgical interference with the frontal lobes has only very slight and negligible effects on personality, but it is doubtful if such a hypothesis would seriously be entertained by most workers familiar with the field.

The dearth of positive findings is much more likely to be due to a fundamental weakness of this whole endeavour. There is no underlying theory according to which investigations were carried out and procedures selected; there does not even seem to have been a set of guiding hypotheses, the disproval of which might have advanced the study of the field.

The Columbia Greystone Associates seem to have proceeded throughout in a spirit of empiricism which selects tests and procedures without the benefit of theory. This must be held responsible for the failure of the whole experiment to give positive results; as A. Petrie has shown in Great Britain, suitable choice of theoretical concepts and the selection of experimental techniques based on such theory can uncover strongly marked changes after psychosurgery.

On the whole, then, we may conclude that while this book is of undoubted interest to the specialist and will be read widely by those professionally interested in psychosurgery, the contribution it makes to scientific knowledge is relatively small.

H. J. Eysenck

## SAND- AND WATER-CULTURE OF PLANTS

### Sand and Water Culture Methods used in the Study of Plant Nutrition

By Dr. E. J. Hewitt. (Commonwealth Bureau of Horticulture and Plantation Crops: Technical Communication No. 22.) Pp. x+241+9 plates. (Farnham Royal: Commonwealth Agricultural Bureaux, 1952.) **42s.**

THE first recorded use of the water-culture method for the growing of plants was that of Woodward, who in 1699 grew potatoes, vetches and mint in water from springs, wells, rain and distillation. Sixty years later Duhamel du Monceau grew tree seedlings in filtered water from the Seine; but it was not until 1804 that the first controlled water-culture experiments were attempted, by De Saussure in France. He was the first to show that nitrates were necessary for growth and that differential absorption of solutes was usual. The method of sand culture was introduced by Boussingault in 1851 and greatly extended by Salm-Horstmar, who, even at that early date, used a technique sufficiently refined to show the essential nature of manganese and iron as well as the 'macronutrients' for plant growth.

Since the time of these early workers, more and more elaborate and precise techniques have been evolved by hundreds of workers in the field of plant nutrition. In the investigation of the roles of the 'micronutrients' or 'trace elements' in plant physiology, and even more in the study of the interrelations of nutrients, small details in the purification of growing-media or nutrient solution, in the preparation of containers, or in the protection of the cultures from chance contamination, may be of vital importance. Any new worker in the field must therefore make himself familiar with the experience of many hundreds before him to be sure that he has missed no point essential to his proposed technique.

In this task Dr. E. J. Hewitt's book will be of quite inestimable value. He has brought together in one volume a prodigious amount of detailed information, critically reviewed, from a literature of some eleven hundred titles. No aspect of the subject escapes minute attention, and the author throws his net wide enough to include even methods for the control of the environment in plant chambers and the design and interpretation of experiments. In the second part of the book, Dr. Hewitt gives a detailed account of the special technique developed at the Long Ashton Research Station, mainly by himself, for large-scale sand culture in pots, an illustration of the perfection achieved by learning from the experience of others.

Few reviews of literature have been so exhaustive, informative and valuable as this, and the author and the Commonwealth Bureau are to be congratulated on the production of a book which will save research workers many weary hours of searching through original papers.

R. H. Stoughton

## A PSYCHIATRIST'S CREDO

### Speaking of Man

By Dr. Abraham Myerson. Pp. 255. (London: Martin Secker and Warburg, Ltd., 1952.) 15s. net.

THIS is not a serious scientific contribution but a collection of essays loosely linked together, describing the author's views on life and mankind. The style varies and is sometimes grave and erudite, and at others slangy and cynical. Yet invariably the personality of the author permeates the whole and shows him as a witty cynic.

Abraham Myerson was a New England neuropsychiatrist who was a student of Morton Prince and became his life-long friend. He was later elected assistant professor of neurology at Tufts Medical School, and after three years was made professor. Warren Stearns, a former dean of the School, said that the large number of students who specialized in neurology did so because of the popularity of Myerson's teaching.

The most important work which he performed was his investigation into the inheritance of mental diseases and upon which he published one of his numerous books. He did not limit himself to one section of psychiatry, however; but his endless curiosity compelled him to study everything from the neuroses of the nervous housewife to sleeping and waking mechanisms.

It is surprising that Myerson should have written so vigorously in this book when one considers that a great deal of it was produced when he was very near death from heart-block. The chapter headings show the type of material upon which he writes: on the worth of living; my father and I discuss matters; my prejudices and prepossessions; woman, the authorities' scapegoat; the liabilities of language; heredity and environment; the great unlearning; the low-down on authorities, including psychiatrists; genius; sterilization; desire and mental health; body and mind; concerning intelligence; etc.

As these essays show, Myerson was essentially broad-minded. It is said that, although he did not believe in psychoanalysis, he made no objection when his son wished to study it. This appears in his attitude to psychiatry, demonstrated by two of his aphorisms: "The physiological approach to the neuroses does not exclude nor minimise the importance of a complete understanding of the psychological life of the individual"; and "Scientific psychiatry should be sceptical, humble, and experimental".

Those who read this book will enjoy the distilled wisdom and wit of one who regarded everything with scepticism, yet who was strongly on the side of truth and who hated pompous inaccuracies.

Clifford Allen

### The Terpenes

By Sir John Simonsen and Dr. D. H. R. Barton. Second edition. Vol. 3: The Sesquiterpenes, Diterpenes and their Derivatives. With addenda to Vols. 1 and 2, by Sir John Simonsen and Dr. L. N. Owen. Pp. xi+579. (Cambridge: At the University Press, 1952.) 50*s.* net.

THE publication of this volume brings to a successful conclusion the arduous task of issuing a second edition of a work that has become a classic in terpene chemistry (see *Nature*, 160, 384; 1947). The vigorous growth of this field of organic chemistry since 1931–32, the date of the original edition, is reflected in the expansion of the second edition from two to three volumes, totalling some seventeen hundred pages. The subject-matter of the original second volume has now been conveniently sub-divided into "Dicyclic Terpenes" (Vol. 2) and "Sesquiterpenes and Diterpenes" (Vol. 3). In the preparation of the new edition Sir John Simonsen has been fortunate in enlisting the general help of Dr. L. N. Owen and Dr. D. H. R. Barton, together with special aid from Prof. W. Cocker in preparing an account of santonin.

The third volume incorporates a review of the important literature up to 1949, and contains some references to 1950; moreover, it includes addenda bringing the matter of the first two volumes up to date. Among the interesting subjects dealt with in this supplement are recent studies on the *iso*propenyl–*iso*propylidene controversy, and a review of the evidence which shows that irone must now be recognized as 6-methyl-ionone, capable of existing in α-, β- and γ-forms, each corresponding to several stereoisomeric modifications. That terpene chemistry still has much to offer to the investigator is shown *inter alia* by the current researches of Ruzicka and his collaborators at Zurich and also by the interesting lists given in the work here under review of compounds of various types, the constitutions of which still await elucidation.

The attractive format and the remarkably clear type and formulæ of the first edition have been reproduced in the new publication. From every point of view this is a major work of the first class, which is certain to receive the warm welcome it deserves.

John Read

### Linear Transformations in *n*-Dimensional Vector Space

An Introduction to the Theory of Hilbert Space. By Prof. H. L. Hamburger and M. E. Grimshaw. Pp. x+195. (Cambridge: At the University Press, 1951.) 25*s.* net.

THE concept of space of infinitely many dimensions, effectively introduced about fifty years ago by Hilbert in connexion with integral equations, co-ordinates and elucidates many of the problems in mathematics and mathematical physics in which linear operators are involved. Prof. H. L. Hamburger and Miss M. E. Grimshaw have provided a useful prolegomenon to this doctrine; they deal with analogous problems in *n*-dimensional linear space, particularly the study of canonical forms of transformations, but they choose, wherever possible, methods which will also serve for Hilbert space. The arguments are crisp but austere, even in this simpler field, and they are mainly algebraic, although Hilbert's variational method for the eigen-values of a Hermitian form is included. Recently obtained inequalities due to Aronszajn indicate an application to the numerical calculation of eigen-values; and the reduction to canonical form of a pencil of operators is illustrated by a detailed study of the familiar dynamical problem of small oscillations.

The topic is abstract, and the arguments, even when geometrical language is used, demand close attention; but the precision with which these powerful methods operate is worth an effort to acquire. It is to be hoped that the authors will produce a sequel in which the methods are shown at work in Hilbert space.

### The Higher Arithmetic

An Introduction to the Theory of Numbers. By Prof. H. Davenport. Pp. 172. (London: Hutchinson's Scientific Library, 1952.) 8*s.* 6*d.* net.

MOST mathematicians, amateur and professional, find the theory of numbers fascinating. Prof. H. Davenport, in his concise, self-contained account, deals with factorization and the primes, congruences, quadratic residues, continued fractions, sums of squares, quadratic forms, and some Diophantine equations. His complete mastery of the field has helped him to give a clear, forward-looking and thoroughly up-to-date exposition. In number theory, results may often be easy to guess but difficult to prove, yet guess-work without proof is almost worthless. Davenport's rigour of demonstration, demanded by the nature of the subject, is always lucid, but it requires the reader's close co-operation, often with pencil and paper; the well-chosen numerical examples, with which the author illuminates practically every step, help to concentrate attention. Little previous knowledge is assumed, but by sticking fairly closely to main themes, the author brings his reader near to the present bounds of knowledge and indicates some of the likely lines for further progress. The novice who wishes to pay his respects to the 'Queen of Mathematics' will be wise to choose Prof. Davenport's presentation.

### Botany

By Prof. Carl L. Wilson. Pp. xi+483. (New York: The Dryden Press, 1952.) 6.10 dollars.

THIS attractive book, intended primarily as an introduction to botany for students in American colleges, succeeds admirably in presenting the elements of the subject in a most agreeable and refreshing manner. The first half of the book follows the normal pattern of botanical text-books by dealing with the structure and physiology of the higher plants. It is noteworthy to find such topics as vegetative reproduction, erosion, food poisoning, hay fever plants, growth substances, viruses and antibiotics introduced in this elementary treatment. The later chapters cover a wide survey of the whole plant kingdom with outline classifications of the various groups and details of significant life-histories. The account of early land plants and their evolution is particularly well written and illustrated.

Each chapter is prefaced with a brief and sometimes historical introduction to the contents and concludes with a useful summary. As may be expected, the examples selected for study are those readily available to American students, and the predominant emphasis is on the vegetation of North America. In spite of this, Prof. Wilson has produced a most stimulating text-book which should be read and enjoyed by students and laymen alike.

There are many photographic illustrations, and special praise must be given to Dr. Hannah Croasdale for the clear and convincing diagrams and figures.

# DISLOCATIONS AND THE THEORY OF SOLIDS*

By Prof. N. F. MOTT, F.R.S.
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A DISLOCATION is the name given to a particular type of defect in a crystalline solid. The concept was introduced into physics by Taylor[1] and others[2,3] in 1934 in a first attempt to devise a mechanism on the atomic scale to describe plastic flow. Since the Second World War, the theory has developed rapidly, and, apart from its applications to flow of crystalline materials and to strain-hardening, it is of importance for the understanding of crystal growth, grain boundaries and also chemical reactions in solids. The aim of this article is to outline these developments; for a description of some of the properties of dislocations the reader should consult the reviews of, for example, Cottrell[4], Nabarro[5] and Mott[6,7].

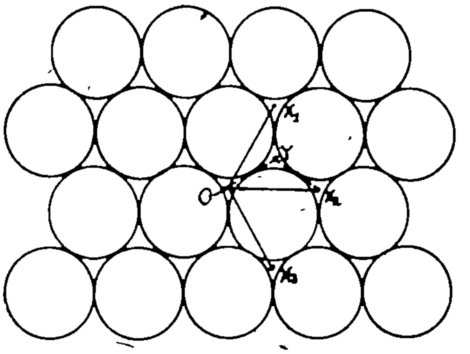

Fig. 1. Close-packed plane of a face-centred or hexagonal crystal, showing the three possible Burgers vectors, $OX_1$, $OX_2$, $OX_3$. $OY$ represents the vector for a 'half dislocation'

A dislocation is a line discontinuity which must either form a closed loop or end on the surface of a crystal. If it lies in a slip plane, it can be defined as the line separating the part of the material that has slipped from that which has not. A dislocation is characterized by its Burgers vector, which represents the distance through which the slip has occurred. Thus, for a close-packed cubic slipping on the (111) planes, there are three possible Burgers vectors, as shown in Fig. 1. Figs. 2 and 3 show the two main types of dislocation, the edge and screw, though intermediate and other types are possible. In the edge type the Burgers vector is perpendicular to the dislocation line, which means that the dislocation line can move only in the plane containing both, whereas the screw, for which the two are parallel, can switch from one plane to another. This has important consequences for the theory of cross-slip (cf. ref. 7).

It will be seen from Figs. 2 and 3 that the crystals are shown as having steps on the surface, and that where a screw dislocation meets the surface a step necessarily ends. Now, on straining a metal crystal or a grain of a polycrystalline metal, steps of just this type are formed, which are frequently observed to terminate. These steps are called 'slip lines', and their height is usually about a thousand lattice spacings, though recent work has shown that steps of much smaller height can be formed[8], especially in creep[9], and by using special techniques slip lines one lattice parameter high have recently been observed on silver crystals[10]. (Steps of much greater height have been shown[11-13] to consist of 'clusters' of elementary lines close together.) So we must distinguish between the elementary (screw) dislocations which terminate at the end of a step one lattice parameter high, and the strong dislocations or groups of 'piled-up' dislocations[14] which mark the end of a slip line of the normal type.

Any theory of plastic flow and of the formation of slip lines starts from the assumption that the annealed material contains dislocations, and it is first necessary to review the evidence for this. First of all, any evidence that a crystal has a mosaic structure can now be interpreted in this sense; a mosaic boundary—or boundary of a polygonized cell—can be analysed into a row of dislocations. This is well shown by the bubble rafts developed by Bragg and by Lomer and Nye[15], of which an example is shown in Fig. 4. Arising out of this concept, many calculations have been made[16,17] of the energies of grain boundaries and mosaic boundaries as a function of the angle between the grains. This approach gives values in very good agreement with experiment, even for angles such that, as Fig. 4 shows, the analysis into dislocations is no longer valid.

Secondly, there is the now well-known evidence from observations of crystal growth (for a review see ref. 18). When crystals are formed from vapours or from solution, they frequently grow by the rotation of a step, such as that of Fig. 3, about the point $A$ where it terminates on a screw dislocation. This mechanism was first proposed by Frank, who showed that the join of the step to the surface would not remain straight but would curl up into a spiral. Since then, spirals have been observed on a large number of crystals[18], and in the case of cadmium iodide growing from solution it has been possible to prepare a film showing the rotation. On cadmium iodide the step—now called a growth step—is several hundred lattice parameters high and, like slip bands on solids, is easily visible under the microscope. On paraffin crystals grown from solution, the height is the length of the paraffin molecule, and, after gold shadowing, the steps are visible with the electron microscope by direct transmission. The much smaller monomolecular steps on beryl, magnesium[19] and silver[10] are visible by means of the optical microscope only because of the 'decoration' of the line of the step by a row of etch pits in the case of beryl[20], and in the case of the metals by a ridge, probably of sulphide, which forms when the metal surface is left for some hours in the presence of 'Plasticine'. Growth steps are thus reactive regions and should be of importance in surface chemistry.

Some of the recent successes of the work on crystal growth have been: the explanation of polytypism on silicon carbide[21]; the prediction that, when growth is by the rotation of a step of considerable height, the centre of the screw dislocation would be a

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* Based on three special lectures delivered in the University of London on Nov. 27, Dec. 4 and 11.

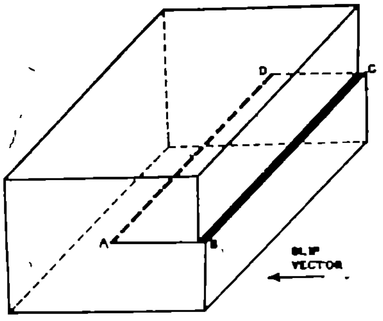

Fig. 2

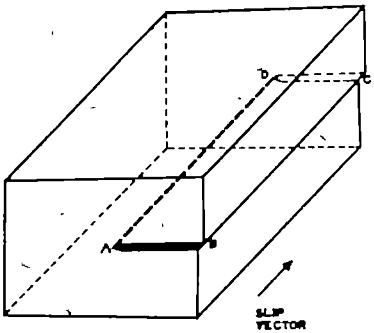

Fig. 3

Fig. 2. An edge dislocation (*AD*). Note the step *BC* on the surface of the crystal

Fig. 3. A screw dislocation (*AD*). Note that the steps *BA*, *CD* terminate at the end-points of the dislocation

These diagrams are reproduced by permission from "Crystal Dislocations", by W. T. Read. (McGraw-Hill Book Co., Inc., 1953.)

cylindrical hole, and also the observation[12] of such a hole in cadmium iodide; and the observation on beryl[13], on paraffins (cf. Fig. 6) and on metals[10] of patterns of the types of Fig. 5. In the case of these observations, they show that, after growth has finished, the screw dislocation on which the growth spiral was locked has moved. They thus give direct evidence that dislocations can move, and represent, to my knowledge, the first observation of slip lines of height equal to one atomic or molecular spacing.

The whole phenomenon of crystal growth gives some clue as to why crystals contain dislocations, since according to this model it is impossible for a crystal to grow unless it contains at least one screw dislocation, which may be formed when the crystal nucleates on some foreign body. It is by no means suggested, however, that this is the only origin of dislocations. Seitz[14] has suggested that they may form by the condensation of vacant lattice-sites as a crystal is cooled, and Teghtsoonian and Chalmers[15] have shown that something of the sort occurs when metals grow from the melt. Also, it is not believed impossible in principle to prepare a crystal without dislocations; Fig. 6 shows a paraffin crystal prepared and photographed by Dawson and Vand which has grown on two screw dislocations of opposite sign; these, after growth was complete, have moved together under their mutual attraction and annihilated one another. This crystal contains at any rate no screw dislocations.

Perhaps the most direct evidence of the existence of dislocations comes from the recent success of J. W. Mitchell[16] in getting photolytic silver to separate out along dislocation lines in a transparent crystal, silver bromide, which has been slightly strained and then annealed. One of his photographs is shown in Fig. 7. The hexagonal form of the dislocation network was predicted two years earlier, following a suggestion by Frank, in a lecture by me[7]. It arises because, as Fig. 1 shows, the three possible Burgers vectors in the face-centred cubic add up to zero, so that three dislocations can meet in a point. This work is at present in its infancy, and promises to give much valuable information.

We turn now to the phenomenon for the description of which dislocations were invented—namely, plastic deformation of crystalline solids. The first two questions to be answered in this field are: Why is slip usually concentrated on relatively few active planes, giving the visible slip lines on the surface, and why do metal crystals deform for stresses so much below the theoretical stress? Both questions are answered by the model of Frank and Read[17], of which several further accounts have appeared in the literature[5–7]. These workers show that a dislocation line which is terminated at its two ends—for example, in the way in which the elements of the network of Fig. 7 are terminated—will, when the material is stressed, produce an indefinite number of 'dislocation rings' which can spread out to the surface of the crystal, there producing a slip line. Thus any of the segments of the network shown in Fig. 7 is capable of acting as one of these 'Frank–Read sources'. If $l$ is the length of one of the segments, the stress required to produce slip is shown to be $Gb/l$, where $G$ is the shear modulus of the material and $b$ the Burgers vector. Values of $l$ of the order $10^{-4}$ cm. give agreement with experiment for the yield stress of single crystals. This is of the order of the distance usually assumed between dislocations or mosaic boundaries.

In materials other than pure annealed metals the resistance to flow is due to three causes as follows. (1) The locking effect of impurities which diffuse to the dislocations and are trapped there[18,19] (Cottrell locking). This effect is particularly marked in the case of interstitial impurities in body-centred metals. In many cases it leads to a sharp but temperature-dependent yield point and is probably connected with the phenomenon of notch brittleness. (2) Internal strains due to precipitates or 'Preston–Guinier zones'. These strains impede the movement of dislocations. Much less dependence on temperature is expected[20] than for Cottrell locking. (3) Internal strains due to cold working.

When a cubic metal is strained at a fairly low temperature, the number of slip-lines observed

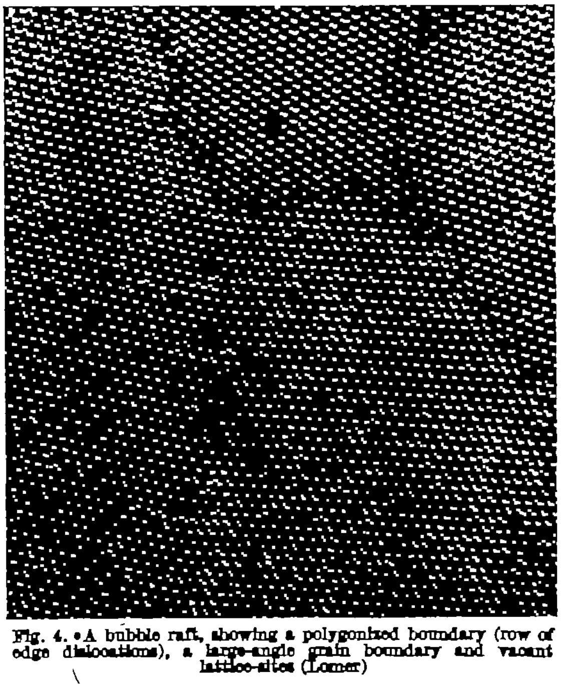

Fig. 4. A bubble raft, showing a polygonized boundary (row of edge dislocations), a large-angle grain boundary and vacant lattice-sites (Lomer)

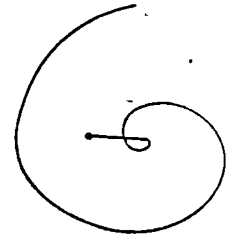

Fig. 5. The type of step on the surface of a crystal which occurs when the screw dislocation has moved after growth has finished

increases, but the amount of slip on each does not. Both I[7] and Fisher, Hart and Pry[31] have deduced from this that the operation of the Frank–Read source is a dynamic process, the dislocations moving with a speed near that of sound and their own momentum keeping the process going until about a thousand dislocation rings are produced; the stress due to these dislocations then stops the action of the source. With this model the formation of a slip line takes about a microsecond (1,000 $l/c$, where $c$ is the velocity of sound), after which its height does not increase, although its length may (Chen and Pond[32]).

When a slip line terminates within a solid, there must be present, as already emphasized, regions of very high strain, where about a thousand dislocations are piled up together. The properties of these groups have been worked out by Eshelby, Frank and Nabarro[14]. According to Stroh[33] they contain the main part of the stored energy. I have ascribed the work-hardening of cubic metals to the strains produced by these groups[6], and my model is similar to that of Taylor[1], except in the following respects: the random internal strain is due to a relatively small number of strong groups instead of a large number of isolated dislocations; and a mechanism is proposed for locking the groups in position. This is based on the demonstration by Lomer[34] and Cottrell[35] that, in the face-centred cubic, dislocations moving on octahedral planes inclined at an angle to each other can combine to form the so-called sessile or immobile dislocations. This observation is supported by the observation by Andrade and Henderson[36] and Lücke and Lange[37] of the phenomenon of easy glide. In good single crystals suitably oriented the dislocations pass out of the solid and no hardening or X-ray asterisms occur; but a condition is that slip should be on one plane only. As soon as sessile dislocations are formed, dislocations are trapped and hardening results.

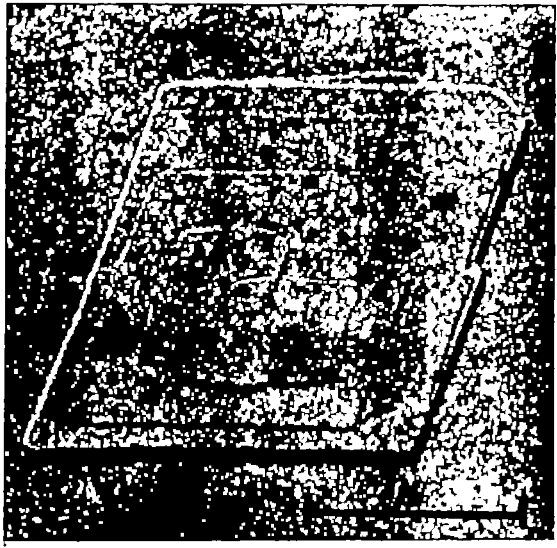

Fig. 6. Electron micrograph of a paraffin crystal, which has grown through the rotation of spirals about two screw dislocations of opposite hand. After growth has finished, the screws have moved together and annihilated each other (Dawson and Vand)

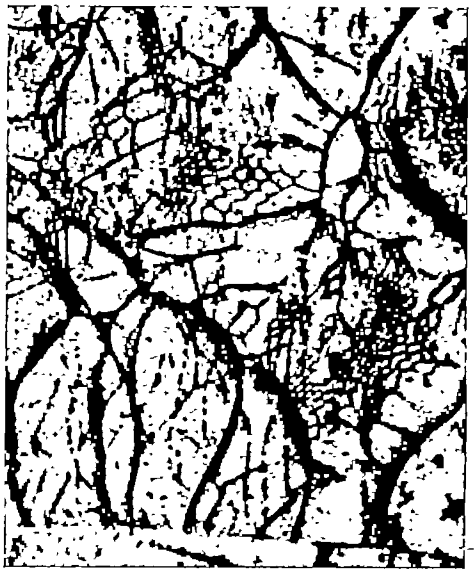

Fig. 7. Dislocation networks in silver bromide. These are formed by a small strain followed by an anneal, and are made visible by exposure to light, which precipitates silver along the dislocation lines (J. W. Mitchell)

Thermal recovery is to be ascribed to the break-up of the piled-up groups of dislocations. To escape from such a group, edge dislocations must 'climb' or leave their slip planes. To do this they must absorb or give off vacant lattice-sites, and the process is thus associated with self-diffusion, which also is believed to occur through the agency of vacancies. Owing to the very great stresses in the piled-up groups, however, the activation energy for 'climb' decreases with increased cold work, and may be less than for self-diffusion[7]. The sensitiveness of recovery to purity is to be explained by the ease with which diffusion of an impurity to the piled-up groups may diminish these stresses.

After escaping from the piled-up groups, some of the dislocations of opposite sign may annihilate each other, but most form polygon boundaries. This must be thought of as a secondary process; the essential process for recovery is the dissolution of the piled-up groups.

The vacancies normally responsible for recovery and for self-diffusion are those formed by thermal agitation. There is now much evidence, however, that cold work itself produces vacancies[38–40]. To this may be described the increased rate of diffusion in some alloys which can be observed after cold work, just as after bombardment by fast particles[41], which also produces vacancies. Following Brown[12], I have suggested[6] that vacancies formed near a slip line can cause some sort of local annealing, and so account for the fact, first pointed out by Heidenreich and Shockley[11] and by Brown[12,13], that, after the formation of one elementary slip line, if the temperature is not too low, others are formed very near it, often at a distance difficult to separate with the optical microscope.

In conclusion, it may be said that there is now strong evidence for the existence of dislocations, and powerful experimental methods exist for studying their properties. With the help of this concept, it has been possible to account for some of the most important facts about plastic flow, though much remains to be done.

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# CHINESE SCIENCE REVISITED (I)

By Dr. JOSEPH NEEDHAM, F.R.S.

DURING the period of the Second World War I had the good fortune to be sent to China with the mission of rendering all assistance possible to Chinese science and technology in its difficult position of blockade. At that time, Chinese scientists were working under many difficulties and with great devotion in the remoter parts of the country, where institutions of learning and production had been set up out of reach of the Japanese. Last year I was able to take advantage of another invitation which enabled me to spend the summer in China. Since circumstances have of late impeded the flow of news between the two countries, it may well be that some information concerning Chinese science and scientists to-day will be welcome to readers of *Nature*.

After twenty-one years of useful life, the Chinese National Academy (Academia Sinica) was re-founded on November 1, 1949, following the assumption of power by the present Government of the Republic. It is placed directly under the Cultural and Educational Commission of the Administrative Council of the Central People's Government, one of the five Commissions stemming directly from the Council or cabinet. The president of the Academy, Dr. Kuo Mo-Jo, one of China's leading historical archæologists, is also chairman of this Commission and one of the Vice-Premiers. Similarly, the vice-chairman of the Commission is also one of the vice-presidents of the Academy, Mr. Ch'en Po-Ta. The other vice-presidents are also well-known men: Dr. Li Ssu-Kuang (geology); Dr. T'ao Mêng-Ho (sociology); Dr. Chu K'o-Chen (meteorology); and Dr. Wu Yu-Hsün (physics).

The recognition of science as basic to the life of the nation is written into the Common Programme of the Chinese People's Political Consultative Conference. Art. 41 states that the education of the country shall be "new and democratic—i.e. national, scientific and popular". Art. 43 says that "efforts shall be made to develop the natural sciences in order to serve industrial, agricultural, and national defence construction. Scientific discoveries and inventions shall be encouraged and rewarded, and scientific knowledge shall be disseminated among the people". The Academy now works along lines which are the consequences of these conceptions and in harmony with the general ideals of the Government. Science is recognized to have close connexions with the needs of the people, and a great effort has been made to overcome the planlessness of former days. While the main task of the Academy is scientific research as such, it gives much assistance in the training of technical personnel. As a government institution, moreover, it advises government departments on scientific matters, and renders assistance in construction works which are proceeding all over the country.

From the beginning of its life, the Academy possessed central research institutes of its own, and was never a purely deliberative and publishing body. But it had to contend with many difficulties. While the greatest of these was the lack of funds in Kuomintang times, it had also in those days to compete with other almost parallel organizations, notably the National Peiping Academy, founded in 1929 largely by students who had returned from France. A re-organization was long overdue, and this has been effected thoroughly since 1949. The two former institutes of physics, for example, were amalgamated and have re-appeared with clearly differentiated spheres of work, so that one is now concerned with subjects such as nuclear physics and cosmic rays, whereas the other deals with the physics of solids and optical research. Formerly, there were in Shanghai and Peking five separate biological research institutes with overlapping and uncoordinated fields of work. These have now been re-organized into three different institutes, each with its own responsibilities.

The following is a list of the institutes:

Institute of Modern History, Peking.
Institute of Archæology (including Medieval History), Peking.
Institute of Linguistics and Philology, Peking.
Institute of Social Researches, Nanking.
  Sub-Department of Social Researches, Peking.
Institute of Mathematics, Peking.

Institute of Modern Physics (nuclear, cosmic rays, etc.), Peking.
Institute of Applied Physics (solids, optics, etc.), Peking.
Institute of Physical Chemistry, Shanghai.
Institute of Organic Chemistry, Shanghai.
  Laboratory of Materia Medica, Shanghai.
Institute of Physiology and Biochemistry, Shanghai.
Institute of Experimental Biology, Shanghai.
  Laboratory of Developmental Physiology, Shanghai.
  Laboratory of Plant Physiology, Shanghai.
  Laboratory of Entomology, Peking.
Institute of Hydrobiology, Shanghai.
  Marine Biological Laboratory, Tsingtao.
  Taihu Limnological Laboratory, Wusih.
  Marine Biological Station, Amoy.
Institute of Systematic Botany, Peking.
  East China Botanical Station, Nanking.
  Lushan Botanical Station (Chiangsi), Lushan
  Northwest China Botanical Station (Shensi), Wukung.
  Southwest China Botanical Station (Yunnan), Kunming.
Institute of Genetics and Plant Breeding, Peking.
Institute of Geology, Nanking.
  Laboratory of Pedology, Nanking.
Institute of Palæontology, Nanking.
  Laboratory of Cænozoic Research and Vertebrate Palæontology, Peking.
Institute of Geophysics and Meteorology, Nanking.
  Geophysical Experiment Station, Peking.
  Geophysical Experiment Station, Shanghai.
Institute of Astronomy, Purple Mountain Observatory, Nanking.
  Astronomical Observatory, Hsu-Chia-Wei (Zikawei), Shanghai.
  Astronomical Observatory, Fêng-Huang-Shan, Kunming.
Institute of Ceramics and Metallurgy, Shanghai.
  Metallurgical Experiment Station, Kunming.
Institute of Metal Research, Peking.
Institute of Psychology, Peking.
Institute of Geography and Cartography, Nanking.
Bureau of Scientific Instruments (Preparatory), Peking.
Committee of Zoological Taxonomy, Peking.

Besides the research activities of the staff of the above institutes, the National Academy fulfils many other responsibilities. Its Bureau of Publications edits about ten scientific journals on behalf of the Academy itself, and a further twenty on behalf of the various societies, such as the Chinese Mathematical and Geographical Societies. The Library of the Academy has been re-organized, and a greater measure of centralization has been introduced; but separate departmental reference libraries in each institute continue, and last summer I was impressed by the amplitude of some of these, even in subsidiary laboratories. The translation of modern scientific terms into Chinese and the acceptance of standard equivalents has been an important problem for more than half a century. Before the end of the Ch'ing Dynasty, Yen Fu, the translator of Huxley and Spencer, was placed in charge of a 'Bureau of Terms', and this was expanded during the Kuomintang period as the 'Kuo Li Pien I Kuan', but its results did not meet the need. This work is now under the direction of the Academy, and is being rapidly pushed forward, with the consultative help of many hundreds of scientific workers from other organizations. A new development is the Bureau of Scientific Instruments, which makes apparatus needed for particular research projects, and is embarking on the production of high-precision instruments unobtainable on the market.

The leading technical body of the Academy is the Council, which is composed of twenty-six members. Its function is to handle the scientific aspect of all important problems. It consists of Ch'en Yin-Ko (history; formerly professor-designate of Chinese at Oxford), Chiang Li-Fu (mathematics), Y. C. Ma (economics), Wu Yu-Chang (philology), Hou Tê-Pang (chemistry), C. C. Chang (physiology), Ping Chi (zoology), Fan Wên-Lan (history), Chou P'ei-Yuan (theoretical mechanics), Ch'ien San-Ch'iang (Tsien San-Tsiang) (nuclear physics), C. C. Yang (palæontology), and so on. Contributory to it are the committees of specialists, corresponding roughly in number to the institutes mentioned above, but composed of scientific men drawn from universities and government departments as well as those who work in the National Academy itself.

The elaborate planning and re-organization in Academia Sinica has been paralleled by great changes in the universities. So far, this affects mainly Peking and Shanghai, where formerly there were many different universities, each with different origins and traditions. In Peking there were (besides smaller and less important ones) three great foundations: Peking University (*Pei Ta*), always a State institution; Yenching University, a missionary university; and Ch'ing-Hua University, based on the returned American Boxer Indemnity funds. It used to be said that the first of these corresponded in spirit to Oxford and the third to Cambridge; but in any event the spirit of separatism no longer corresponded with the urgent needs for social efficiency recognized to-day. In the formation of a single university analogous to the University of London, the humanistic subjects are being concentrated in Pei Ta, the applied sciences and engineering in Ch'ing-Hua Ta, and the pure sciences in Yenching (which will cease to exist as an independent university). So great is the emphasis upon geology and the importance of expanding the Geological Survey for the full use of China's mineral wealth that a new teaching institution for geology and mining will be created, based on the amalgamated geological departments of all the former universities.

Of course, the description of science in Academia Sinica and in the universities is only part of the story. Vast and elaborate research facilities have been set up under the Ministry of Health, a body which has the same governmental status as the National Academy. Apart from the National Institute of Medical Research, located mostly in Peking, there is the National Institute of Biological Products, an expansion of the former institutes which manufactured vaccines and sera. It now produces these on a far greater scale than formerly, but adds therapeutic hormone preparations and is beginning to make antibiotics on a mass scale. An immense production of modern insecticides is also carried out in the New China; but this is done mostly by firms in cities other than Peking. The production of vaccines by the National Institute of Biological Products and its seven subsidiary factories is still under the direction of that admirable bacteriologist T'ang Fei-Fên, to whose work I referred in *Nature* in 1943. Among its more interesting new developments is the production of a vaccine for Chinese summer–autumn encephalitis using mouse brains.

So far, there has been little or no realization in Europe of the extraordinary progress in public health which the Government has been able to achieve. In the cities and villages there has been a universal campaign against flies, mosquitoes, and other noxious insects, so that Peking, for example, has become freer from flies than most European cities. Thirty-five million rats were killed in north-east China in 1951, and another ten million in the first months of 1952. Formerly, vaccination was infrequent, the largest number of persons vaccinated in any one year being 7·3 million (1946); but since 1949, 307 million (more than half the total population) have been vaccinated. Infantile and maternal mortality have been reduced by a half since 1949. A very interesting development has been the mobilization of the old-fashioned practitioners who follow the traditional system of Chinese medicine; they have been instructed sufficiently in modern medicine to enable them to play a valuable part as inoculators, dressers and givers of first-aid who can deal with minor complaints. Midwives have also been systematically re-educated. The health-education movement, in which all possible methods of publicity are employed, and in which every member of the community participates, is almost unprecedented in history, and constitutes the active execution of measures formerly vainly urged by successive international health organizations. It reaches into the remotest corners of the country.

Naturally, all this costs money, but it is not spared. For scientific research institutes as a whole, the budget for 1952 was ten times that of any year in the Kuomintang period, and for 1953 the four-fold expansion planned will bring it to no less than forty times. Thinking of former conditions, I asked last summer when visiting the Laboratory of Entomology of the Academy how many research workers there were, perhaps a dozen or so; and received the reply that they had more than fifty, though quite a number were away on field expeditions.

The effectiveness of collaborative scientific work is also much greater than before. Dr. Li Ssu-Kuang told me that whereas, under the Kuomintang, meetings of scientists could scarcely ever do more than pass resolutions which were never executed, the atmosphere in the New China is much more practical. For example, at the beginning of 1950 a conference of geologists in Peking took decisions concerning field-work for a number of units, and, before six weeks were out, more than eighty geologists were on the way to the north-east, the north-west and central China, to study the structural geology of the areas and to search for iron, coal, oil and non-ferrous metals. The greatest importance is attached to the geological sciences as vital for the development of China, and in August 1952 the Geological Survey was raised to the status and title of a Ministry, with Li Ssu-Kuang (J. S. Lee) as minister. There can be no other nation where the sciences of the earth are so highly regarded.

The close union between science and the people in New China is a fact which must impress every Western visitor who spends some months in the country. Perhaps by the very fact that the standard of their life was formerly so low, they look to science and technology as one of the great forces able to lead them into a state of freedom from poverty, disease and want. Chinese scientific workers are now inspired by this faith and trust. Moreover, they are given the means to respond to it. Dr. Li himself has written: "In the situation which has arisen with the victory of the Chinese people's revolution, it will readily be understood that science is no longer looked upon as an esoteric activity reserved for a leisure class, but as a public enterprise to be shared by all people, who instead of being reticent as formerly, now conscious of what they need, raise their voices in positive demands in every walk of life. It can now be said that in every sphere, the people will accept nothing that is mechanically imposed on them. They are determined to make their own choice in matters of policy, a choice which demands knowledge and the scientific outlook".

# OBITUARIES

## Sir Charles Arden-Close, K.B.E., C.B., C.M.G., F.R.S.

Sir Charles Frederick Arden-Close, who died at Winchester on December 19, was born in Jersey on August 10, 1865. He was the eldest son of Major-General Frederick Close, of Shanklin, Isle of Wight, and took the name of Arden-Close in 1938, in compliance with the terms of a bequest.

Commissioned in the Royal Engineers on July 5, 1884, Close served first at Gibraltar, and later with the R.E. Balloon Detachment. In 1888 he was ordered to India, and, next year, joined the Survey of India, gaining in that service a varied experience of practical surveying which he put to good use in later years.

In 1893 Close returned to England, and, two years later, was placed in charge of the survey of the Nigeria–Kamerun boundary. After this he joined the Ordnance Survey in Great Britain, and in 1898 was appointed British Commissioner on the Tanganyika–Nyasaland Boundary Commission. Having completed this work, he returned to the Ordnance Survey, and, in 1900, was ordered to South Africa in charge of a small R.E. survey detachment. He contracted enteric fever, however, and soon had to return to England, rejoining the Ordnance Survey as soon as his health had been restored.

In 1902 Close was appointed instructor in surveying at the School of Military Engineering, Chatham, and, while there, prepared his well-known "Text-Book of Topographical Surveying", which quickly became, and has remained ever since, the standard work on the subject throughout the British Commonwealth.

In 1905, he became chief of the Geographical Section of the General Staff at the War Office, and in that capacity played a prominent part in securing the establishment of the Colonial Survey Committee, and in drawing up the working rules for the production of the Carte Internationale du Monde au Millionième at the London Conference of 1909.

In 1911 Close was appointed director-general of the Ordnance Survey, holding this appointment throughout the First World War. Naturally, the War interfered with the civil work of the Survey, but the department sent a detachment to France in 1918, and printed enormous numbers of maps for the armies in France and elsewhere.

Sir Charles retired in 1922, but continued to devote himself to geographical work and study. He became president of many geographical organizations, and, with his wide knowledge and dignified yet genial personality, filled these offices with unusual distinction and success. He was president of the International Union of Geography during 1934–38, president of the Royal Geographical Society during 1927–30, president of the Geographical Association in 1927, and also, for many years, chairman of the Palestine Exploration Fund.

Sir Charles married, in 1913, a daughter of Mr. Thomas Percival, of Shanklin, and had two sons and a daughter. He was the recipient of many honours and distinctions. He was made a C.M.G. in 1898, a C.B. in 1916, a K.B.E. in 1918, F.R.S. in 1919, and he received an honorary Sc.D., Cambridge, in 1928. In 1914 he gave the Halley Lecture at Oxford, and, in 1927, was awarded the Victoria Medal of the Royal Geographical Society.

M. N. MacLeod

## Dr. J. T. Edwards

Dr. J. T. Edwards, who died on November 7, made noteworthy contributions to veterinary science. He had a brilliant scholastic career, and when he qualified in 1911 was undoubtedly regarded by many of his seniors as the best veterinary graduate of his generation.

After study at the Pasteur Institute, Paris, under a three-years research scholarship, study in Germany having been prevented by the First World War, he served for two years in France with the Army Veterinary Corps, and was mentioned in dispatches. Some years of research under the late Sir John M'Fadyean followed, and he was then appointed to the new chair of veterinary hygiene at the Royal Veterinary College, London, in 1920. He received the degree of D.Sc.(London) in 1926, the title of his thesis being "The Chemotherapy of Surra in Horses and Cattle in India".

In 1921, Edwards was appointed director of the Imperial Bacteriological Laboratory (later Imperial Institute of Veterinary Research), Muktesar, India, the most important veterinary appointment in that country, and for the next eight years produced work of remarkable value, carrying out intensive investigations on a wide range of animal disease subjects.

His research work on rinderpest proved to be of a very high order, although its full value was not universally recognized until after an interval of nearly twenty years. The results of this investigation were not published in detail at the time because of preoccupation with current work.

Rinderpest immunization had tended to be hazardous, partly because of the danger of intercurrent infection with piroplasmosis and certain other diseases precipitated by the body reaction to the vaccine, and partly because of varying susceptibility of cattle to the virus. Edwards conceived the idea of adapting the virus to rabbits as unnatural hosts on the basis of the work of Jenner and of Pasteur, in the hope of obtaining a living virus which would immunize without producing the disease, and he laboriously set out on what appeared to be a hopeless task. He achieved success, but not final success. At the peak of the work his rabbit stock was wiped out by bacterial infection. In India there was no stock of rabbits to replace them and he turned his attention to the goat, again in the hope of producing a suitably modified virus. He succeeded, and his goat-adapted strain of the rinderpest virus has proved to be a highly efficient live vaccine for the immunization of Indian cattle, and it has been used systematically in India ever since with great success. After suitable modification for cattle in Africa, it has proved of great value also in that continent.

Japanese workers produced a rabbit-adapted rinderpest virus in the nineteen-thirties and acknowledged the inspiration of Edwards's work. Their rabbit strain has since proved to be immensely valuable. So Edwards's work on the rabbit-adapted and the goat-adapted strains of the rinderpest virus has stood the test of time and provided outstanding developments in all work on this terrible disease of cattle. Now, for the first time, and entirely as a result of these developments, leaders at international conferences are speaking hopefully of the eradication of rinderpest from continents.

There has been a further development of this work. In the United States in recent years the swine-fever virus has similarly been adapted to rabbits, and the modified strain has been used with great success for the immunization of pigs. American workers have acknowledged the lead provided in this work by the results Edwards achieved with the rinderpest virus. At the present time this new swine-fever vaccine is regarded as the most important advance made in the study of that disease, and great advantages are anticipated from its use.

In 1929 Edwards returned to England and joined the staff of the Foot and Mouth Disease Research Committee, working first at the Lister Institute and later at the Pirbright laboratory.

Edwards published many papers on a variety of subjects, and a number of his contributions will maintain their importance for years to come. He was active over a wide range of veterinary activities in Britain during the past two decades and was very highly respected in his profession.

He was awarded honours by his profession, and when on deputation to the Egyptian Government was awarded the Order of the Nile (3rd Class) by the late King of Egypt. He was a past president of the Section of Comparative Medicine of the Royal Society of Medicine. He was a member of the Councils of both the Royal College of Veterinary Surgeons and of the British Veterinary Association.

During 1916–21 he edited the *Tropical Veterinary Bulletin*, and, after the death of Sir John M'Fadyean, he became one of the editorial board formed to continue the *Journal of Comparative Pathology and Therapeutics*.

Edwards was deeply interested in psychology and in animal behaviour. In recent years he devoted much of his literary activities to veterinary history, on which he published important contributions in the *Veterinary Record* and elsewhere.

W. A. Pool

## Prof. Johan Böhm

The newly organized Czechoslovak Academy of Science and the Research Institute of Organic Syntheses have suffered a great loss by the decease of the distinguished physical chemist, Prof. J. Böhm, on November 27, 1952. Born in 1895 in Budějovice, Southern Bohemia, Böhm studied at the German Institute of Technology and at the University of Prague, and also worked in the Kaiser Wilhelm Institut für physikalische Chemie, Berlin. At that time this Institution was at its height under the leadership of Prof. F. Haber, with collaborators such as v. Hevesy, Willstätter, Zsigmondi, Freundlich and Polányi. Böhm graduated at the period of the successful start of X-ray applications to structural analysis of crystals, and himself added much to the perfection of this method. His first work elucidated the binding of water in zeoliths, and later research solved the structures of several metallic hydroxides, especially of γ-AlO.OH, which modification has been called 'böhmite' in his honour. This was in 1926, in which Böhm also investigated the strongly exothermic spontaneous recrystallization of finely powdered silver and antimony. At the same time, Böhm constructed with Weissenberger the well-known X-ray goniometer.

Soon after that, Böhm went with v. Hevesy to Niels Bohr's laboratory; but when v. Hevesy was invited by the University of Freiburg-im-Breisgau to fit up the Institute of Physical Chemistry he took Böhm with him. Böhm remained in Freiburg until 1934, first building and installing X-ray laboratories, introducing there his new 'secondary' method of structural X-ray analysis, and, as research director in physical chemistry, practical classes in photochemistry and colloids. He became assistant professor in 1934.

However, the Nazi era altered Böhm's scientific life. Profs. v. Hevesy and Böhm had to leave Germany. The latter, who always kept his Czechoslovak nationality, accepted the invitation of the Czechoslovak government to the chair of physical chemistry at the German University in Prague. During the German occupation of Prague, Böhm was again subjected to political pressure; but he never joined the Nazi party, and continued to help his numerous Czech friends in their scientific work in a fearless manner.

Böhm's own research work in the war years concerned again X-ray investigations and photography; but it remains mostly unpublished, as his pupils left Prague in the critical year 1945. When conditions settled down again, Böhm was employed as a research chemist in the national enterprise Rybitví near Prague, and remained there in spite of several offers of a post as a university teacher. The many sufferings he had sustained had deprived him of self-confidence. At last he consented to work in the physico-chemical laboratory of the Czechoslovak Academy of Science and was one of the first of the nominated corresponding members of that institution.

Prof. Böhm possessed not only a great capacity for experimental work, but also a unique strength of character. His philosophical attitude and faith in social justice guided him safely through national and political struggles. His great modesty, self-denial and willingness to help others led to over-work, which destroyed the hopes of his friends just when he had returned to academic research.

J. Heyrovský

## Prof. Otto Pratje

Prof. Otto Pratje, who was both head of the marine geological section of the German Hydrographic Institute and lecturer in geology at the University of Hamburg, died on December 11, at the age of sixty-two.

Although originally committed to a commercial career, Pratje studied geology concurrently for several years in Britain and Sweden. After the First World War, he decided that his profession was not to his taste, and took his doctor's degree at Freiburg in 1921 under Deecke. During the ensuing period he worked as an assistant at the University of Freiburg on the marine sediments of the Continent of Europe.

The course of his life's work was, however, decided by his move to Königsberg, where he acted as a university assistant and lecturer during 1923–27. His chief study was the geology of the sea-bed, and it was to this that he owed his participation in the *Meteor* Atlantic expedition during 1925–26. In 1937 he was appointed to establish and direct the marine geological section of the Deutsche Seewarte at Hamburg. After the Second World War he joined its successor, the German Hydrographic Institute, and also became a member of the lecturing staff of the University of Hamburg.

The abundance of Prof. Pratje's publications bears witness to his diligence and fertile mind, and will be a lasting monument to him. While his earlier papers were devoted to the geological and palæontological problems of the Continent, in particular those of the Jurassic formations of south-west Germany, marine geology came more and more into the foreground during the Königsberg period. At first he wrote several papers on Heligoland, including the well-known geological guide, but then turned completely to the sea-bed. He also made a systematic collection of bottom samples during many research voyages. In addition to a number of papers on the formation of sediments in the North Sea and the Baltic, we owe to him what are believed to be the most detailed geological charts of these seas yet compiled. Parallel with this work, Pratje carried out the laborious evaluation of the bottom samples collected during the *Meteor* expedition, of which two parts have appeared in print. Unfortunately, his official duties, combined with war-time and post-war conditions, prevented the completion of this work. Finally, in an extensive paper in the "Handbuch der Naturwissenschaften", he described the techniques and methods of collecting and evaluating samples from the ocean bottom, supplementing it, in the "Jahrbuch der Geographischen Gesellschaft", with references to his most recent experience.

Prof. Pratje laboured much and achieved much, though some of his work was incomplete when he died. What remains is the memory of a kindly man who was always ready to collaborate, in whose presence no harsh word was ever heard, and who knew how to suffer hard blows with a quiet mind.

## Prof. Francesco Vercelli

We regret to report that the distinguished Italian geophysicist, Prof. F. Vercelli, director of the Geophysical Observatory and of the Thalassographical Institute of Trieste, died, at the age of sixty-nine, on November 24.

Prof. Vercelli contributed to research in several branches of geophysics. In oceanography he investigated the transmission of solar radiation through sea and lake water and the effects of wind and pressure variations on the tides, and led oceanographic expeditions in Italian naval vessels to various parts of the Mediterranean and Red Sea. He devised a method of harmonic analysis and applied it to the prediction of pressure changes. He sought for the sunspot cycle in tree-ring records. His earliest geophysical work was concerned with temperature in tunnels in connexion with the construction of the Simplon tunnel; later, he founded a seismological station at Trieste and took part in seismic and electromagnetic prospecting for oil in the Po valley.

He was appointed director of the Geophysical Institute of Trieste in 1920. When the Institute was divided in 1949, he became director of both the Geophysical Observatory and the Thalassographical Institute. His last years were devoted to preparing a second edition of his book on meteorology, "L'Aria", and to writing a large work on oceanography, "Il Mare".

We regret to announce the following deaths:

Prof. G. D. Hale Carpenter, M.B.E., Hope professor of zoology in the University of Oxford during 1933–48, on January 30, aged seventy.

Prof. J. H. Orton, F.R.S., emeritus professor of zoology, University of Liverpool, and formerly director of the Marine Biological Station, Port Erin, on February 2, aged sixty-eight.

# NEWS and VIEWS

## Prof. P. M. S. Blackett, F.R.S.

On his appointment to the chair of physics at the Imperial College of Science and Technology, London, in succession to Sir George Thomson, Prof. P. M. S. Blackett resigns at the end of the present session from the Langworthy chair of physics in the University of Manchester which he has held since 1937. In the two years before the War, Prof. Blackett created a large and important school of cosmic-ray research in Manchester. Largely through his inspiration at this time, a chair of theoretical physics came into existence—occupied first by Prof. D. R. Hartree and later by Prof. L. Rosenfeld. But perhaps Blackett's most significant achievements belong to the post-war period. As a member of the Barlow Committee he was prominent in securing the expansion of the universities of Great Britain, and with his own department he set a brilliant example in the use of the new opportunities thus provided. An honours school numbering little more than a dozen was immediately increased six-fold, and this expansion in teaching was accompanied by spectacular developments in research, in which Blackett's wide interests and sound judgment were everywhere apparent. After the discovery of the *V*-particles by Rochester and Butler in 1947, the work was extended to the Jungfraujoch and Pic du Midi; while in Manchester, J. G. Wilson's magnetic cosmic-ray spectrograph was constructed and considerable developments took place in all aspects of cosmic-ray research. At the same time the Jodrell Bank Experimental Station was being developed for work in radio astronomy, and Blackett was working on his theory of the magnetic field. Experimental work on the latter provided Blackett with a new outlet for his individual experimental skill, in which he developed magnetometers of very great sensitivity. The width of his interests and activities was again emphasized in 1951 when chairs of theoretical astronomy and of radio astronomy were established in his department.

Blackett exercised a great influence on the post-war developments in the University of Manchester and in administrative affairs. He was dean of the Faculty of Science during 1948–50; a member of Council during 1949–52 and pro-vice-chancellor during 1950–52. He is a member of the National Research Development Corporation and has served on many atomic energy and defence committees. The award of the Nobel Prize in 1948 gave great pleasure to Blackett's many friends throughout the world, who will join in wishing him continued success in his new post. Manchester regrets the loss of one of the world's most distinguished scientists, who enhanced in a brilliant manner a remarkable heritage of Langworthy professors.

## Prof. Willis Jackson

Prof. Willis Jackson has been appointed director of research and development at Metropolitan-Vickers Electrical Co., Ltd., as from July 1 next, in succession to Dr. C. Dannatt, who took over from Sir Arthur Fleming in 1951 (see *Nature*, 168, 587; 1951). Prof. Willis Jackson is professor of electrical engineering in the University of London at the Imperial College of Science and Technology, having succeeded the late Prof. Cecil L. Fortescue in 1946. His career has been closely associated with Manchester, for after graduating from that University he became a college apprentice in the firm to which he is now returning, and later joined the research staff of the organization. He relinquished this position in 1938 on his appointment to the chair of electro-technics at Manchester.

Prof. Jackson's work at the Imperial College has been characterized by the energy and enthusiasm which those who know him expect as a matter of course, and both as head of the Department of Electrical Engineering and, during the past two years, as dean of the City and Guilds College, he has won the respect and affection of his colleagues for the efficient and cheerful way in which he has carried out his many duties. His energies have, however, not been confined to academic matters; among many extra-mural interests he has served on the Council of the Institution of Electrical Engineers and its Education Committee for nine or ten years, has been a member of the Technology Sub-Committee of the University Grants Committee and a member of the Scientific Advisory Council of the Ministry of Supply since 1948, and has taken an active part in the work of many other important bodies concerned with professional education and research. In spite of these varied demands he has found time for personal research, his main interests being in the properties of electrical insulating materials and in micro-wave measurements. Prof. Jackson's wide experience in both education and research augurs well for his success in the responsible position which he is to assume, and the high standards set by his predecessor, Sir Arthur Fleming, whose work at 'Metro-Vick' has won the admiration and respect of the whole engineering profession, will be in safe keeping.

## Higher Technological Education in Britain

In a written answer in the House of Commons on January 29, to questions as to whether the Chancellor of the Exchequer could now give details of plans for the establishment of a technological university or university college of technology in Britain, Mr. J. A. Boyd-Carpenter, Financial Secretary to the Treasury, stated that after consulting the University Grants Committee, the Government proposes to place further resources at the disposal of the University of London to facilitate the expansion of the Imperial College of Science and Technology. The aim would be to raise the number of full-time students from the present 1,650 to 3,000 during the academic quinquennium 1957–62. So that the work of the Imperial College could be co-ordinated with that of other schools of the University, and full advantage taken of the whole of the University's resources, as well as to minimize disturbance of current work of the College, the expansion would take place around the existing site of the College in South Kensington. The College had been invited to submit plans based on the assumption that the College would have first claim on other parts of the area between Prince Consort Road and Imperial Institute Road as it became possible to release them from their present uses. The phasing of the plans would, of course, require careful consideration in consultation with other interests affected.

This development is clearly in pursuance of the policy already announced by the Government of building up at least one institution of university rank devoted predominantly to the teaching and study of higher technology. In addition, the Government proposes to make resources available for further developments in other parts of Great Britain, and the University Grants Committee has been asked to advise the Chancellor of the Exchequer where such further resources might be deployed. These projects are to be additional to the developments of higher technological education already in progress.

### International Council of Scientific Unions: Report for 1951

THE report of the executive committee of the International Council of Scientific Unions for 1951, edited by Prof. F. J. M. Stratton (pp. 108; from the Secretariat, Gonville and Caius College, Cambridge; 1952), includes the text of the revised agreement between the Council and the United Nations Educational, Scientific and Cultural Organization (Unesco) which brings the agreement into line with those made between Unesco and other organizations. The Council has also been granted consultative status by the Economic and Social Council of the United Nations. Rules for Joint Commissions of the Council have been approved by the executive board and are also appended, and under the new rules the future status of five Joint Commissions, which have been in existence for more than three years, was discussed. The Joint Commission for Rheology was renewed for one year on the understanding that it would become a section of the International Union for Theoretical and Applied Mechanics, and the Joint Commissions for the Ionosphere, for Solar and Terrestrial Relationships, for Radiometeorology and for Oceanography were renewed for three years, but the terms of reference of the last-named were restricted to "the investigation of the deep-sea floor". The title of the Joint Commission for Radioactive Standards, Units and Constants has been changed to Joint Commission on Radioactivity. A proposal to form a new Joint Commission on Electronomic Microscopy was approved. The Joint Committee on Physics Abstracting was dissolved at its own request, and the formation of an International Service of Science Abstracting was approved; the new International Abstracting Board--the agreed title for the service—will not accept fresh subjects, however, until the experimental stage with the Committee on Physics Abstracting is complete and the Board well established in that field. Decisions on the admission of the International Unions of Biochemistry and of Scientific Psychology were deferred. In spite of the steady position of the financial balance in the accounts, printing costs give rise to anxiety. Appended to the report of the Executive Committee are the customary reports from the International Unions and the various Joint Commissions. These include a first report from the Joint Commission on High Altitude Research Stations, which held its first meeting at Bagnères-de-Bigorre during August 23–26, 1950, a meeting which appears to have considerably stimulated, *inter alia*, high-altitude research in South America as an international activity.

### Short Circuits set up by Kestrels

MR. H. LLOYD, of the Yorkshire Electricity Board, writes: "66,000 volts transmission lines in the Yorkshire and North Lincolnshire areas had been subject to a number of mysterious faults, which nearly always occurred about dawn, for several years before the trouble was found to be caused by kestrels which were escaping alive. The points of interest in pursuing the investigation into this were, first, how it was that the birds were surviving 38,000 volts applied across their bodies, and second, what was attracting them to the lines? The incidents always occurred in the early morning or in the misty weather when the birds' plumage could be assumed to be damp. The flashover is initiated across the damp wings when the bird is banking steeply with its back to the insulators, and current does not pass through the bird's body. The speed at which the bird is travelling takes it out of the path of the arc before it becomes too severely burnt. Other birds subject to high voltages are normally completely carbonized. It was at first thought that a few enterprising birds had discovered that it was possible to survey the surrounding ground less obtrusively and with less effort when static from a 45-ft. high perch. Gamekeepers and others thought this improbable, and the theory did not agree with the damage to the birds. There was no evidence that small birds were using the somewhat exposed cross-arms as perches, and we were informed again that kestrels generally preferred ground game. One day, a substation attendant, during misty weather, noticed a kestrel circling a string of insulators in ever-narrowing circles and, had the bird not been scared off, it would probably have run into trouble. The insulators, as is usual under humid conditions, were discharging and emitting an intermittent buzzing noise, and this seems to provide the attraction. In a very recent case the weather was foggy and visibility limited to a few yards. This seems to imply that kestrels hunt by ear as well as sight, and it occurred to me that this might be of interest to ornithologists and others. Bird lovers will be glad to know that, with later forms of construction, two kestrels will have to execute a very complex movement before they get into trouble".

This interesting observation is most likely explained by the possibility of kestrels hunting by ear as well as by sight. Miss Frances Pitt writes: "The kestrel certainly has good hearing. A tame one I had came from a considerable distance when called in a quite low voice. But the bird's method of hunting suggests that it depends on its eyes to find prey".

### Science and Film

A RECENT issue of *Science and Film* is largely taken up with the activities which went on at the International Scientific Film Association's sixth yearly congress in Paris during September 1952 (1, No. 4; December 1952). Among the films which were presented at the congress was one, "Introducing the New Worker", which deals with the problem of works relations and factory psychology. A remarkable film was one from Eastern Germany called "Arbeit aus neuem Geist", dealing with methods of raising production-levels by means of the analysis of work done and by creating a profitable emulation or 'activism' in each team of workers. The high-speed camera was used in France for making a valuable research film on argon arc-welding, while another research film from France was the "Study of Flames", made for the Institut de la Recherche dans la Sidérurgie. Among industrial training and instructional films presented at the congress were the British films, "Basic Principles of Lubrication", "Submarine Control" and "Hardening and Tempering Carbon Steel". From Czechoslovakia came the "Polarograph" and "Electro-erosive Machining", while France supplied "Les Miroirs Plans", a teaching film on plane mirrors. Among the more outstanding documentary films were "Le Cuivre", describing the process of copper-mining in the Belgian Congo; "Charge de Rupture", describing the work of the

Laboratory for Research into Reinforced Concrete Techniques at the University of Ghent; and "Volga-Don Canal", the preliminary to a major Soviet film in colour on the same subject which is shortly to be made available for public distribution. The journal also describes various technical demonstrations at the congress, the use of sound film loops in industrial training, stereoscopic cinematography and a new device for automatic photometry.

### Experimental Elimination of Chromatophores and Eyespot in *Euglena*

E. G. and O. Pringsheim (*New Phytol.*, 51, No. 1, 65; 1952) have reported a very interesting case of the permanent elimination of plastids and eyespot in *Euglena gracilis* by exposure to high temperature and also by treatment with streptomycin. When *E. gracilis* was grown for 5–6 days at 34–35° C.—just below the maximum for multiplication—the chromatophores of most strains were caused to disintegrate and permanently apoplastidic strains were obtained. In a few of the strains the eyespot also disappeared permanently. Considerable differences in response to the treatment were observed in different strains, the effect of streptomycin, strain for strain, yielding parallel results. Both the chromatophores and eyespots are independent, self-reproducing cell components, and once destroyed do not reappear. The artificially produced strains apparently retain their heterotrophic nutrition and vigour indefinitely. The differences in the response of different strains of the organism to the experimental treatments are due to inherent, that is, genetical, factors.

### Integration of Scientific Thought

Some years ago, the inherent dangers of specialist knowledge—when carried to extremes—were foreseen, and its impact upon Western culture in general led to the formation of the Institute for the Unity of Science as an outgrowth of the American Academy of Arts and Sciences. Prof. P. Frank, in some interesting remarks to a meeting of the Institute, reported in a recent publication entitled "Contributions to the Analysis and Synthesis of Knowledge" (*Proc. Amer. Acad. Arts Sci.*, 80, Part 1; 1951; pp. 112, 2 dollars), pleads for the reinstatement of philosophy as a link between the arts and sciences, while President J. B. Conant (Harvard University) stresses the dynamic nature of science. A threefold scheme is then developed by some of the leading methodologists and semanticists of the United States, namely: science and man; the 'meaning' of scientific statements; and the role of 'abstract objects' in science. As a collection, the contributions are stimulating, and calculated to advance the integration of a wide field of studies.

### British Astronomical Association: Annual General Meeting

At the annual general meeting of the British Astronomical Association, held in Burlington House, London, on October 29, the retiring president, Dr. G. Merton, delivered an address in which he dealt first of all with the internal affairs of the Association. It is very satisfactory to know that the membership, which was 856 in 1942, is now well over two thousand and is still increasing, and also that the observing sections continue to flourish with increasing membership as well as with increasing activity when observing conditions are favourable. Dr. Merton took as his main subject, "Photography and the Amateur Astronomer", in which he gave a historical sketch of the developments in photography, referring to a number of astronomers who had carried out very useful work in this branch. The address was illustrated by a series of lantern slides, and, in concluding it, he pointed out a number of ways in which amateur astronomers could make use of photography. In particular, Dr. Merton referred to the scheme of the new director of the Aurora and Zodiacal Light Section for obtaining co-operative work in parallactic photography with fast cameras. During the evening the Walter Goodacre Medal and Gift were presented to Mr. Frank Maurice Holborn. Dr. Merton gave a short account of Mr. Holborn's work in astronomy in different branches, but more especially on variable stars, and paid a high tribute to his devotion to the work of the Variable Star Section, as well as to his contributions to other sections. The new president of the Association, Mr. E. H. Collinson, who took over from Dr. Merton, is well known for his contributions to astronomy in various branches, especially for his papers on meteors, and his photography of them, a branch on which he has worked for many years.

### Bibliography of Differential Thermal Analysis

Any material which undergoes a phase change when heated can be studied by the method of differential thermal analysis, and this method is widely used by geologists, investigators in the fields of ceramics and agriculture, and by chemists, metallurgists and fuel technologists. At the Institute of Science and Technology of the University of Arkansas, Fayetteville, Prof. W. J. Smothers, Y. Chiang and A. Wilson have compiled a "Bibliography of Differential Thermal Analysis" (Research Series No. 24; pp. 44; 1951) which lists 165 papers published between 1887 and 1950 inclusive, and facilitates the identification of relatively unknown substances that are often present in materials subjected to thermal analysis. The bibliography consists of four parts. The first presents a brief description and history of the method; then follows the chronologically arranged list of technical papers; the third is an author index, and the last part is an index of materials analysed by the differential thermal method. The physicist will probably find the short section dealing with equipment of most interest. The best type of thermocouple and its position in the sample, the heating-rate, furnaces with uniform heating-rate and the replacement of photographic by electronic recording, are briefly discussed. As an initial, and quick, reference work, this pamphlet should prove useful.

### Royal Sanitary Institute: Annual Health Congress

The annual Health Congress of the Royal Sanitary Institute will be held in Hastings during April 28–May 1, under the presidency of Lord Eustace Percy. The Congress will be divided into eight sections (*A–H*) and four conferences (1–4) as follows: sections (*A*) preventive medicine, (*B*) engineering and architecture, (*C*) maternal and child health, (*D*) veterinary hygiene, (*E*) food and nutrition (in conjunction with the Food Group, Society of Chemical Industry), (*F*) housing and town planning, (*G*) tropical hygiene, and (*H*) occupational health; conferences (1) medical officers of health, (2) engineers and surveyors, (3) sanitary inspectors, and (4) health visitors. It is anticipated that about two thousand five hundred persons will attend the Congress, including representatives of local authorities, government departments, public bodies, universities and learned societies in Great Britain and elsewhere. Further details can be obtained from the Institute at 90 Buckingham Palace Road, London, S.W.1.

### Thirteenth International Congress of Pure and Applied Chemistry

THE Thirteenth International Congress of Pure and Applied Chemistry will be held in Stockholm during July 29–August 4, 1953, and in Uppsala during August 5–7, 1953. At the same time the Seventeenth Conference of the International Union of Pure and Applied Chemistry will take place. The Congress will comprise a Physical Chemistry Section with the following groups: chemical thermodynamics and thermochemistry, electrochemistry, surface chemistry, colloid chemistry, macromolecular chemistry, chemical kinetics, reactions of free radicals, and other fields of physical chemistry. There will also be a symposium on the chemistry of wood and wood constituents, which will be divided into three sections: structural chemistry of wood constituents, chemistry of cellulose and hemicellulose, and the chemistry of lignin. Immediately after the Congress a symposium on macromolecules will be held in Uppsala. Application forms for attendance at the Congress (to be completed by March 1) and further information can be obtained from the general secretary, Dr. Bengt Sandberg, Thirteenth International Congress of Pure and Applied Chemistry, Stockholm 70.

### First World Congress on Fertility and Sterility, New York

THE First World Congress on Fertility and Sterility will be held during May 25–31 at the Henry Hudson Hotel, New York City, under the sponsorship of the International Fertility Association with the co-operation of the American Society for the Study of Sterility. About eighteen hundred scientific workers from fifty-one countries are expected to attend. Twenty-three scientific sessions will be held, which will embrace the entire field of fertility and sterility, including sessions dealing with socio-economic factors, psychosomatic aspects and artificial insemination. The sessions will be conducted in English, French and Spanish, with the use of earphones and simultaneous translations, as in the United Nations meetings. In addition to the scientific sessions there will be medical round-table discussions, question-and-answer periods, scientific exhibits and films. Those who wish to attend should register as soon as possible with the Chairman of the Local Arrangements Committee, 1160 Fifth Avenue, New York 29, N.Y.

### Third International Conference on Soil Mechanics and Foundation Engineering

THE Third International Conference on Soil Mechanics and Foundation Engineering will be held in Switzerland during August 16–27. The first part of the Conference will take place in the Kongresshaus, Zurich, during August 16–21, when the programme will consist of the main bulk of the lectures and discussions with receptions, excursions, visits to laboratories, and a banquet and ball. During August 22–25 there will be a four-day tour through Switzerland, when the opportunity will be given of seeing not only points of interest for geotechnical and foundation engineering but also something of the country's natural beauty. The final session will be held in Lausanne on August 26, after which an excursion will be made to the dams of Grande Dixence and Mauvoisin, which are under construction. The official languages of the Conference will be English and French. Reservations for hotels at Zurich and Lausanne and for the excursions should be made not later than June 15, preferably as soon as possible. All inquiries should be addressed to the general secretary of the Conference, Dr. A. von Moos, Gloriastrasse 39, Zurich 6.

### Developments in Microscopical Methods

THE Royal Microscopical Society (Industrial Section), in co-operation with the Optical Group of the Physical Society, the Physical Methods Group of the Society of Public Analysts and Other Analytical Chemists, and the Industrial Spectroscopy Group of the Institute of Physics, is organising a meeting under the above title, to be held at King's College, London, on March 20. The first session of the meeting, at 2.30 p.m., will be a lecture demonstration, "The Use of the Polarizing Microscope in Organic Chemical Research". The second session, beginning at 4.30 p.m., will consist of a number of short papers, the general theme of which will be "Useful Attachments to the Microscope and Analytical Methods"; a number of exhibits and demonstrations illustrating the same theme will be on view in adjacent laboratories. In the third session, at 6.15 p.m., there will be a lecture demonstration on "Cinemicrography". Full details of the meeting, with synopses of the papers and short descriptions of the exhibits, are given in the programme, which can be obtained (price 1*s*.) from the Assistant Secretary, Royal Microscopical Society, Tavistock House South, Tavistock Square, London, W.C.1.

### Guido Fubini Prize in Mathematics

AN international prize in mathematics, in memory of the late Guido Fubini, has been founded by his friends and admirers and will be administered by the Unione Matematica Italiana. The prize will consist of Italian currency equivalent to about 550 gm. of gold and will be awarded for important contributions in the field of differential geometry published between January 1, 1946, and December 31, 1953. Applicants are invited to submit their work to the Unione Matematica Italiana (address: presso Istituto Matematico 'Pincherle', Università di Bologna) before March 31, 1954; but the awarding committee may also consider publications for which no such application is made. If there should be no suitable work in differential geometry, the committee can award the prize for contributions made in the same period to the theory of automorphic functions and related topics.

### University of Birmingham

THE following appointments have recently been made in the University of Birmingham. To be lecturers: Dr. W. O. Lock (physics), T. Broom (industrial metallurgy), Dr. G. F. Eveson (mining), and Dr. R. C. Porter (chemical engineering). To be Imperial Chemical Industries, Ltd., Research Fellows: Dr. A. J. Nutten (chemistry) and Dr. G. K. Williamson (metallurgy). J. T. Edward, Imperial Chemical Industries, Ltd., Research Fellow in the Department of Chemistry, has resigned. The title of University Research Fellow has been conferred on K. H. Stark during the tenure of his post in the Department of

Electrical Engineering. The degree of D.Sc. of the University has been conferred on F. R. N. Nabarro (metallurgy) and F. J. Richards (botany).

### Nuffield Foundation Awards in Dentistry, Biology and the Social Sciences

THE Nuffield Foundation is offering a number of fellowships, scholarships and bursaries in the fields of dentistry, biology and the social sciences as follows. The fellowships for dentistry are for persons, aged 25–35 years, with dental qualifications, to receive additional training in pure and applied science so as to undertake an academic career in dentistry, and also to enable graduates in medicine or science to receive training (not necessarily for a registrable dental qualification) that will fit them for teaching and research in dental health and disease; the fellowships are worth £500–800 a year for one to three years, and applications must be received by March 1. Dental scholarships, normally for one year only, are available for students at university dental schools in the United Kingdom and cover tuition fees and a subsistence allowance of not more than £200; applications must be received by June 30. The Foundation's scholarships and bursaries in biology and the social sciences are for graduates of British universities, preferably within the age-group of 22–35 years. The awards in biology are for persons who have graduated in physics, chemistry or mathematics but who have had no training in a biological subject, and who wish to receive such training in biology as will enable them to undertake research and teaching in the United Kingdom in the biological sciences; the scholarships are for persons with some previous experience in postgraduate research in their own subject, and the bursaries for those who have recently graduated, and in both cases the Foundation will pay the cost of university and/or college fees in addition to a maintenance award; applications must be received by April 1. The awards for the social sciences are the same as those for biology except that the application forms must be received by May 1 and the holder may have a degree in any subject other than the social sciences, psychology or economics, though one in the natural sciences or mathematics is preferable; subjects suitable for study are political science, social psychology, anthropology, social statistics and sociology generally, but not economics. Application forms for all these awards and further information can be obtained from the Secretary, Nuffield Foundation, Nuffield Lodge, Regent's Park, London, N.W.1.

### Sociological Research in Africa South of the Sahara

A MEETING of specialists engaged in the planning of sociological research will be held during the last week of this month in Kampala, Uganda, by the Scientific Council for Africa South of the Sahara, on the occasion of the second seminar of Belgian and British sociological research workers. The meeting will consider present major problems and projects of sociological research in Africa south of the Sahara, and will make suggestions for special studies and means of co-ordination concerning sociological research. Among those who are expected to attend will be Gouverneur Deschamps from the Ministère de la France d'Outre-Mer, Paris; Prof. Griaule, professor of ethnology in the University of Paris; Dr. L. van den Berghe, director of the Institut pour la Recherche Scientifique en Afrique Centrale, Congo Belge; Dr. A. I. Richards, director of the East African Institute of Social Research, Kampala; Prof. A. Mendes Correa, director of the École Supérieure Coloniale, Lisbon; Mr. V. R. Sutton, of the South African National Institute for Personnel Research; and Dr. Clyde Mitchell, director of the Rhodes-Livingstone Museum, Northern Rhodesia.

### Announcements

DR. E. MARSDEN, representative of New Zealand on the Executive Council of the Commonwealth Agricultural Bureaux, Farnham Royal, Bucks, has been elected chairman of the Council in succession to Mr. J. E. Cummins, representative of the Commonwealth of Australia. Mr. W. F. C. Morton (Union of South Africa) follows Dr. G. R. Bates (Southern Rhodesia) as vice-chairman of the Council.

APPLICATIONS are invited for Lady Tata Memorial Fund grants, scholarships and fellowships to scientific workers of any nationality for research on diseases of the blood, with special reference to leukæmia, in the academic year beginning October 1 next. Grants are made for research expenses, scholarships are awarded as personal remuneration, their normal value being £600 for whole-time research, and fellowships will be for workers with considerable research experience, the stipend being £1,000 a year. Applications must be submitted before March 31, and the awards will be announced in June. Forms of application and further information can be obtained from the Secretary of the Scientific Advisory Committee, c/o Medical Research Council, 38 Old Queen Street, Westminster, London, S.W.1.

No. 6 of the "Bibliography of Scientific Publications of South Asia", covering India, Burma and Ceylon for the period July–December 1951 (pp. 124. Delhi: South Asia Science Co-operation Office, 1952), includes a catalogue of scientific periodicals besides the usual classified list of titles and supplementary list of new periodicals and changes of name, address, frequency, etc. The periodicals are listed alphabetically by title, and details of scientific periodicals which have ceased to appear but which are still of interest to scientific workers are included. Besides particulars of frequency, size and purpose of the periodicals listed, the catalogue gives the publisher's address and the first date of publication.

LIKE many of its contemporaries in the petroleum field, *The Lamp*, which is the house organ of the Standard Oil Co. (New Jersey), combines knowledge with entertainment. Issue No. 3 for 1952 is particularly characterized by reproductions of life in the Canary Islands, painted by John Groth. Other features describe a push-button parking-system for cars, in a tall building twenty-five feet wide in Washington, D.C., where seventy-two cars can be automatically garaged in a space which, on the ground, would only accommodate nine; this innovation could well engage the attention of local authorities in congested cities in Great Britain. There is an article on Bermondsey, one of London's oldest boroughs, some account of the Company's oil explorations in foreign lands, and an interesting section on 'hurricane hunters' by the United States Air Weather Service in the Caribbean region.

ERRATUM. We much regret that in the communication entitled "Height of the Potential Barrier in Barrier Layer Cells" in *Nature* of January 31, p. 219, the graph has been inverted.

# NEW SCIENCE BUILDING AT BEDFORD COLLEGE, UNIVERSITY OF LONDON

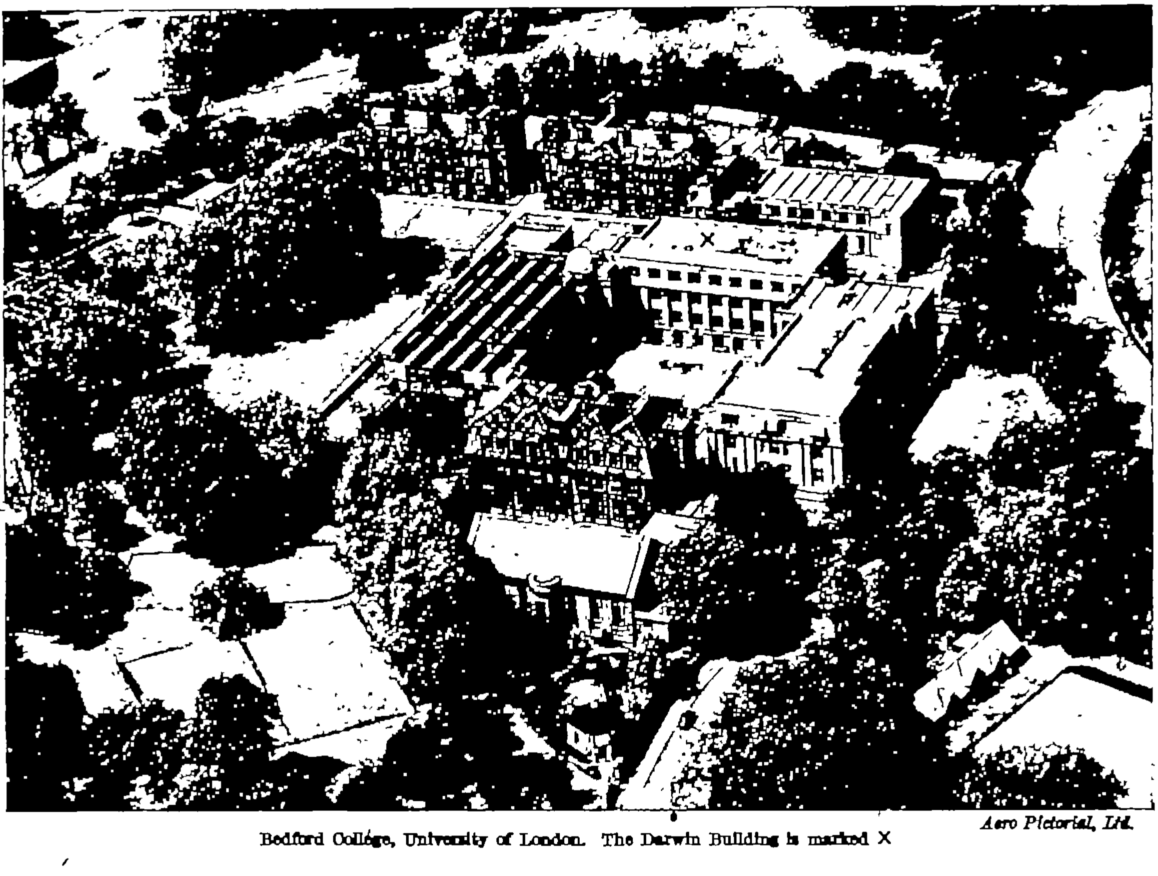
THE Biology and Geology Departments of Bedford College were destroyed by enemy action in 1941. A new building has now been completed on the original site. It was formally opened by the Chancellor of the University of London, the Earl of Athlone, and Princess Alice on October 28 last.

The new structure, of which the architects were Maxwell Ayrton and Partners, has been named the Darwin Building. The name is particularly appropriate for biological and geological laboratories, recalling, as it does, Charles Darwin; but the building is actually dedicated to his son Leonard, who was a member of the College Council during 1898–1925. Another link with the Darwin family is the fact that Erasmus, elder brother of Charles, was an original trustee of the College in 1849 and a member of the Council for nearly twenty years. A grand-daughter of Charles Darwin, Mrs. Ruth Rees Thomas, is to-day a governor of the College.

Zoology is housed on the top story, with botany beneath it and geology on the upper ground floor. Special features of the building are the large windows, valuable for microscopic work, teak benches and floors, heating by ceiling panels, and compressed air and vacuum services. Each department has its own library. A large lecture theatre is common to the three departments, while each of them has its own lecture room. The lower ground floor is shared between the departments and there is a passenger lift.

The Zoology Department (Prof. H. Munro Fox), in the planning of which the senior lecturer, Miss F. E. Ince, gave valuable help, is designed so that a large teaching laboratory occupies two-fifths of the floor space, with windows on three sides. The museum collection is displayed in glass cases around this laboratory. The Department contains individual research rooms for the five members of staff and three research rooms for five postgraduate students, grouped around preparation rooms and stores. The lower ground floor provides a workshop, dark-room, aquarium room, and two constant-temperature rooms. The research work deals at present with respiratory pigments and with the metabolism, osmoregulation, taxonomy and embryology of Crustacea.

The Botany Department (Prof. L. J. Audus), in addition to general and honours teaching laboratories, has a laboratory for instruction in special experimental disciplines (for example, biochemistry, plant physiology, soil chemistry, etc.). The departmental museum collection is housed in glass-fronted cupboards in laboratories and corridors. There are five staff research rooms, a postgraduate research laboratory and a large constant-temperature room provided with high-intensity fluorescent light for growth experiments with plants in artificial day-lengths. Current research is mainly on the physiology of growth, with particular reference to chemical regulators, ecology and wheat genetics. The herbarium has built-in insect-proof cabinets for both teaching and research collections. There are also two dark-rooms, a medium room, a sterile room and a workshop.



Aero Pictorial, Ltd.

Bedford College, University of London. The Darwin Building is marked X

The Geology Department (Prof. L. Hawkes) comprises one large general laboratory and museum, a smaller palæontology laboratory, three research laboratories, a chemical laboratory and a technician's room. Two rooms on the lower ground floor are equipped for rock-cutting and optical work.

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# CENTRAL PUBLIC HEALTH LABORATORY, COLINDALE

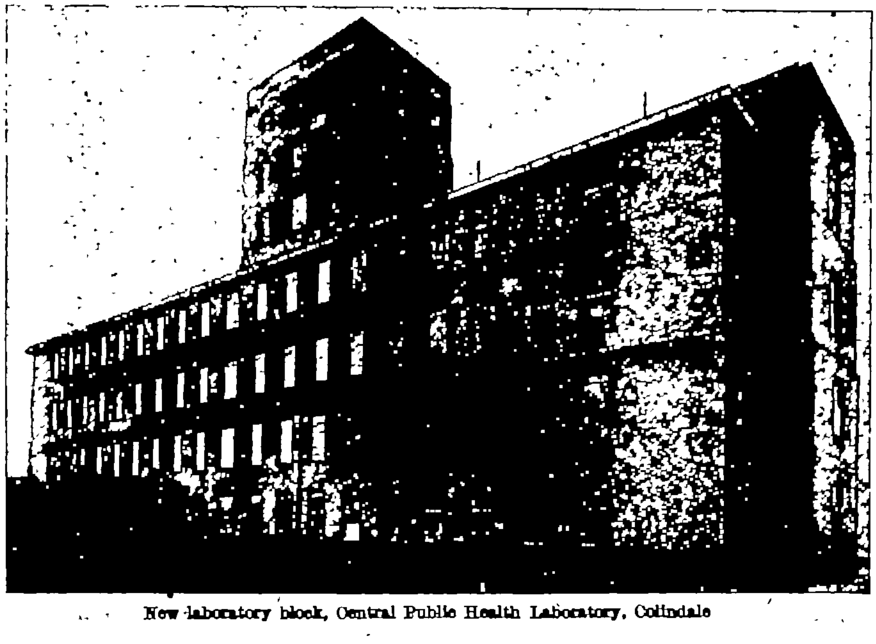
## NEW LABORATORY BLOCK

On January 15 the new laboratory block of the Central Public Health Laboratory at Colindale was formally opened by the Minister of Health. The Minister, accompanied by his Parliamentary Secretary, Miss Hornsby-Smith, Sir John Hawton and Sir John Charles, were met by the chairman of the Medical Research Council (Lord Limerick), the first secretary (Sir Harold Himsworth), the second secretary (Sir Arthur Landsborough Thomson), the director of the Public Health Laboratory Service (Dr. G. S. Wilson), and were conducted over the main buildings by the director of the Colindale Laboratories (Lieut.-Colonel H. J. Bensted).

There were no formal demonstrations set out and the Minister met the heads of the various departments and their staff carrying out their normal duties; of topical interest were the roll-tube tissue culture technique for the cultivation of the poliomyelitis viruses, and the chick embryo cultivation of the influenza virus.

In the library of the new building, the Minister was introduced by Lord Limerick, and in a short address he described the development of the Public Health Laboratory Service and how it came about that the Medical Research Council is directing, and will continue to direct for an indefinite period, this Service for the Ministry of Health. In declaring open the new building he paid tribute to the architect, Mr. Maxwell Ayrton, and the builders, Messrs. Trollope and Colls, Ltd.

The new building consists of a four-floor block of a pleasing brick construction, approximately 180 ft. long and 45 ft. wide, with a central tower extending upwards for a further four floors. The top of the tower houses reinforced concrete water-tanks to supply the needs of all the laboratory buildings. The rooms under this are designed for office and record purposes. A door from the vestibule on the fourth floor leads to the roof space, which runs the full length of the building and in which is housed ventilating plant, air filters, etc., and some of the compressors for the refrigeration units on the laboratory floor below. There is also ample storage accommodation in this space.


New laboratory block, Central Public Health Laboratory, Colindale

A basement under the central part of the building houses more plant and also a gas-fired incinerator, the flue of which passes up to the top of the tower more than 90 ft. above.

The front of the building faces west, and all the windows on that side are protected from the setting sun by green sun-blinds operated from the inside. At the south end there is a service lift for animals and equipment travelling directly to the third floor (Virus Department) without intermediate stops, and at the north end a similar type of lift serves all the other floors. In the centre a passenger lift goes up to the top of the tower. There is a central staircase, broken at the third floor, for normal foot traffic, while there are emergency downstair cases at either end of the corridors.

In designing this laboratory block, one of the principles kept in mind was, so far as possible, to standardize the layout for each floor but at the same time to make provision (should future requirements necessitate it) for alteration in the size of some of the rooms without interfering with the main construction. On each floor, the first rooms at the south end of the building form a suite comprising preparation room, sterilizing and wash-up kitchen, sterile glass-ware store and sterile room, where a positive pressure of filtered air can be maintained. Each floor also has shower-baths and changing rooms. There are also incubator rooms (37·5° C.) and cold rooms (+ 4° C.). Secretarial assistance in adjacent offices is provided for each group of laboratories.

Central corridors run the full length of the building with laboratory rooms approximately 14 ft. deep on either side. Single-unit rooms are just under 8 ft. wide, and two-, three- and four-unit rooms are multiples of this figure in width. The most common size is the standard two-unit room with a working bench across the windows at 2 ft. 9 in. high, containing one small staining sink in the centre and a drip sink for filter pump, etc., at one end. There are a side bench for water-baths, etc., and a washing-up sink with draining board on the opposite side. A convenient double bench is placed centrally, half of which is 3 ft. high, and the other half, serving as a writing desk, is 2 ft. 6 in. All benching is of teak, and the under-bench furniture is of West African mahogany. The front and side under-bench furniture consists of movable nests of drawers, paired cupboards with adjustable shelves, and open microscope cabinet containers. The central benches are supported by suitable linking of similar cupboard or drawer units.

Simple services are carried on the walls under the benches and consist of electric points, gas, and hot and cold water only. Other gas and electric points are 9 in. above floor-level for small refrigerators, centrifuges and incubators. Ample ceiling lights are provided by opal tungsten lights, while fitted 'Anglepoise' lamps cover each front bench for close work. 'Opalite' shelving for reagents is fitted over staining sinks and at the sides. A capacious double cupboard with adjustable shelving is suitably placed in one corner.

The above description is typical of the standard two-unit room, and although somewhat different arrangements appear in the rooms of other sizes, the same general principles are observed.

The top laboratory floor is devoted to the study of virus diseases, and it is here that refrigeration units are of greatest importance. There is a large + 4° C. room, a − 30° C. room, and inside the latter are chambers maintained at − 70° C. The compressors for these are housed in the roof space. In the centrifuge room on this floor there are also two small independent − 70° C. refrigerator cabinets and a high-speed refrigerated centrifuge. Two animal inoculation rooms with special inoculation boxes connected to exhaust ducts are not quite complete; these ducts are being provided with high-temperature heaters to burn away virus-laden air before it passes out to the open.

The second floor houses the Air Hygiene Laboratories and, under the same director, the Streptococcal and Staphylococcal Reference Laboratories. The novel feature here is an experimental room for research into the bacterial contamination of air. On the same floor is an assembly room for special apparatus required in this section, much of which is machined in an associated outbuilding workshop.

On the first floor are the Food Hygiene Laboratory, Salmonella and the Dysentery Reference Laboratories. These are situated in one-, two- and three-unit rooms of standard design.

The Epidemiological Research Laboratory occupies one-half of the ground floor, the remainder of which consists of small and medium-sized research laboratories for individual workers.

The Routine Department, the Central Enteric Reference Laboratory and Bureau, the Standards Laboratory for Serological Reagents and the Media Kitchens, etc., remain in the old building, but with improved accommodation, while the National Collection of Type Cultures continues to occupy the same rooms as previously.

Owing to economy cuts, it has not been possible to carry out all the improvements originally planned; but it has been possible to convert the old stable, used for inoculating calves when the building belonged to the Government Lymph Establishment, into an excellent research library. It can serve also as a lecture hall for an audience of about a hundred persons, and it was in this very recently completed room that the Minister of Health addressed the invited gathering after his inspection of the new building.

H. J. Bensted

# THE 'COMET' AIR-LINER

In a Friday Evening Discourse delivered at the Royal Institution, London, on November 21, Mr. C. T. Wilkins, assistant chief designer of the De Havilland Aircraft Co., Ltd., discussed the new 'Comet' air-liner.

The end of the Second World War left United States aircraft manufacturers with undisputed supremacy in the field of transport aeroplanes. Some six to eight years are needed to bring a modern air-liner into service from the initial design stage, and Mr. Wilkins pointed out that any attempt of the De Havilland Co. to base its designs on United States practice would not have been likely to produce an aeroplane with the necessary competitive margin. Instead, it was decided to draw on the mounting British experience with the jet engine, the main potential gains being speed, absence of vibration and relative simplicity.

The most promising configuration of aeroplane for this engine appeared to be the tail-less with swept-back wings, and a De Havilland 'Vampire' was modified into the 'D.H. 108'. This became the first British aeroplane to fly faster than sound in a dive, while level speeds at a little more than 600 m.p.h. were possible. This layout, when translated into air-liner practice, promised to be only 50 m.p.h. faster than the rather more orthodox configuration now seen in the 'Comet', and this latter was chosen mainly in order to provide a design for which production orders could be prudently made from the 'drawing board'. The British Overseas Airways Corporation, the former British South American Airways Corporation and the Ministry of Supply were courageous enough to give orders for a total of sixteen 'Comets' at that stage. This has meant a saving of two years in getting the aircraft into service due to the elimination of the 'prototype' stage. It took two and three-quarter years from the time that the conception was settled to the first flight, and an equal period until the 'Comet' came into service. The following are some of the problems which had to be solved.

*Choice of engine.* The 'Comet I' is fitted with the 'Ghost' centrifugal engine. This choice was dictated by expediency, and the later 'Comet' series will have the more powerful and efficient 'axial' engines which are now available.

*Flying at high altitude.* The optimum altitude for a flight of given stage-length is a function of the aircraft weight, and it therefore changes during flight as the fuel is consumed. A typical cruising procedure worked out for the 'Comet' requires an initial climb to 33,000 ft. in thirty minutes, followed by a gradual ascent to 40,000 ft. At this height the atmospheric pressure is 2 lb./sq. in., a temperature of − 73° C. has been recorded and the air is practically dry. These figures indicate the need for reliably engineered cabin pressurization, heating and humidification. At the time of design, little was known of conditions in the upper atmosphere, and a De Havilland 'Vampire' was adapted for making the necessary high-altitude research. This aeroplane established the present world altitude record of 59,446 ft.

*Drag.* The critical Mach number of flight above which the 'compressibility' drag rise becomes severe has been kept relatively high by the use of a thin swept-back wing and by careful design of the rest of the aeroplane. This is particularly necessary, since the speed of sound at the cruising altitude is only nine-tenths of its sea-level value.

*Tare weight.* The pay load of the 'Comet' is one-tenth of its 'all-up weight', while the fuel accounts for 49 per cent of the weight at take-off, and any unexpected changes in the weight of structure or fuel therefore have rather larger effects on the magnitude of the payload. However, the absence of airscrews ameliorates the problem not only due to the direct saving in weight but also due to the considerable reduction in the size of the undercarriage.

*Fuel storage.* Seven thousand imperial gallons of fuel are fitted into a thin wing of 115 ft. span, since it is inadmissible to use the fuselage for storage. To save space, tanks integral with the wing structure are used. The problems to be overcome here arise from the structural deformation in flight and from the high permeability of kerosine. The use of metal-to-metal bonding is superior to the classical riveted joints in this connexion, and it is used extensively throughout the 'Comet'. The fuel should be carried far out along the wing in order to reduce the bending moment at the wing root. In a swept wing this presents problems of the shift of centre of gravity, and the order of fuel usage becomes important. Kerosine is a safer fuel than petrol, but fire precautions are taken very seriously since the relighting of 'out' engines is to take place in the air.

*Controls.* The achievement of light control-surface operation is possible by aerodynamic means or by the use of power operation. The former alternative was decided against, in view of the long time usually taken in the early flight-trials to get the controls 'right'. No other useful flight-tests are possible until this stage is reached. A power-operated system, however, may be given thousands of hours of use in a ground rig in which most of the conditions of flight are simulated. For safety, each control is provided with two entirely independent power-units.

The solution of these and many other problems is the business of a design team consisting of designers, aerodynamicists and stress-men. Further necessary departments are structural testing, experimental, production and service. The organization is now developing the 'Comet II', which is the original machine modified to take the more powerful Rolls Royce 'Avon' engine, and the 'Comet III', a larger aeroplane altogether.

## BRITISH GELATINE AND GLUE RESEARCH ASSOCIATION

THE sixth meeting of the Research Panel of the British Gelatine and Glue Research Association was held at Beale's Restaurant, London, N.7, on November 27, 1952, with Mr. S. G. Hudson (Richard Hodgson and Sons, Ltd.), chairman of the Association, in the chair. Seventy-two persons attended the meeting, including representatives of the manufacturers of plant for the industry.

The meeting was the first held by the Association at which the papers were concerned with practical questions closely related to manufacture. This provided increased opportunity for discussion, of which full advantage was taken. The first paper, "Tannery Treatment of Pieces and Fleshings", by Dr. W. E. Braybrooks (Stokes and Co., Ltd.), described the processes to which the raw materials of the hide gelatine and glue industry are subjected in the tannery prior to dispatch to the gelatine works. The effect was discussed of short dehairing processes, using rotating drums in place of lime pits, on the hide itself, and often using substantial quantities of sodium sulphide in addition to lime.

In the second paper, "The Extraction of Hides", Mr. D. Fysh, of the Association's staff, described a series of experiments in which the industrial treatment of hides by lime suspensions, followed by neutralization, and then extraction of gelatine, was repeated on the laboratory scale. This enabled a number of variables to be studied, such as pH of extraction, time and temperature of extraction, period of lime treatment, etc. The gelatine produced was evaluated by means of measurements of its physical properties. The third paper was by Mr. D. B. Hall (John Knight, Ltd.), entitled "Bones Processing", in which he presented a detailed account of the origin, handling and processing of the raw material of the bone glue factory. The stage-by-stage analysis of the process showed the problems which arise in the various plant operations. Dr. E. M. Vyner (Sheppy Glue and Chemical Works, Ltd.) gave the final paper, under the title "Aspects of the Evaporation and Drying Process in the Glue and Gelatine Industry". Dr. Vyner reviewed the many possible methods by which a dry end-product may be obtained from a gelatine or glue solution. Apart from the normal methods of multi-effect evaporation, setting and drying, spray-drying and freeze-drying have been tried.

On the previous day, at the annual general meeting, Mr. G. W. Odey, chairman of Barrow, Hepburn and Gale, Ltd., was re-elected president of the Association. The chairman of the Association, Mr. S. G. Hudson, stressed the importance to firms using gelatine and glue of the work on this aspect being commenced by the Association. The director of research, Mr. A. G. Ward, in his report, and Sir Roger Duncalfe, chairman of British Glues and Chemicals, Ltd., who proposed a vote of thanks to the council and staff, both emphasized the value of close contact between the Association and the industry.

## CAREERS IN BIOLOGY

THE Institute of Biology recently held a second symposium on "Biology as a Career", at which were discussed fields not covered by the Edinburgh conference (*Nature*, 169, 1034; 1952). A theme common to many of the papers was the need for more biologists having a better training in chemistry and physics.

Sir Harold Himsworth (secretary, Medical Research Council) said that in modern medical research the collaboration of workers from many scientific disciplines is needed. On the scientific staff of the Medical Research Council there are some 440 graduates of whom one-third are medically qualified. Apart from the National Institute for Medical Research, the majority of the Council's staff work in special units which are similar in constitution and size to university professorial units and most of which are associated with universities. In addition, the Council has a system of scholarships for training in research methods. These are designed to enable first-degree graduates to supplement their training and experience in order to equip them for biological research in many fields for which competence in several branches of natural science is necessary. It is perhaps significant that, of those who have received grants, more than half needed training in chemistry and a quarter in anatomy, physiology, pharmacology, embryology or histology.

The work of the Agricultural Research Council in promoting investigations on fundamental problems as well as work of immediate importance was described by its secretary, Sir William Slater. Research is carried out in twenty-three research institutes and units and through some 150 research grants to individuals: this involves an annual expenditure of about £3,000,000. Biologists can be divided into 'naturalists' (or observers) and 'experimentalists'. Both types are needed by the Agricultural Research Council, which employs some 190 'naturalists' and 430 'experimentalists'. It is desirable that a person be well trained as an experimentalist or a naturalist with a general knowledge of the other aspect of his subject, but those poorly trained in both aspects are very difficult to place.

Dr. G. A. C. Herklots (secretary for Colonial Agricultural Research, Colonial Office) described how agricultural research in the Colonies is being developed, and gave details of the work carried out on some problems of considerable economic importance. A Colonial agricultural officer is selected from graduates in biology or agriculture and has two years further training, first in England and then in Trinidad. He then goes to a Colony as an adviser for an area, where he has the assistance of specialists working in a commodity, or a regional, research institute. To assist small Colonies with little or no resident specialists, pools of experts have been established in Britain so that a person can be sent to investigate *ad hoc* problems.

The attainments needed by a person attempting to solve the complex problems arising in applied entomology were given by Dr. W. E. Ripper (Pest Control, Ltd.) as a good knowledge of insect physiology and taxonomy, fair chemistry, some botany and a good grounding in methods. Dr. Ripper looks forward to applied entomology being practised in a manner similar to medicine by a self-governing profession.

The emergence of the antibiotics industry and developments in food processing are considered by Mr. H. J. Bunker (Barclay Perkins, Ltd.) to have accentuated the demand for microbiologists, resulting in favourable prospects of employment for those suitably trained. A biological subject with chemistry as subsidiary is the more desirable combination as a basis for a career in microbiology. Courses, sometimes specialized for a particular field, are offered by a number of universities, but there are as yet insufficient honours degree courses.

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# STATISTICAL METHOD IN TRANSPORT MANAGEMENT

THE number of suggested definitions of statistics runs into hundreds: many of them are practically indistinguishable one from another, but there have grown up, during the first half of this century, two main schools of thought on the subject. One (with history on its side) regards statistics primarily as the routine and exhaustive compilation of data and their arrangement into tables capable of revealing the required information, if not at a glance, at least without any esoteric mathematical manipulations; the other tends to stress the more modern concept of statistics as the science of drawing, by arguments depending on the theory of probability, generally valid conclusions from particular bodies of data, acquired either by a sampling process or as a product of experiment.

Statistics of the first type has always been an indispensable adjunct to management, whether of a State, a hospital, a factory, or a public undertaking such as the London Transport Executive. More recently, however, the 'small-sample' methods of the second school, developed first for research in biology and later applied to industrial experimentation, have become accepted as potentially valuable tools for managements anxious to investigate not merely the occurrence but also the reasons for the occurrence of observed social phenomena. A public-transport undertaking cannot reasonably hope to run at full efficiency without some knowledge, on one hand, of the social habits and requirements of its potential users and, on the other, of the various changeable factors which may affect such quantities as journey times, fuel consumption, accident-rates, and the useful life of vehicles. These problems have been intensively studied by the London Transport Executive; some results of its sample survey of the travelling habits of the London public were given in the "London Travel Survey"[1], and Mr. F. A. A. Menzler, chief development and research officer of the Executive, has now given, in his paper on "Statistical Methods and Operational Research in Transport", read before the Institute of Transport on November 17, 1952, some examples of the methods in use for the study of routine vehicle operation.

The 'control chart' method, extensively developed during the Second World War for the control of mass-production processes, has many obvious applications in routine management. Mr. Menzler gives examples of its use for investigating weekly failure-rates of various components, including an analysis of puncture-rates in which the control-chart exhibited a periodic fluctuation.

Many investigations have been made of 'passenger habits', some by selective observation, others by actually interviewing a sample of passengers. Habits studied include boarding and alighting at or between stops (the results were used in conjunction with accident statistics to determine the relative dangers of these practices—a nice example of the use of operational research methods to assist in the interpretation of routine statistics), and use of destination blinds. (It appeared that "a substantial proportion rely upon word-of-mouth sources of information, and are mistrustful of notices, maps or posters".)

The standard methods of experimental design, derived to eliminate and allow for the effects of heterogeneous biological material, can be profitably used in dealing with the even more heterogeneous conditions prevailing in transport operation. Mr. Menzler describes, among others, a 'latin square' design used in comparing the fuel consumed by various driving techniques, and a 'cross-over' design used to study the effects of different carburettor settings. Also described is an interesting example of a regression analysis illustrating the amounts by which various causes contributed to an increase in fuel consumption for 1951 over that for 1950.

Mr. Menzler ends by asserting, clearly with reason, that "there are few aspects of transport operation and engineering that might not gain from operational research".

M. R. SAMPFORD

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[1] London Transport Executive, 1949.

# INHIBITION OF TUMOUR GROWTH BY D-GLUCOSAMINE

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AND

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THIS article constitutes a preliminary report of our experiments on the effects of D-glucosamine on the inhibition of tumour growth in mice.

Our interest in D-glucosamine arose with the work of Harpur and Quastel[1] on the phosphorylation of D-glucosamine by adenosine triphosphate in presence of hexokinase of brain tissue. Brown[2] showed that this reaction also occurs in the presence of yeast hexokinase, D-glucosamine-6-phosphate being formed. A competition between glucose, fructose and D-glucosamine takes place in brain tissue for the enzyme responsible for the phosphorylation of these sugars[1], the affinities of fructose and D-glucosamine for the enzyme being of the same order and less than that of glucose. Harpur and Quastel[3] then observed that the rate of acetylcholine synthesis in brain extracts is inhibited by the presence of D-glucosamine. This is due to the fact that the process of phosphorylation of D-glucosamine diminishes the amount of adenosine triphosphate available for the acetylcholine synthesis. It thus became clear that the addition of D-glucosamine to a tissue may provide a means of diverting adenosine triphosphate from its normal metabolic paths.

Owing to the fact that the energy required by rapidly proliferating tumour cells for their synthetic processes seems to come largely from the breakdown of glucose and the participation of adenosine triphosphate, it seemed possible that administration of D-glucosamine in sufficiently large quantities into tumour-bearing animals might divert adenosine triphosphate activity sufficiently to affect the rates of the metabolic paths involved in tumour proliferation. Even if the diversion only occurred to a small extent, it might be large enough to impede the rate of proliferation of the rapidly growing tumour cells.

Accordingly, experiments have been carried out during the past two and a half years to observe the effects of the administration of D-glucosamine to mice bearing the tumour sarcoma 37. The results indicate that at concentrations of D-glucosamine which produce no adverse effects on the normal animal, and which give rise to no signs of shock or toxicity, a marked inhibitive effect on the growth of the tumours takes place. The survival-rate of the tumour-bearing animals is practically doubled, while the value for the activity of liver catalase, which is lowered in the presence of tumours, is considerably increased after D-glucosamine administration. It is to be noted, however, that Lustig and Wachtel[4] have examined the effects of a large number of substances of biochemical interest (alkaloids, amino-acids, sugars, amines, and also D-glucosamine) on the development of Ehrlich mouse carcinoma, and reported D-glucosamine to be without effect.

## Experimental Details

*Animals.* Experiments were carried out with mice of the *C.F.W.* strain, as well as with a strain of hybrid albino mice supplied locally. The tumour (sarcoma 37) used was originally obtained from the National Cancer Institute, Bethesda, Maryland. Transplantation of the tumour was carried out by injection, either into the right flank or the right hindquarter of the mouse, of approximately 0·05 ml. of a tumour mash composed of 1 volume of minced tumour tissue diluted with 1 volume of 0·9 per cent sodium chloride solution. This preparation of tumour mash, which was obtained with aseptic precautions, gave a high percentage of successful grafts. The tumours were six days old when they were used for transplantation. They were then usually between 0·5 and 1·0 cm. in diameter, and were well vascularized and showed no necrosis.

Spontaneous regressions were very rare in the animal strains employed once a palpable tumour had been observed, that is, when the inoculant had been successfully grafted and no bacterial contamination had taken place.

*Technique.* Groups of twenty animals, male and female, were used in this investigation, ten animals in each group serving as untreated controls.

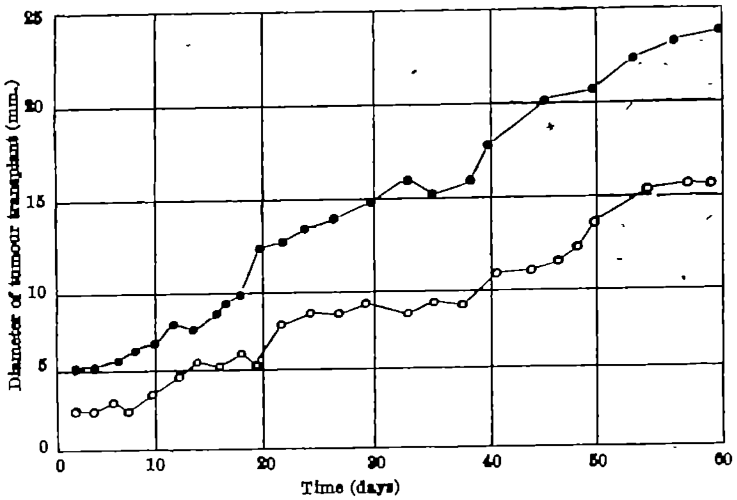
Aqueous neutral solutions of D-glucosamine hydrochloride, or of other substances, were injected intraperitoneally into mice bearing four- to six-day old tumours. Daily injections of either 0·1 ml. (containing 2·5 mgm. D-glucosamine hydrochloride) or 0·2 ml. (5 mgm.) were made and the tumours were examined daily for regression or inhibition of growth. In one group of experiments injections were given the day following implantation of the tumours with subsequent daily injections. The injected mice were carefully compared with equal numbers of control untreated tumour-bearing mice, at least ten animals being used for each test. The animals were usually killed after three weeks and the tumours examined for gross and microscopic effects. Representative slices of the tumours were fixed in Zenker–formol solution, sectioned, and stained with hæmatoxylin-eosin and evaluated histologically.

*Rate of development of sarcoma 37 in C.F.W. mice* (Carworth Farms mice). Typical results showing the effects of D-glucosamine injection on the growth of the tumours are given in the accompanying graph. It is obvious that the administration of D-glucosamine brings about a marked inhibition in the rate of growth of the tumour. At the given rates of admin-

Table 1. MORTALITY OF TUMOUR-BEARING MICE, WITH AND WITHOUT D-GLUCOSAMINE HYDROCHLORIDE ADMINISTRATION

Treatment of the groups of 20 mice in single daily doses started 2–6 days after transplant. The average survival-time for mice treated with D-glucosamine was 70–80 days, whereas that for untreated mice or those treated with glucose was 30–40 days

| Treatment of groups of 20 mice | No. of animals dead 20–50 days following tumour implantation | No. of animals dead 50–100 days following tumour implantation |
|---|---|---|
| Control. No treatment | 20 | 0 |
| 0·1 ml. (2·5 mgm.) D-glucosamine hydrochloride injected daily | 2 | 18 |
| 0·1 ml. (2·5 mgm.) D-glucose injected daily | 19 | 1 |
| 0·2 ml. (5 mgm.) D-glucosamine hydrochloride injected daily | 0 | 20 |
| 0·2 ml. (5 mgm.) D-glucose injected daily | 19 | 1 |



Rate of development of sarcoma 37 in groups of *C.F.W.* mice, with and without D-glucosamine treatment

●, Control mice, after 6-day transplant (ten animals per group); ○, mice, after 6-day transplant, injected daily with 0·2 ml. D-glucosamine hydrochloride (5 mgm.) solution (ten animals per group)

istration of D-glucosamine no complete inhibition of the development of the tumour takes place. A considerable retardation in the development of the tumour mass, however, occurs.

*Mortality of the tumour-bearing mice.* While all the implanted animals die between twenty and forty days following tumour implantation, the majority dying between thirty and forty days, those animals that have been injected with D-glucosamine hydrochloride survive this period and usually do not die until between seventy and eighty days following the implantation of the tumour. Some animals have survived for a hundred days. This has not been found to occur in tumour-bearing animals that have not been treated with D-glucosamine. Administration of glucose instead of D-glucosamine in approximately the same amount has no effect on the mortality-rate of mice bearing sarcoma 37. Typical results of these experiments are shown in Table 1, and indicate the specific activity of D-glucosamine in affecting the survival-rate of the tumour-bearing mice.

*Liver catalase of C.F.W. mice.* As is now well known, the amount of catalase in livers of tumour-bearing mice is lower than that of the normal animals[4-7]. Expressing liver catalase activity in ml. of oxygen produced per second, using the technique of Greenstein and Andervont[6], the liver catalase for normal mice is found to vary between 1·0 and 3·0. The liver catalase, however, of mice bearing sarcoma 37 falls to between 0·1 and 0·5 after forty days following the transplantation of the tumour. When mice bearing sarcoma 37 are injected daily with D-glucosamine solution (2·5 mgm.), the liver catalase activity forty days after transplantation has a value of 1·7. In certain animals, the activity even at seventy-five days is 1·0, and at eighty-five days following transplantation it is 1·2. With mice bearing sarcoma 37, which have been given glucose injections instead of D-glucosamine, the liver catalase activity is not increased.

Table 2. LIVER CATALASE ACTIVITY OF TUMOUR-BEARING *C.F.W.* MICE, WITH AND WITHOUT D-GLUCOSAMINE HYDROCHLORIDE ADMINISTRATION

Activity expressed as ml. oxygen/sec. (Greenstein and Andervont, ref. 6). Results are the average for ten mice (average weight, 23·5 gm.)

| | Activity |
|---|---|
| Normal *C.F.W.* mice | 1·0–3·0 |
| Sarcoma-37 mice after 40 days. (6 days transplant.) No treatment | 0·1–0·5 |
| Sarcoma-37 mice after 40 days. Treated daily with D-glucosamine hydrochloride (5 mgm.) | 1·7 |
| Sarcoma-37 mice after 40 days. Treated daily with D-glucose (5 mgm.) | 0·1 |
| Sarcoma-37 mice after 40 days. Untreated but tumour removed | 1·8 |

It is therefore clear that administration of D-glucosamine to tumour-bearing mice not only results in a retardation of tumour growth but also in a marked diminution of the rate of fall of the catalase activity of the liver. The results given in Table 2 indicate these findings, and show also that the removal of tumours from mice bearing sarcoma 37, after forty days transplantation, also results in an increase of the liver catalase activity.

*Effects of administration of glucose–ammonium sulphate mixtures.* Experiments were carried out to observe whether administration of mixtures of equimolecular quantities of glucose and ammonium sulphate might have effects resembling those of D-glucosamine on mice bearing sarcoma 37. An injection of 2 ml. of a mixture containing 90 mgm. glucose and 67 mgm. ammonium sulphate per ml. into groups of ten mice of mixed sexes was followed by the death of all the animals three days after the injection. Death was due to pulmonary œdema and toxic hepatitis. The minimum lethal dose of the mixture was 0·1 ml. Injection of this quantity into the mice had no toxic effects on sarcoma transplants following ten daily injections. No regression of the tumour mass, nor toxic hepatitis, nor pulmonary œdema was found. Injection of ammonium sulphate solution alone at the minimum lethal dose of 0·1 ml. caused no regression of the tumour mass. Injection of larger quantities—1·0–3·0 ml. of the ammonium sulphate solution—gave rise to toxic effects on lung, liver and kidney. But even in these circumstances no effects on the tumour mass were found during the time that the animals survived.

The results of these experiments seem to indicate that the cytotoxic effects of D-glucosamine on sarcoma 37, and the inhibition of tumour growth, cannot be ascribed to the liberation of ammonia by decomposition of the glucosamine.

*Pathological findings following D-glucosamine administration.* After the injection of D-glucosamine into mice bearing sarcoma 37, there usually appears extensive hæmorrhagic areas in the tumours, which also show some softening. This may occur 24–48 hr. after the initial injection when the tumour shows diffused hæmorrhage.

The microscopic findings resemble the gross findings. Cytotoxic effects, due to D-glucosamine injection, are obvious. The earliest damage is observed after about two hours, when there occurs a shrinkage of the nuclei, retraction of cytoplasm and marked eosinophilia. Between 6 and 8 hr., further degeneration takes place. The nuclei become markedly pycnotic with further cytoplasmic retraction and definite eosinophilia.

At a later stage, there is stasis with more extensive pycnosis and necrosis. This is soon followed by the production of distorted mitotic figures. After 48 hr., normal proliferating cells may be seen frequently at the periphery of the tumour, while cellular disintegration is observed in the severely affected portion.

The necrosis is followed later by autolysis, the supporting structure is destroyed and only a few abnormal cells, mostly near the periphery, can be distinguished. The tumour decreases in size but no complete regression has been noted.

*Effects of* D-*glucosamine administration to normal animals.* No toxic effects, or signs of shock, have been noticed when D-glucosamine, in the quantities mentioned, are injected intraperitoneally into normal mice.

A routine histological examination of all animals treated with D-glucosamine has shown that no abnormal effects are present in the liver, spleen, kidneys, suprarenals, or the intestinal mucosa of the animals. Blood counts (red and white cells) of both normal mice and tumour-bearing mice are unaffected by D-glucosamine administration.

Too few experiments have yet been carried out to discover whether injections of high concentrations of D-glucosamine will bring about abnormal changes in the animal tissues. So far, we have observed no toxic symptoms in normal animals following D-glucosamine injections.

## Conclusions

The observations recorded indicate that the administration of D-glucosamine to mice bearing the tumour sarcoma 37 results in a marked inhibition of the rate of growth of the tumour and in the development of cytotoxic effects in the tumour itself. No complete regression of the tumour has been observed under our experimental conditions, but the results indicate a marked specificity of action of the substance on the tumour mass as compared with that on the host tissue. Many substances are now known to have cytotoxic effects on tumours, but it is the relative inactivity of D-glucosamine on the host tissue which is a striking feature. The fact that the liver catalase activity does not diminish to the same extent in animals that have been treated with glucosamine as in those that have not been so treated is in agreement with the pathological findings. The survival-rate of tumour-bearing mice treated with D-glucosamine is considerably greater than that of untreated animals, and gives rise to the hope that D-glucosamine (or its derivatives) may represent a substance with distinct chemotherapeutic possibilities.

It is significant that D-glucosamine was investigated because of its ability either to compete with glucose in its initial reactions with adenosine triphosphate, or to divert the latter substance from its normal metabolic pathway in tumours. The cytotoxic effects of D-glucosamine on sarcoma 37 do not necessarily mean that the substance is behaving in the manner that has been pictured. The results do indicate, however, that this line of approach may be well worth following up. It seems to us very possible that D-glucosamine derivatives or analogues may be found which are much more effective than D-glucosamine itself, and that these substances, while having relatively little effect on the host tissue, may bring about marked changes in the rate of development of the tumour. Very recent experiments of Ikawa *et al.*[8] seem to indicate that certain polysaccharides having tumour-inhibiting properties possess D-glucosamine as part of their structure.

We are grateful to the National Cancer Institute of Canada for grants which have made this work possible. [Dec. 11.

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# FLUOROMETRIC ANALYSIS OF URINARY STEROIDS

By Dr. M. FINKELSTEIN

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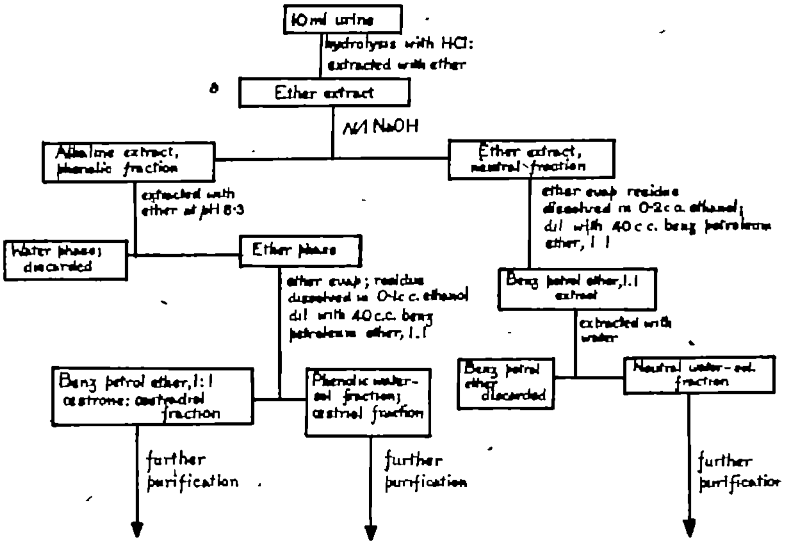
The study of the metabolism of œstrogenic hormones was made difficult by the lack of suitable quantitative methods for the determination of the three naturally occurring œstrogens, namely, œstradiol, œstrone and œstriol, and of their metabolites.

To meet this difficulty in part, with the collaboration of Drs. Hestrin and Koch, I elaborated, some years ago, a fluorometric method for the quantitative determination of crystalline œstrone, œstradiol and œstriol[1]. This method was based on the old observation of Wieland, Straub and Dorfmueller[2] and of Marrian[3] that these œstrogens when heated with sulphuric acid develop a bluish-green fluorescence. We have found, however, that sulphuric acid was not suitable for quantitative determination, because high and irregular blank readings were encountered and the reproducibility of the results was unsatisfactory. Phosphoric acid, on the other hand, showed only negligible blank readings, and by taking suitable precautions a linear relationship between the concentration of any of the œstrogens and of the fluorescence intensity was obtained.

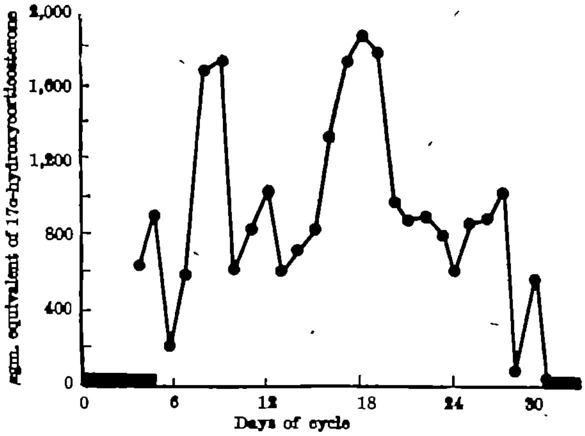
As the ultimate object of our study was to adapt this method for the determination of the œstrogenic hormones in urine and blood, attempts were made to make use of existing partition methods for the urinary œstrogens and to apply the fluorometric measurements to the purified fractions. However, it soon became evident by comparison of the fluorometric results with bioassay and also from recovery experiments that the fractions under investigation contained some substances, different from the œstrogens, which interfered with the fluorometric readings. This led us to re-investigate the partition procedure and, as a result, a modified partition method was developed[4]. The accompanying chart shows schematically the course adopted; crude extract has thus been divided into three fractions: (1) œstrone–œstradiol fraction, (2) œstriol fraction, and (3) neutral water-soluble fraction. Recovery experiments using this partition procedure gave satisfactory results both in the œstrone–œstradiol and in the œstriol fraction. As little as 20 γ of any of these œstrogens added to 1 litre of urine could be determined with an accuracy of ± 20 per cent. Comparison of results obtained by bioassay and fluorometry performed on several samples of preg-


10 ml urine
hydrolysis with HCl: extracted with ether
Ether extract
N/1 NaOH
Alkaline extract, phenolic fraction
Ether extract, neutral fraction
extracted with ether at pH 8·3
Water phase; discarded
Ether phase
ether evap; residue dissolved in 0·1 c.c. ethanol dil with 40 c.c. benz petroleum ether, 1.1
ether evap residue dissolved in 0·2 c.c. ethanol; dil with 40 c.c. benz petroleum ether, 1.1
Benz petrol ether, 1.1 extract
extracted with water
Benz petrol ether, 1:1 oestrone: oestradiol fraction
Phenolic water-sol fraction; oestriol fraction
Benz petrol ether discarded
Neutral water-sol. fraction
further purification
further purification
further purification

Partition of the crude urinary extract

nancy urine showed good agreement in respect of concentrations of oestrone and oestriol. Urine of normal menstruating women yielded also a comparable result by both methods. On the other hand, fluorometric analysis of normal male urine consistently furnished values of oestrone about five times higher than the values obtained by bioassay. We have also obtained the same ratio when analysing urine of two female pseudohermaphrodites. It seems to us that in both cases we are dealing with one substance, which may prove to be a metabolite of the oestrogens.

With regard to the neutral water-soluble fraction, we have observed that it also contains some substance, or substances, which on treatment with phosphoric acid give rise to fluorescence. This fluorescence was usually somewhat more intense in the case of male urine than in normal female urine. Calculated in terms of 17-hydroxycorticosterone, the mean excretion of the fluorogenic material was about 1,300 γ/litre in the case of male and about 800 γ/litre in female urine. With the collaboration of Miss Berlin, we have carried out daily analyses of female urine throughout the menstrual cycle. Two peaks in excretion were usually observed: one at about the tenth day of the cycle and the second at about the twentieth day (see graph). Urine of postmenopausal women did not show these cyclic changes, but day-to-day fluctuations were recorded.



Excretion of the neutral fluorogenic substance during a menstrual cycle

A very pronounced increase in the excretion, about five times higher than in the normal female, was found in the case of the two female pseudohermaphrodites previously mentioned[4]. The excretion of the fluorogenic material in these cases was 4,000–5,000 γ per litre urine, and was fairly constant. The urine of these patients seemed to us to be a good source for isolation purposes, and accordingly we carried out the extraction and partition of about 100 litres of urine. The neutral water-soluble fraction was sent to Prof. T. Reichstein; he isolated three crystalline compounds, one of which showed the characteristic fluorescence. Work on the identification of these compounds is now in progress in Prof. Reichstein's laboratory in Basle.

In addition to the two female pseudohermaphrodites, we have found thus far an increased excretion of the fluorogenic substance in one case of arrhenoblastoma, and constantly in late pregnancy urine. There it amounts to about 2–4 mgm. per litre urine. Injection of 300 mgm. adrenocorticotropic hormone in daily doses of 100 mgm. resulted also in a fourfold increase over the control period.

Since some corticosteroids also produce fluorescence on being heated with phosphoric acid, the question arose whether the increased excretion might be attributed to their presence in the neutral water-soluble fraction. Parallel determination of urinary extracts for corticosteroids and for the fluorogenic substance did not result in a positive correlation.

In the case of the two pseudohermaphrodites, the excretion of corticosteroids was either within normal limits or only very slightly elevated, whereas the fluorometric values were much above 'normal'. In cases of the Cushing syndrome and in several cases of hirsutism and virilism, excretion of corticosteroids was increased, whereas excretion of the fluorogenic substance was unchanged. A marked increase in excretion of both corticosteroids and the fluorogenic substance was observed only in late pregnancy urine.

Isolation studies have been undertaken in order to determine whether the excretion of the fluorogenic material in the cases cited here consists of one and the same compound, or whether we are dealing with several fluorogenic compounds.

I would like to express my thanks to the staff of the Hormone Research Laboratory of the Hebrew University for their collaboration, and to Prof. Bernhard Zondek for his guidance during the performance of these experiments. My thanks are also due to Prof. C. W. Shoppee, University College, Swansea, for his valuable suggestions made in the course of the preparation of the manuscript. [Sept. 12.

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# LETTERS TO THE EDITORS

*The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications*

## Effects of Daily Irradiation by Fast Neutrons on Male Fertility

SINCE January 1, 1951, the smaller pile at Harwell has been used for irradiating *CBA* mice daily with fast neutrons. These were fission neutrons obtained by allowing thermal neutrons escaping from the graphite reflector to interact with uranium on the floor of the compartments in which the animals were housed. It is believed that less than 5 per cent of the biological effects produced was due to contaminating radiations. Dose-rates were measured with homogeneous 'tissue' ($C_{0\cdot18}$ $H_{1\cdot00}$ $N_{0\cdot04}$ $O_{0\cdot48}$) and hydrocarbon (CH) ionization chambers, an allowance being made for gamma-ray ionization by simultaneous readings with an argon chamber[1].

The purpose of this preliminary report is to record the unexpected sensitivity of the mouse testis. A dose of 70 rep. at the weekly dose-rate of 8·3 rep. reduced the fertility of *CBA* mice to half that of controls, using a standard mating test in which the test male is left for four nights with four *CBA* females aged 2–5 months. An accumulated dose of 100 rep. halved the average weight of the testis, and after the same dose there has been no recovery of fertility at any time right up to the age at which unirradiated controls become naturally sterile.

In contrast, the female *CBA* mouse was less sensitive to the sterilizing effects of fast neutrons. An accumulated dose of 140 rep. in seventeen weeks did not seem to affect the ability to conceive or produce young.

The difference in sex sensitivity is opposite to that usually accepted for X- and gamma-rays[2], and the low dose for absolute sterilization in males is also noteworthy[3]. The dose-rate which produced such striking testicular damage had no effect on growth-rate or body-weight for thirty-five weeks, produced no great hæmatological changes by the time the male mice were permanently sterile, and did not appear to produce cataracts until some time after considerable losses in weight occurred.

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## Electron Microscope Studies of the Structure of the Influenza Virus

FROM studies of the growth-cycle of influenza virus, Hoyle[1,2] formed the hypothesis that the virus elementary body consisted of an aggregate of smaller units, and Burnet and Lind[3] arrived at a similar concept from studies of virus variation. Hoyle[2,4] showed that the virus could be disintegrated by shaking with ether, with the production of separate red-cell agglutinating and complement-fixing particles of smaller size than that of the elementary body.

Fig. 1

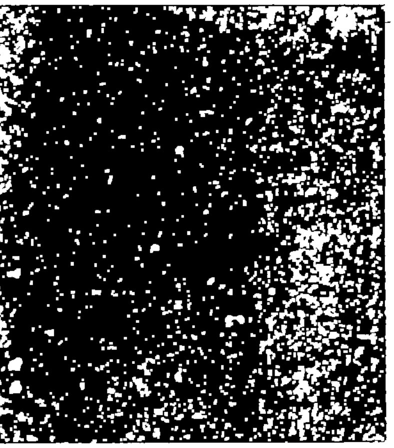
Fig. 2

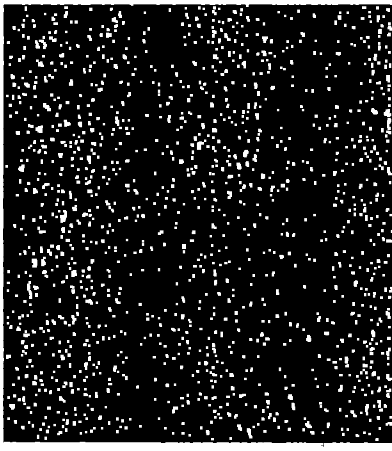
Fig. 3

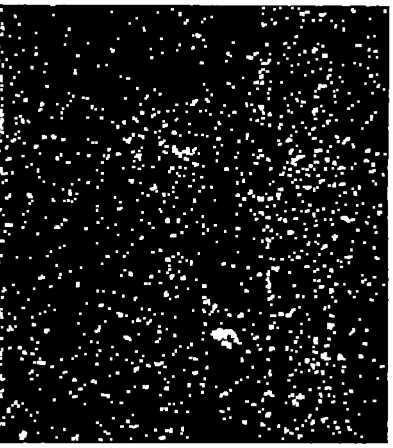
Fig. 4

A concentrated suspension of *DSP* strain of virus *A* was prepared as described by Hoyle[4] from infected allantoic fluid by adsorption on and elution from chick-embryo red cells. The preparation was fixed with osmic acid, and electron micrographs at an instrumental magnification of 7,500 were taken of drops on collodion-filmed grids, which were first drained, dried and washed with distilled water, then dried again and shadowed with chromium. Fig. 1 is an enlarged negative print showing elementary bodies of average size about 1250 A., together with smaller particles ranging from about 100 A. to 500 A. Many of the elementary bodies have a roughly hexagonal outline.

The elementary bodies observed in infected allantoic fluid appear to be released from the cells of the chorio-allantoic membrane by a process of cytoplasmic disintegration; but a similar disintegration may occur in normal cells, with the result that particles of cytoplasmic origin are found also in normal allantoic fluid[2]. Fig. 2 shows an electron micrograph of a preparation made from uninfected allantoic fluid. Large particles are present; but they are rather smaller than the virus elementary bodies, and are more flattened and less regular in outline. These particles may be derived by disintegration of the cytoplasm of desquamated chorio-allantoic membrane cells present in normal allantoic fluid. They do not agglutinate red cells.

When the suspension of *DSP* virus was shaken with ether and then incubated overnight, the elementary bodies were completely disintegrated and the ether-treated suspension showed only a great number of small particles ranging from about 100 A. to 500 A. By adsorption with red cells this suspension could be fractionated into two components: a red-cell agglutinating fraction recoverable from the red cells by elution, and a complement-fixing fraction not adsorbed by the cells. The properties of these fractions have been described[4].

Fig. 3 is an electron micrograph of the complement-fixing 'soluble antigen' fraction. It shows numerous small particles mostly of size about 120 A. There is also a fair number of about twice that size; but larger particles are very infrequent. Filtration of the preparation through a 'Gradocol' membrane of average pore diameter 300 A. removed both the particles and the complement-fixing antigen.

The red-cell agglutinin fraction (Fig. 4) shows a greater range of particle sizes. Numerous particles of about 120 A. are present; but there are also many others of larger size, notably about 500 A. Adsorption of the preparation with red cells removes both the smaller and larger particles, and both can be recovered by elution.

The concept that the influenza virus elementary body consists of an aggregate of smaller units is therefore supported by electron microscope studies. It seems clear that the particles seen in the electron micrographs include those that carry the biological properties of the two fractions, and moreover the indications are that both the red-cell agglutinin and the complement-fixing antigen have a particle size of about 120 A., the larger particles being probably aggregates.

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Nov. 18.

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[2] Hoyle, L., *J. Hygiene Camb.*, 48, 277 (1950).
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## Application of the Quantum Hit Theory to Tumours Induced by Ultra-violet Radiation

WE have previously described the application of the quantum theoretical hit theory to tumours induced by carcinogenic hydrocarbons[1] and by viruses[2]. We have now applied the theory also to skin tumours induced by ultra-violet radiation.

In the experiments of Blum, Grady and Kirby-Smith[3], several groups of mice were irradiated with various doses, $D$, of ultra-violet light, given at different regular intervals of time, $t_i$. The mean induction time, $\bar{t}$, between the first irradiation and the appearance of the first tumour was measured as a function of $D$ and $t_i$. According to our theory, the variation of $\bar{t}$ with $D$ and $t_i$ should follow the expression:

$$\bar{t} = \frac{t_i}{k_e D} + T. \qquad (1)$$

Here $k_e$ and $T$ are two constants, the former denoting the probability per unit time and unit dose of an excitation of a cell by the ultra-violet radiation, the latter denoting the mean time of growth of a tumour from the time of excitation to the time at which the tumour has grown sufficiently to be palpable or visually detectable. From (1) we see that if $\bar{t}$ is plotted against $1/D$, we should get straight lines cutting the ordinate axis in the common point $(0,T)$ and having slopes proportional to $t_i$ with the proportionality factor $1/k_e$. In Fig. 1 we give for $t_i = 1 \cdot 0$, $1 \cdot 4$ and 7 days, respectively, the experimental mean induction times (in days) as found by Blum, Grady and Kirby-Smith, which are seen to cluster around three straight lines.

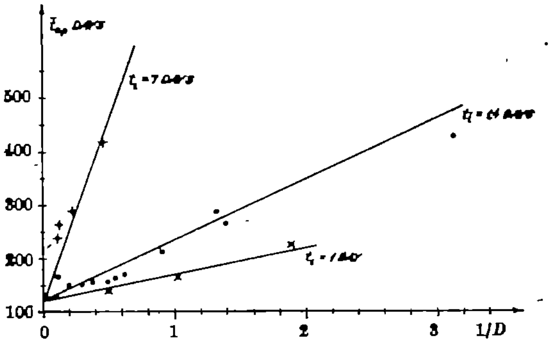

Fig. 1

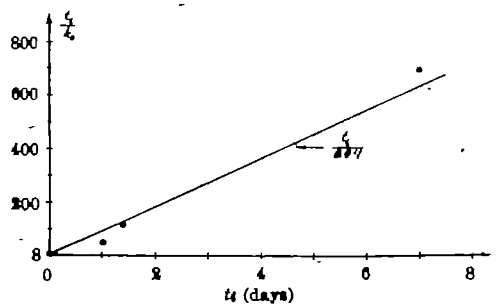

Fig. 2

In Fig. 2 we have plotted the slopes of these lines against $t_i$, and it is seen that they lie about a common straight line corresponding to $k_e = 0 \cdot 011$. Thus the experimental findings of Blum, Grady and Kirby-Smith are in satisfactory agreement with our theory, and consequently they give new and independent evidence for the applicability of the quantum hit theory to the problem of the mechanism of carcinogenesis.

A detailed account of the application of the quantum hit theory to tumours induced by ultra-violet radiation, including the theoretical deduction of the incidence versus induction time curves, will shortly be published (*Acta Path. et Microbiol. Scand.*).

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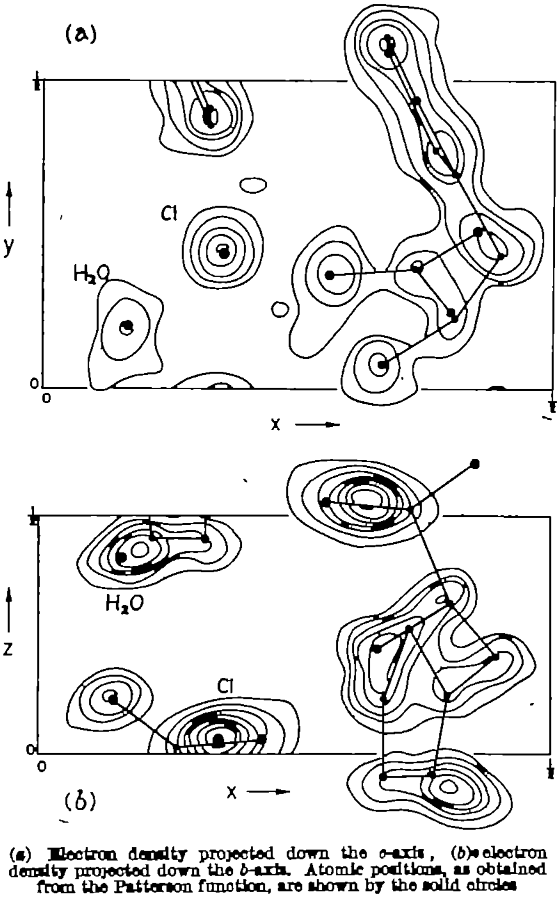
## Crystal Structure of Histidine Hydrochloride Monohydrate

Crystals of the hydrochloride monohydrate of the important amino-acid histidine can be obtained as rather thick tablets by evaporation of aqueous solutions containing a little hydrochloric acid. X-ray examination shows that the crystals are orthorhombic, with unit cell edges $a = 15{\cdot}36$ A., $b = 8{\cdot}92$ A. and $c = 6{\cdot}88$ A. The space group is $P2_12_12_1$, and there are four molecules in the unit cell. The structure was obtained from a three-dimensional Patterson function which was interpreted by means of the vector convergence method[1].

The atomic parameters as indicated by the vector convergence diagram were adjusted somewhat in order to improve the agreement of the calculated interatomic vectors with observed Patterson peaks. The structure factors of the three prism zones were then calculated; the average discrepancy, $R$, for the 256 observed reflexions was 27 per cent. The structure factors of 170 of these reflexions were then treated by the method of least squares[2]. Shifts in the atomic parameters averaging 0·06 A. were obtained.



(*a*) Electron density projected down the *c*-axis, (*b*) electron density projected down the *b*-axis. Atomic positions, as obtained from the Patterson function, are shown by the solid circles

Plots of the electron density projected down the *c*- and *b*-axes were then prepared, by use of 89 of the 121 observed ($hk0$) reflexions and 57 of the 98 observed ($h0l$) reflexions respectively. The resulting maps are reproduced herewith. Contours were drawn at equal arbitrary intervals, except about the chlorine atoms, where they are drawn at half that interval. The atomic shifts suggested by these plots are in fairly good agreement with those obtained from the least-squares treatment.

From the degree of resolution in these projections it is doubtful whether the structure in three dimensions could have been obtained from them alone. On the other hand, once having determined the structure from the Patterson function, it is probable that a satisfactory refinement can be achieved without recourse to laborious three-dimensional Fourier and least-squares analyses, which involve complex structure factors.

The parameter refinement has been temporarily postponed, and since at the present stage of the work the standard error in a parameter is about 0·05 A., any discussion of the structure, such as which of the many tautomeric forms of the imidazole ring is present in the crystal, the precise dimensions of this heterocyclic ring, and the nature of the hydrogen bonding, must be deferred. At present, nevertheless, it is established that the histidine molecules in the crystal do not assume an extended configuration, but tend rather to curl back on themselves—a situation which may arise from significant attraction between the carboxyl group and the imidazole ring.

This work was carried out under Contract Nonr-220(05) with the Office of Naval Research.

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Oct. 30.

[1] Beevers, C. A., and Robertson, J. H., *Acta Cryst.*, 3, 164 (1950).

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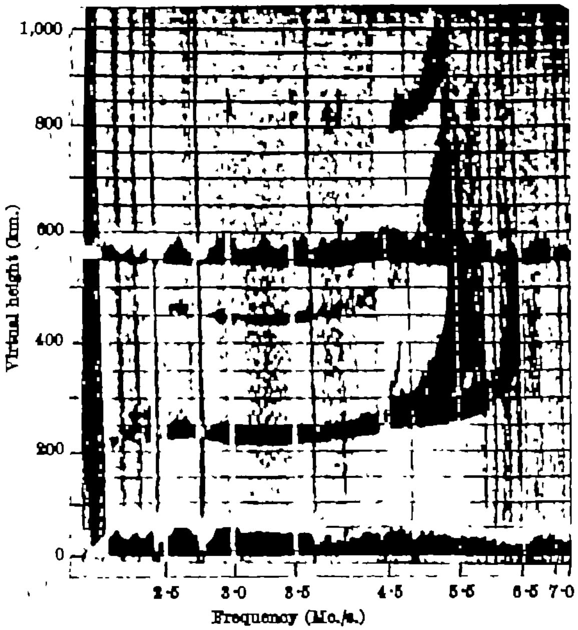
## Angle of Arrival of Z Echoes

It has been suggested by Scott[1] that uncoupled *F*-region *Z* echoes are due to longitudinally propagated waves reflected from an area near the magnetic zenith.

Measurements of the angle of arrival of *Z* echoes have recently been made at Hobart (geomagnetic latitude 51° S., dip 72°) in order to test this suggestion. The mean direction was found to be in the magnetic plane 7·8° north of the vertical. Thirty-four measurements were made between July 13 and August 3, 1952, on a frequency of 4·65 Mc./s. In all cases the *Z* echoes were observed during the late afternoon, the height of reflexion being between 170 km. and 210 km.

According to Scott's hypothesis, a collision frequency of about $1{\cdot}5 \times 10^5$ per sec. would be needed to explain the observed angle. This is inconsistent with previous estimates of collision frequency, which suggest that it is about $10^4$ per sec. at 200 km.



I wish to thank the Electrical Engineering Department of the University of Tasmania for the provision of facilities and assistance in building the apparatus, and also the Radio Research Board of the Commonwealth Scientific and Industrial Research Organization for a grant in aid of the investigation.

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Prediction Service,
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Aug. 8.

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## Reflexion Coefficient of Radio Waves from Frozen Terrains

During the period January–February 1952, measurements were made in northern Canada in order to determine the reflexion coefficient of radio waves for normal incidence from deeply frozen land or sea. The frequency used was 1,600 Mc./s.

The method of measurement was to transmit a linearly polarized pulse signal vertically downwards from an aircraft flying at heights between 10,000 ft. and 20,000 ft. and to receive the signal re-radiated from the ground on a suitable receiver in the aircraft. Attenuation was inserted in the aerial lead of the receiver to maintain a constant received signal strength as the reflexion from the ground varied. The loop gain of the equipment was checked periodically to confirm that the performance of the equipment remained unchanged during the measurements. In addition, the signal was compared, whenever possible, with reflexions from open-water leads in Hudson Bay or the Great Lakes shortly before or after the measurements over the terrain in question. This was used as a standard for comparison.

It had been believed that the smallest reflexion coefficients likely to be met would not be lower than that from dry desert sand. This had already been checked over the shifting sand dunes of the Sinai Desert and also in desert areas in North Africa. The measurements agreed quite well with figures quoted previously by other authorities.

The reflexion coefficient from frozen muskeg and from the barren gravel areas north of the tree line in Canada was found to be roughly equal to that from dry sand. The frozen ice on Hudson Bay also gave a similar result. The ground temperatures were below − 35° F., and the ground and sea were frozen to a depth of several feet.

When flying over deeply frozen land where the land was heavily wooded, the land being covered with loose snow several feet deep and the trees thickly covered with snow and ice, a reflexion coefficient appreciably less than that from muskeg was observed. This was checked in two or three different areas, and the same figure was obtained on each occasion.

The figures of received signal power as compared with a sea reflexion were − 13 db. for sand, frozen muskeg or gravel, etc., and − 20 db. for frozen snow-covered forest. The accuracy of measurement was not worse than ± 2 db. The reflexion coefficient of sea water has been measured by other observers and is 0·83. Using this figure, the reflexion coefficients for various frozen terrains have been calculated and are as follows:

| Terrain | Reflexion coefficient |
|---|---|
| Sea | 0·83 |
| Deep ice on sea | 0·20 |
| Frozen muskeg or barren gravel | 0·20 to 0·25 |
| Frozen lakes | 0·25 |
| Frozen snow-covered forest | 0·08 |

Acknowledgment is made to the Chief Scientist, Ministry of Supply, for permission to publish this communication.

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## Light Scattering by very Stiff Chain Molecules

Very precise light-scattering measurements by B. H. Bunce[1] on several thymonucleic acid preparations have shown that the scattering function of these gigantic macromolecules—the molecular weights are between 2·6 and 6·7 millions—differ remarkably from that of a random coil. The angular dependence of the reciprocal reduced intensity $1/P = I(0)/I(\vartheta)$, for all samples, reveals that the molecules are not perfectly coiled. The experimental points are situated between the curves for a random coil and that for a stiff rod.

Therefore it seemed worth while to compute the scattering function for a thread-like molecule of finite length with variable flexibility. In some previous work on viscosity and sedimentation[2] of such relatively short molecules, the usual 'pearl-necklace' model was chosen. By variation of the valency angle $\alpha = 180° - \beta$ between two consecutive links and the length of link $b$, all kinds of flexibility from the stiff rod ($\cos\beta = 1$), to the quite soft thread ($\cos\beta = 0$), can be represented. This model is not very suitable for the consideration of light scattering; it can be replaced by the 'thread' model with continuous mass distribution and curvature, introduced by Kratky and Porod[3] in the theory of X-ray scattering.

The measure of the flexibility is the persistence length $a$, the average value of the projection of an infinitely long thread on the tangent at one end of the thread : $a = b/(1 - \cos\beta)$.

This model fits much better the conditions for the scattering of visible light than for X-rays, as the fine structure of the macro-molecule, that is, the linking of the monomers, does not matter compared to the wave-length of some 1000 A.

According to Kratky and Porod, two thread elements, $dl_1$ and $dl_2$, separated by the length $l_{12}$ of the chain, on the average give rise to a scattered intensity proportional to

$$\exp - k^2s^2R^2{}_{12}/6,$$

where $k = 2\pi n/\lambda$, $s = 2\sin\vartheta/2$, $R^2{}_{12} = 2a^2(x_{12} - 1 + \exp - x_{12})$, $x_{12} = l_{12}/a$, provided the distribution-function of their mutual distance $r_{12}$ does not differ too much from the Maxwellian. This does not apply to the stiff rod, $x = 0$, and is also a bad approximation for small values of $x \sim 1$, but gets rapidly better with increasing $x$.

With this simplification, the scattering function for the molecule reads :

$$P(\vartheta) = \frac{1}{L^2}\int_0^L\int_0^L \exp(-k^2s^2R^2{}_{12}/6)\,dl_1\,dl_2 =$$

$$\exp p\left[F(p,x) - \frac{p}{1!}F(p+1,x) + \frac{p^2}{2!}F(p+2,x)\ .\ .\ .\right],\ x \gg 1,$$

with

$$F(p,x) = \frac{2}{(px)^2}(px - 1 + \exp - px)\quad p = k^2s^2a^2/3.$$

The accompanying graph shows $1/P(\vartheta)$ for various values of $x$, where the variable

$$v = 3p\left[\frac{x}{3} + F(1,x) - 1\right] = A(a,x)\ .\ \sin^2\frac{\vartheta}{2}$$

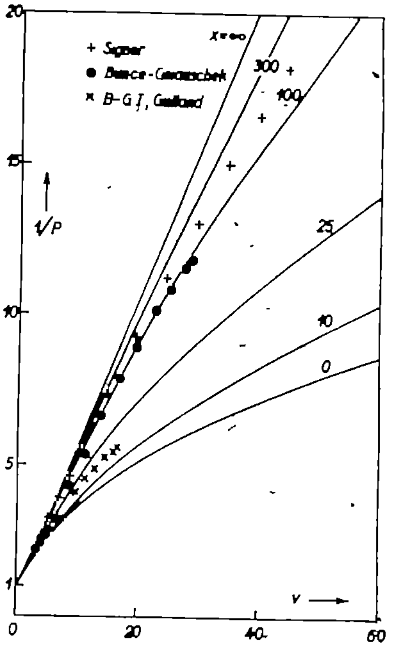
is chosen in such a way that the initial slope is the same for all curves. The curve $x = 0$ is the known scattering function for rods. Even at very large values of $x$, the limiting curve $x = \infty$ is not reached. In fact, the deviations are quite noticeable at as large a value as $x = 300$.

The experimental data of Bunce on various samples fit into this picture very well. The following dimensions may be deduced :

| Sample | $M$ | $x$ | $a$ | $L$ | $R$ | $M/L$ |
|---|---|---|---|---|---|---|
| Present writer | $6{\cdot}7 \times 10^6$ | 150 | 287 A | 43,000 A. | 4950 A. | 156 M.U./A |
| Bunce–Geiduschek | 4·0 | 100 | 263 | 26,300 | 3750 | 152 |
| Bunce–Geiduschek degraded* | 2·64 | 16 | 541 | 8700 | 2970 | 305 |
| Gulland | 4·0 | 16 | 541 | 8700 | 2970 | 462 |

* The sample had been left for 20 hr. in an acid solution of $p$H 3·0.

In the first two samples, the structure of the thymonucleic molecule seems to be very similar, the persistence length $a$ being markedly the same in both. The last two samples also agree completely with each other in their geometrical dimensions. The large value of $a$ signifies that the coil is twice as extended. The overall length, however, is much smaller than that of the first two samples. Hence, the mass density $M/L$ is increased to 305 and 462 M.U./A. The shortening of the chain may be the consequence of an internal association of neighbouring chain segments. The additional linkages coupled with the increased density evidently stiffen the molecule and yield a more extended coil. Very careful preparation may prevent such an internal association, which takes place also on degradation in acid solutions.



Reciprocal reduced intensity, $1/P(\vartheta)$, plotted against $v = A(a,x)\,.\,\sin^2\vartheta/2$. The experimental points for the Gulland and Bunce–Geiduschek degraded samples coincide

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Ljubljana. June 5.

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## 'Newtonian' Time in General Relativity

A result recently given by Eisenhart[1] suggests an interesting application in general relativity. According to it, we can choose co-ordinates in which a line element showing spherical symmetry would take the form :

$$ds^2 = -r^2(d\theta^2 + \sin^2\theta d\varphi^2) + \gamma dt^2 + 2\alpha dr dt,\quad \gamma = \gamma(r,t),\quad \alpha = \alpha(r,t) \qquad (1)$$

and a radial null vector $w^\mu$ will have $w^2 = w^3 = w^4 = 0$, so that the velocity of light along radial directions (given by $w^1/w^4$) is infinite. Hence we may call the co-ordinates $(r,t)$ the 'Newtonian' co-ordinates.

Several well-known solutions in general relativity take up very simple forms when expressed in these co-ordinates. Schwarzschild's exterior solution has :

$$\alpha = 1,\quad \gamma = 1 - 2m/r. \qquad (2)$$

Here $m$ is the constant giving the mass of the particle at the origin. If, however, we take $m$ to be an arbitrary function of $t$, the same solution will represent the gravitational field of a radiating star found by us[2], thus showing that our solution of a non-static mass is the natural generalization of Schwarzschild's solution for a static mass.

Again, for describing the field of a mixture of matter and flowing radiation within the interior of a star, where the energy-tensor is of the form[3]:

$$T_{\mu\nu} = (p + \rho)v_\mu v_\nu - p g_{\mu\nu} + \sigma w_\mu w_\nu,$$
$$v_\mu v^\mu = 1, \quad w_\mu w^\mu = 0, \qquad (3)$$

we can choose co-moving Newtonian co-ordinates in which $v^1 = v^2 = v^3 = 0$, $w^2 = w^3 = w^4 = 0$. We shall then find that:

$$T_1^{\,1} = T_2^{\,2} = T_3^{\,3} = -p; \quad T_4^{\,4} = \rho. \qquad (4)$$

These relations are the same as the familiar relations for static solutions. Of course, here, $T_1^{\,4} \neq 0$.

Recently, we have found that even in the unified field theories described by a non-symmetrical $g_{ik}$, co-ordinates of this type introduce a great deal of simplification in problems involving radiation flow. Details of this investigation are awaiting publication elsewhere.

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## Serological Relationships of Hyrax and Elephant

ORIGINALLY classed with the Pachyderma, the hyraxes (rock rabbits or conies) have in turn been placed in the orders Rodentia and Perissodactyla. More recently, they have been placed in a separate order, the Hyracoidea[1]. It is, however, still open to discussion whether there is not a relation between hyrax and elephant; one of the more recent contributions on the subject is based on the similarity of the placental formation in animals of the two orders concerned[2].

In the course of some recent work on the development of the use of precipitating antisera for the identification of blood meals of tsetse flies and other African blood-sucking arthropods, an antigenic relationship between elephant and hyrax has been observed. Serological relationships have been noted by various workers between related animals of many different species since the original work of Nuttall[3] on this subject. Qualitative determinations made by the ring test have been shown to be valid, providing the antisera used in the reaction are devoid of non-specific antibodies. Before absorption, antisera prepared in rabbits by repeated injections of alum-precipitated serum give reactions at a high titre with the serum of all the mammals which were tested and which included representative samples from most orders[4].

Two antisera were prepared in rabbits by the repeated injections of alum-precipitated sera of the Indian elephant (*Elephas elephas*) and hyrax (*Heterohyrax syriacus prittwitzi* Brauer) respectively, and both antisera gave positive reactions at high titre with the sera of all mammals which were tested. Each antiserum was then absorbed with the sera of man, ox, sheep, horse, pig, dog and cat in the proportions necessary to remove the corresponding antibodies. These absorbed antisera were then re-tested as before with the sera of a wide range of species of mammals and were found to react only with elephant and hyrax in both cases. The anti-elephant serum reacted at a titre of 1 : 64,000 with elephant serum and at 1 : 32,000 with hyrax serum, while the anti-hyrax serum reacted at a titre of 1 : 16,000 with hyrax serum and at 1 : 8,000 with elephant serum.

These observations, which were similar to those previously made with known related mammals, indicate a very marked relationship between the sera of hyrax and elephant; they are also of interest in relation to the taxonomic position of the Hyracoidea.

I am grateful to the Zoological Society of London for supplying the elephant serum, and to T. C. S. Morrison Scott for identifying the species of hyrax.

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## Assessment of Consciousness during Curarization

MODERN surgical techniques and experimental methods make increasing use of muscular relaxants combined with anæsthetics to produce the optimum conditions for surgery. This practice leads to certain difficulties in assessing consciousness, since the usual muscle reflexes are impaired by the action of the relaxant. The change in heart-rate in response to a pain stimulus has recently been investigated and found to be a reliable indicator of consciousness during electrical curarization in animals, and during ether anæsthesia in man[1]. It therefore seemed possible that this cardiac pain reflex might be useful as an index of consciousness when muscular relaxants were being used.

'Flaxedil' was injected intravenously into rabbits so that the voluntary muscles were paralysed, and the heart-rate was recorded continuously on one channel of an electro-encephalograph machine; the pain stimulus consisted of a pin-prick on the nose of the animal. This stimulus resulted in an increase in the heart-rate which varied from 9 to 14 per cent with different individuals and lasted for about thirty seconds; the cardiac pain reflex before injection was similar in size and duration, but during light anæsthesia it was reduced, and in surgical anæsthesia it was abolished.

The pupillary reflex to light, which can sometimes be used when voluntary muscle is paralysed, is not easy to observe after injection of 'Flaxedil' because ptosis and nystagmus occur. If a suitable heart-rate indicator is available, or could be designed, it might now have considerable practical application in human and veterinary surgery when curarizing drugs or new anæsthetics are being used.

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## Chromosomal Re-arrangements in the Progeny of *Drosophila* Males treated with Mustard Gas

WHEN *Drosophila* males are treated with mustard gas, the proportion of chromosome re-arrangements to sex-linked lethals in their progeny is lower than after an X-ray treatment which yields the same frequency of sex-linked lethals. This observation has been made by genetical methods[1]. It has been confirmed by the cytological findings of Slizynska and Slizynski[2], who examined the salivary chromosomes of strains carrying sex-linked lethals induced by mustard gas and reported that these chromosomes had many fewer structural changes than would have been expected if the lethals had been induced by X-rays. Since these investigations were based on selected samples of chromosomes—namely, *X*-chromosomes already shown to carry a lethal—it seemed important to check them on unselected samples. Accordingly, wild-type *Drosophila* males were given different doses of mustard gas, and unselected female $F_1$ larvæ were analysed for chromosomal changes in their salivary glands. The apparatus for the treatment was designed by Dr. H. Moser and has been described elsewhere[3]. The genetical effectiveness of each dose was measured in terms of sex-linked lethals. For comparison, exposures were carried out with doses of X-rays which approximately matched those of the mustard gas in respect of their ability to produce sex-linked lethals. The results are summarized in the accompanying table.

The observations bear out the previous genetical and cytological findings. In the overall result, as well as at each dosage-level, there is a marked shortage of re-arrangements in the mustard-gas series as compared with the X-ray one. The overall difference between 7·6 per cent re-arrangements in the X-ray series and 1·3 per cent in the mustard gas series is significant at the 0·1 per cent level. The results are not sufficient to decide whether, as the table suggests, the ratio between the two frequencies tends to shift in favour of irradiation as the dose is increased. If this should be true, it would indicate a difference in the mechanisms by which these two mutagenic agencies produce re-arrangements. Experiments to test this point are under way in this department.

A point worth noting is the occurrence of two reversed repeats among the eleven chemically induced structural changes. No repeat occurred among the forty-eight radiation-induced changes; in general, repeats appear to be rare after radiation treatment. The occurrence of two of them in a very small sample of chemically induced changes is remarkable. It is, however, in line with the observation made by Auerbach[4] that a high proportion of visible mutations induced by mustard gas occur first as mosaics in the progeny of treated males; for repeats, like mosaics, are changes which must have arisen after the treated chromosome had separated into its daughter chromatids.

FREQUENCY OF LARGE CHROMOSOME RE-ARRANGEMENTS AFTER DIFFERENT DOSES OF X-RAYS AND OF MUSTARD GAS

| Expt. | X-rays | | | | | | Mustard gas | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | % sex-linked lethals | No. larvæ examined | No re-arrangements | | | | % sex-linked lethals | No. larvæ examined | No. re-arrangements | | | |
| | | | between chromosomes | within chromosomes | total No | total % | | | between chromosomes | within chromosomes | total No. | total % |
| I | 3·2 ± 0·7 | 172 | 1 | 1 | 2 | 1·1 | 3·7 ± 0·6 | 195 | 0 | 0 | 0 | 0 |
| II | 4·6 ± 0·9 | 162 | 4 | 7 | 11 | 6·8 | 4·1 ± 0·8 | 234 | 4 | 1 | 5 | 2·1 |
| III | 8·0 ± 1·2 | 137 | 5 | 2 | 7 | 5·1 | 7·1 ± 1·1 | 216 | 0 | 1 | 1 | 0·5 |
| IV | 10·4 ± 1·3 | 165 | 13 | 15 | 28 | 16·9 | 15·0 ± 4·0 | 177 | 0 | 5 | 5 | 2·8 |
| | | 636 | 23 | 25 | 48 | 7·6 | | 822 | 4 | 7 | 11 | 1·3 |

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## Chemical Constitution of the *L*-Forms of Bacteria

THE *L*-forms of bacteria, a study of which has been described recently[1], are dwarf organisms derived from a complex transformation of bacteria, either spontaneously or under various noxious influences. Their morphological as well as biological characters are so different from those existing in the bacteria they are derived from that it seemed interesting to us to compare the chemical constitution of these two forms of the same organism.

The material used for our chemical study was *L*-forms of *Proteus* (*P* 18), three to four weeks old, grown on a liquid medium[2]. The *L*-forms are separated from the medium by centrifugation, washed twice in physiological serum, then in distilled water, concentrated by centrifugation at 12,000 r.p.m. and resuspended in distilled water. It is emphasized that this material is not absolutely homogeneous. It consists of a mixture of about 80 per cent of *L*-forms and 20 per cent of various stages in the evolutionary cycle of these forms. We have not been able, so far, to get rid of these intermediate forms; nevertheless, we do not think that this would affect seriously the relative value of our results.

The comparative estimation of nitrogen and phosphorus shows that the nitrogen content is higher in the normal *Proteus* than in the *L*-forms, while the phosphorus content, on the contrary, is lower.

Treatment of the *L*-forms with cold 5 per cent trichloroacetic acid gives an acid-soluble fraction, the total nitrogen of which represents about 6 per cent of the total nitrogen of the micro elements, and the phosphorus 55 per cent of the total phosphorus; under the same conditions, the normal *Proteus* loses about 8·5 per cent of its total nitrogen, but only 22 per cent of its phosphorus. This demonstrates in the *L*-forms an accumulation of small molecules of phosphorus compounds.

Treatment with boiling alcohol for 1 hr. and with boiling ether for 30 min. allows the extraction of

COMPARATIVE ANALYSIS OF NORMAL *Proteus* AND OF THEIR *L*-FORMS (per 100 parts dry weight)

| | Total N | Total P | $\frac{N}{P}$ | Total lipids | Total proteins | Total nucleic acid | DNA | RNA | $\frac{RNA}{DNA}$ |
|---|---|---|---|---|---|---|---|---|---|
| Normal *Proteus* | 14·77 | 2·45 | 0·60 | 6·0 | 73·0 | 11·59 | 3·28 | 8·31 | 2·50 |
| *L*-forms | 10·27 | 2·88 | 0·36 | 24·3 | 58·9 | 1 65 | 1·45 | 0·20 | 0·14 |

24·3 mgm. lipids per 100 mgm. of dry weight. The quantitative importance of this lipidic fraction should be noted. It is much more important than that which can be extracted from normal *Proteus* (for example, 4–8 per cent). The lipidic fraction contains 2·16 per cent phosphorus.

Analysis of the nucleic acids[3] in the *L*-forms free from lipids and the acid-soluble fraction shows clearly an amount of deoxyribonucleic acid (1·45 per cent of the dry weight of the initial material) greater than that of ribonucleic acid (0·20 per cent). The ratio of ribonucleic to deoxyribonucleic acid is thus, for the *L*-forms, just the reverse of that found in normal bacteria. The amount of ribonucleic acid in ordinary bacteria, even in the lag phase (that is, at the time when ribonucleic acid is at its lowest), is generally equal to, or greater than, the amount of deoxyribonucleic acid.

A summary of our results is given in the accompanying table.

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## Contamination of Nectar with the Systemic Insecticide 'Schradan'

RIPPER *et al.*[1] have shown that the organophosphorus insecticide, octamethylpyrophosphoramide ('Schradan'), when sprayed on leaves, is absorbed and translocated to other parts of the plant. Metcalf and March[2] have demonstrated the tolerance to 'Schradan' shown by the honey bee. Using radioactive 'Schradan', containing phosphorus-32, we have examined the possibility of the unchanged insecticide being present in the nectar of flowers and afterwards appearing in honey.

The leaves of white mustard plants (*Sinapis alba*) were sprayed during July 1952 with an aqueous solution of radioactive 'Schradan' (about 0·75 μC. per ml.) also containing radioinactive 'Schradan' (0·16 per cent) and a wetter. A total of 4 ml. per plant was applied in five applications over five days. The plants when treated were approximately 1 ft. in height and had doubled their size by the end of the experiment (five weeks). All flowers open on the last day of spraying and on the following day were removed, to obviate the possibility of direct contamination of nectar by the spray. Flowers that opened three to twelve days after the completion of the spraying were used as the source of a bulk sample of nectar for assessment of 'Schradan' content. After chloroform fractionation, as recommended by Ripper *et al.*[1], radio-assay indicated a concentration of 5·5 p.p.m. of unchanged 'Schradan' in the nectar. Nectar collected over later periods showed lower contents of the unchanged insecticide.

Another test made with borage (*Borago officinalis*) confirmed that unchanged 'Schradan' could occur in nectar. In this plant the comparable value was 2·5 p.p.m.

Other work has shown that 'Schradan' is not decomposed while in the honey stomach of the bee or in honey during a storage period of ten weeks.

Full details of this work are being published elsewhere.

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## Transmission of Hop Mosaic by *Phorodon humuli* (Schrank)

MOSAIC disease of hops was first described by Salmon[1]. Later Thrupp[2], and Salmon and Ware[3], showed it to be transmissible by grafting. This was followed by the extensive studies of Mackenzie *et al.*[4], who showed that some commercial varieties were symptomless carriers. Growers' observations of spread from carrier varieties to adjacent susceptible hops were confirmed by Keyworth[5].

It was suspected that insects were responsible for the spread of mosaic, and in 1948 an extensive experiment was carried out to test the ability of the hop–damson aphid, *Phorodon humuli* (Schrank), to transmit the virus. Eggs of this aphid, laid on *Prunus* spp. in the autumn, hatch in early spring and, after several wingless generations, winged forms develop which migrate to hop. There follows a succession of asexual wingless generations throughout the summer. Another winged generation occurs which returns to *Prunus* and produces wingless sexual females. These are fertilized by winged males which develop to maturity on hops and then migrate to *Prunus*. 3,520 summer wingless *P. humuli* were tested as vectors with short and long feeding periods, using eight different sources of hop mosaic as infectors, but there was no transmission to the 128 indicator plants.

Work was therefore started to find other insects that might be suspected of transmitting hop mosaic. A survey of the insects occurring on hops was made by Paine[6], and an experiment designed to determine the period during which mosaic spreads. Monthly collections of insects were made at five gardens in which mosaic was known to be spreading. Thirty-five species were recorded in one year and twenty-three in the next; only six species were found in both years. As mosaic had spread in both years it was inferred that one or more of these six species might have been involved in its transmission.

All the insects that had been collected in one hour from a hundred plants each month were allowed to feed on mosaic-infected hops and then transferred to ninety test hop plants (Bramlings), each of which received one or more species. Four of these plants developed mosaic within one year; and the only species which all four had received was the spring winged form of *P. humuli*.

To find out the period during which mosaic spreads, ten plants of a susceptible variety (Petham Golding) were placed in a garden of a carrier variety (Brewers Gold) each month from March to August. Each batch of these indicator hop plants was stored at 0° C. and then grown for one month in an insect-proof glasshouse; the potted plants were then exposed in the field of infected hops for one month and then returned to the glasshouse for observation. Two of the plants exposed in June and one exposed in July later developed mosaic.

The facts—(1) that the spring winged form of *P. humuli* had occurred in both years collections; (2) that four plants developed mosaic after treatment with this form of the aphid; (3) the spread of this disease had occurred during the later period of the spring winged generation flight—suggested that this aphid should be retested as a vector of mosaic, using the spring winged generation.

In 1951 Petham Golding hops were infested with winged *P. humuli* collected from hedgerow *Prunus* species. Each of the ten test plants received some aphids direct from the *Prunus* and others which were first fed on mosaic-infected hops for 1 hr.–30 days. Nine of the ten test plants developed a line-pattern symptom later in the same year, and early in 1952 six of these test plants developed vein banding and downward leaf curling for a short period and then apparently recovered. Since then, four of the test plants have developed mosaic symptoms, including the plant that did not show line pattern in 1951. No symptoms have developed on any of the controls.

No other case is known where one form of an aphid is able to transmit a virus while another form of the same species is not, and further investigations are being made to elucidate this phenomenon. Work is also being continued to determine the relationship between viruses occurring in *Prunus* species and those found in the hop.

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## Spermatogenesis in *Lumbricus terrestris* L., Müll.

While the histology of spermatogenesis *s.str.*, that is, the maturation of the spermatids to form ripe spermatozoa in *Lumbricus terrestris* L., is known in detail, explanations of the orientation of the developing spermatid remain somewhat obscure. The only complete and easily available information is contained in the general text-book of Borradaile[1], where diagrams show the 'tail' of the sperm arising at the cytoplasmic vesicle at the periphery of the morula and remaining in this position during its subsequent elongation away from the cytophore. The cytoplasmic vesicle and the cytophore are shown in Fig. 1 (*c.v.*, *cph.*). The account of Hesse[2] interprets the orientation of the spermatid in the same way as Borradaile, stating that the acrosome or 'head' end arises from the cytoplasmic pedicle which is directed towards the centre of the morula (Fig. 1, *c.p.*). Depdolla[3], however, explains the orientation in the reverse way and regards the cytoplasmic vesicle as representing the acrosome or 'head' end of the sperm, and states that the 'tail' develops from the cytoplasmic pedicle. More recent work by Chatton and Tuzet[4], who made a very detailed histological examination, confirms this view, though no figures are given in their work of the final relationship of the ripe spermatozoa to the cytophore.

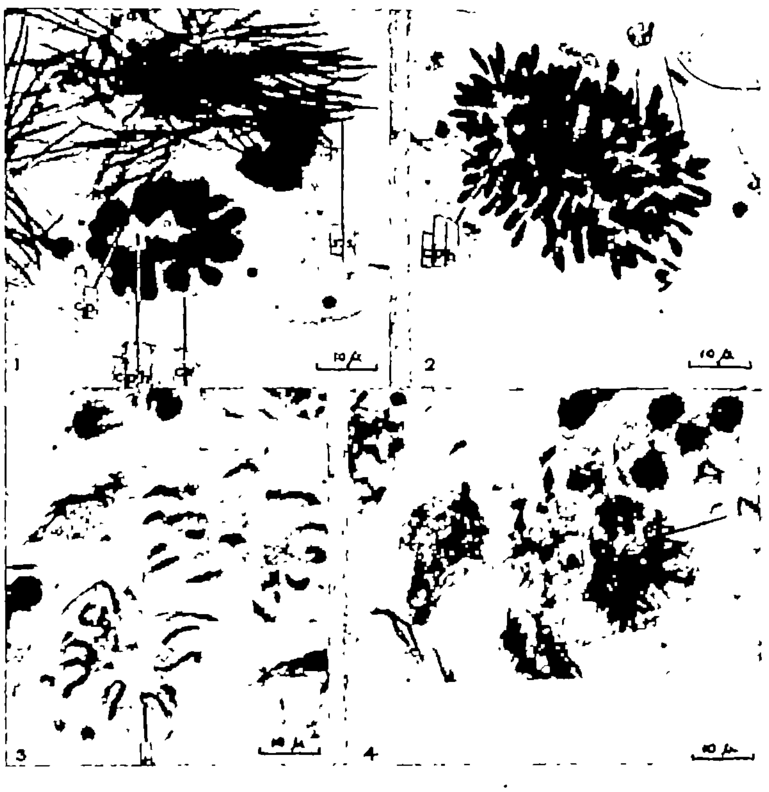

Fig. 1. Early stage in spermatogenesis of *Lumbricus terrestris*

Fig. 2. Later stage in spermatogenesis of *Lumbricus terrestris*

Figs. 3 and 4. Successive stages in spermatogenesis of *Fasciola hepatica*, showing origin of 'tail' region next the cytophore

*c.p.*, Cytoplasmic pedicle; *cph.*, cytophore; *c.v.*, cytoplasmic vesicle; *r.s.*, ripe sperm; *t*, tail

Fig. 2 shows the elongating nuclei of the spermatids, with the broad ends which were nearest the cytoplasmic vesicle towards the outside and the pointed ends directed inwards towards the cytophore (Fig. 2, *cph.*). If this orientation persists throughout maturation it follows, on the basis of the interpretation of Chatton and Tuzet, that the ripe spermatozoa of *Lumbricus* adhere to the cytophore by the tips of their 'tail' ends, which is the reverse of what the Borradaile diagram shows, and the reverse of that observed by me on living unstained material. Whitehouse and Grove[5] confirm the latter observation and state that in most stained smears only the 'head' of the sperm stains, and that is attached to the cytophore (Fig. 1, *r.s.*).

Accordingly, I suggest that there may be a reversal of orientation of the spermatid between the stage shown in Fig. 2 and the final stage. As a result of investigating spermatogenesis in the trematode, *Fasciola hepatica* L., and in the cestode, *Eubothrium crassum* (Bloch), it appears that there is some evidence to support this view (assuming the basic process to bear some similarity in the Platyhelminthes and Annelida). In both the Platyhelminthes there is, as in *Lumbricus*, a similar outpushing of the wide end of the elongating spermatid nucleus at the cytoplasmic vesicle, while the inwardly directed, pointed end of the nucleus coils and appears to form the 'tail' of the sperm, moving towards the periphery at the same time (Figs. 3 and 4, *t.*). Wilmott[6], working on the trematode *Gigantocotyle bathycotyle* Nasmark, figures a stage very similar to that observed by me, though she makes no comment upon orientation. Observation of this stage is made easier in the Platyhelminthes because, first, the development concerns only the nucleus—it is doubtful if any cytoplasm enters into the final composition of the ripe spermatozoa in this group—and, secondly, the cytophore is here formed sooner and is relatively more extensive, making the change in orientation more plainly visible and possibly causing the process to slow down. Unfortunately, in the Platyhelminthes the ripe spermatozoa do not adhere for long, if at all, to the cytophore, so that there is no stage visible which corresponds with the final stage in *Lumbricus terrestris*. However, it seems very possible that the mobility of the 'tail', together with its elongation, coiling and subsequent uncoiling, would cause the 'tail' to be thrown free of the cytophore before the 'head' end.

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## Change in the Composition of the Bottom Fauna of the Dogger Bank Area

UNDER the above title, Erik Ursin[1] reports certain differences between the bottom fauna found by him during 1950–51, and its composition as reported by F. M. Davis[2] during 1921–23. I am able to confirm most of these differences, because part of my work took me to the same area, and at the same time, as Ursin. But I think that caution is needed in assuming that the differences are due to real changes in the bottom fauna. It will be remembered that Davis thought that the spatfalls of molluscs are likely to be local and uncertain, and his 'soil-current' theory is an enunciation of this belief. The substitution of *Ensis ensis* and *Tellina fabula*, during 1950–51, for *Spisula subtruncata* and *Mactra corallina* as the dominant lamellibranchs, lends support to Davis's theory. But Davis worked with a Petersen grab, and Ursin and I are both using van Veens, and since the latter is probably more efficient at digging in sand than the former[3], it is likely that these differences in fauna are at least partly the results of changed gear. There is much need for a thorough comparison of the two instruments.

It is also important to remember that the comparisons were made between an October cruise of 1921 and a spring survey during 1950–51, and that important spatfalls are likely to occur in the summer, which, if all the molluscs should disappear before spring of the following year, will not yield results similar to those of a spring survey. In fact, I have just (October 31–November 4) surveyed the west Dogger Bank again. I discovered the presence of many hundreds of 1–1·5 cm. *Mactra corallina* in a large patch, roughly twenty miles north-north-east of where Davis discovered the same species to predominate. I have always found enormous numbers of freshly coloured large (2–3 cm.) empty shells of *M. corallina* in this area; but the living ones had up to now escaped me, presumably because of the timing of the surveys. In November there were 2,775 *Mactra* per m.$^2$ at the greatest density.

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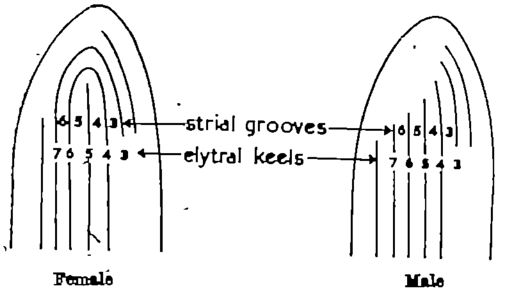
## A Simple Method for Sexing the Confused Flour Beetle

THE sub-basal pit, on the front femora of males of several species of *Tribolium*[1], is very difficult to observe in *T. confusum* Duv., and its use in sexing large numbers of the beetles is not practical.

I have now found that *T. confusum* can be much more conveniently sexed by examination of the elytral declivity, where the keels and strial grooves form a pattern characteristic of the sex (see accompanying diagram). In the female the keels on the seventh and third intervals are united distally, as are those on the sixth and fourth. The keels may be, in part, absent or reduced to slight ridges; but the sixth strial groove is always clearly distinguishable up to its junction with the third. In addition, the apical area of the elytron beyond the keels does not have a distended appearance and has punctures approximately the same size as those on the striæ. In the male the keels on the seventh and third intervals are never united distally, and the sixth strial groove is never continuous with the third. The apical area beyond the keels has a distended appearance and has punctures coarser than those on the striæ. Most individuals could be sexed with certainty by examination of one elytron, under a binocular microscope (× 15); but in a doubtful case the other elytron should be examined. In a test of the method more than two thousand beetles were correctly sexed. Dead desiccated beetles or anaesthetized living beetles



*Tribolium confusum* Duv. Dorso-lateral view of apical halves of right elytra of female and male

can be equally easily sexed, and with practice can be examined at the rate of 400–500 per hour.

*T. destructor* Uyttenb. can be readily sexed on similar elytral characters. Reliable results can also be obtained with *T. castaneum* Herbst; but the characters are much less obvious and considerable practice is necessary.

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[1] Hinton, H. E., *Nature*, 149, 500 (1942); *Bull. Ent. Res.*, 39, 13 (1948).

## Urea Complexes of Rape-oil Fatty Acids

In the course of investigations on the catalytic autoxidation of highly purified brassidic acid (*trans* docos-13-enoic acid), methods for the isolation of erucic acid, the *cis* isomer, have been examined.

The source of this acid has been the mixed fatty acids from the saponification of rape-oil which, in addition to about 50 per cent erucic acid, contain quantities of oleic acid and smaller amounts of linoleic and $C_{16}$–$C_{24}$ even-numbered saturated acids.

Schlenk and Holman[1] have prepared urea complexes of a number of higher saturated and unsaturated fatty acids by treatment with urea in methanol solution. These workers have shown that complex yields increase with molecular weight of the acid but decrease with unsaturation. The yields from linoleic acids were found to be zero under the conditions used. From the methyl esters of mixed olive-oil fatty acids, these workers isolated highly purified methyl oleate by a urea-complex methyl ester fractionation technique, and it appeared that a similar method could be applied to the mixed fatty acids of rape-oil.

In a preliminary experiment, 4 gm. of mixed fatty acids (iodine value 100) were treated with 15 gm. urea in 100 ml. methanol. On warming to dissolve and cooling, 14 gm. of needle-shaped crystals of the complex were deposited, which, on warming with water, yielded a white solid acid (iodine value, 68·3). It appeared that separation from unsaturated fatty acids had been effected, the solid acid consisting of erucic acid (iodine value, 75) and saturated fatty acids. A large-scale separation of the mixed fatty acids was then attempted by addition of urea in sufficient successive quantities to separate saturated acids, erucic acid, and lower monoethenoid and polyethenoid acids. 140 gm. mixed fatty acids yielded 94 gm. erucic acid concentrate (iodine value, 76·1; acid value, 171). Difficulty was experienced in completely removing saturated acids by this method, since urea-complex yields of erucic and saturated stearic, arachidic and behenic acids are similar, and a final purification of the acid was effected by a lead salting method.

Urea complex fractionation appears to be advantageous for a preliminary separation of mixed rape-oil fatty acids during the preparation of erucic acid. The complete one-stage elimination of polyethenoid acids from the product is achieved. According to Hilditch[2], this is essential when the purified acid is used for investigations into the mechanism of autoxidation of monoethenoid unsaturated fatty acids.

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## Influence of Trypan Blue on the Number of Circulating Eosinophils in Rats

Gordon and Katsh[1] suggested that the adrenal cortex exerts a regulatory influence upon the function of the macrophagic system. Selye[2] observed an increase of the phagocytic activity of the reticulo-endothelial system in the alarm reaction.

In the present study, an attempt has been made to determine whether the eosinopenic response in stress is influenced by the functional state of the reticulo-endothelial system. It has been observed recently that the functional depression which follows the 'blocking' of the reticulo-endothelial system is of short duration[3]. In my experiments, 'blocking' was produced by repeated injections of trypan blue.

Young male white rats weighing about 100 gm. were used. Stress was produced by the subcutaneous administration of adrenaline (Upjohn) in doses of 0·05 mgm./100 gm. body-weight. Eosinophil counts were carried out by the method of Speirs and Meyer[4]. One group of rats received intraperitoneally, on two subsequent days, a solution of 1 per cent trypan blue in saline (dose, 1 ml./100 gm. body-weight). Another group received on the first day the same amount of an isotonic solution of sodium chloride, on the second day trypan blue. The third, control, group received the solution of sodium chloride on both days. Eosinophil counts were performed in all the groups 20 hr. after the second injection. Epinephrine was then administered and eosinophil counts repeated 3 hr. later. The results are summarized in the accompanying table.

It is obvious that the injection of trypan blue is followed by a significant ($P < 0.001$) increase of the number of circulating eosinophils, whereas the

EFFECT OF TRYPAN BLUE AND ADRENALINE ON THE NUMBER OF CIRCULATING EOSINOPHILS IN RATS

| No. of animals | Treatment | Eosinophils in 1 c.mm. | Fall in eosinophil count following adrenaline (% of initial value) |
|---|---|---|---|
| 35 | Sodium chloride | 290 ± 8·14* | 29·40 ± 8·47 |
| 24 | Sodium chloride + trypan blue | 432 ± 24·78 | 46·16 ± 5·68 |
| 12 | Trypan blue | 606 ± 73·05 | 70·50 ± 3·78 |

* Standard error of the mean.

response to adrenaline stress is not abolished. It seems, therefore, that although the 'block' produces an increase of circulating eosinophils, the functional state of the reticulo-endothelial system has no influence on the eosinopenic response observed in stress.

Detailed hæmatological and bone-marrow studies of rats treated with trypan blue will be published elsewhere.

INES WESLEY

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## Extraction of Acetylcholine from Brain Tissue

In some recent attempts[1] to follow rapid changes in the concentration of acetylcholine in mammalian brain *in vivo*, the experimental animals were killed by freezing in liquid air, a method which had already yielded valuable results when applied to the study of certain other labile metabolites[2]. As an accompaniment to these studies, one of us[3] reported that the amount of acetylcholine which can be extracted from excised brain frozen in liquid air is some 13 per cent greater than when it is extracted from unfrozen tissue by the more usual methods. Since this work was completed, however, Elliott and his colleagues[4,5] have claimed that a complete extraction can be achieved only by homogenizing the unfrozen brain in an acid saline solution; according to these workers, previous freezing of the excised tissue results in a loss of up to 50 per cent of its contained acetylcholine. It has, however, proved impossible to confirm these findings, as the following experimental results testify.

Acetylcholine was extracted from the excised brains of adult rats, using the method described by Elliott *et al.*[4], except that the extracts were assayed in the frog rectus muscle. While histological examination showed that the homogenization had been efficiently carried out, the amount of acetylcholine extracted corresponded to a brain concentration of only 1·69 ± S.E. 0·12 µgm. per gm. (ten animals). A second series of brains was extracted by a similar method, using a bladed homogenizer (10,000 r.p.m.), and was found to contain 1·73 ± S.E. 0·03 µgm. acetylcholine per gm. (four animals). These figures are very much lower than those reported by Elliott and his co-workers, namely, 3·45 µgm. per gm., and are similar to those usually quoted for excised tissue. It seems possible that the leech muscle used by the Canadian workers was affected by sensitizing substances. MacIntosh[6] found that saline extracts of mouse brain do exert a sensitizing effect on the leech preparation, though Elliott and his colleagues[4] deny that their extracts had a similar effect. Tobias and his co-workers[7] used an extraction technique similar to that of Elliott *et al.* but assayed their preparations on the frog rectus muscle, which is known to be very susceptible to the effects of sensitizing substances in brain extracts. Though they failed to eliminate the effects of these agents and must therefore have obtained an exaggerated estimate of the amount of acetylcholine present in their extracts, their results are very similar to those quoted by Elliott *et al.* In the present experiments, it was found that, for saline extracts of brain, an acetylcholine assay of 1·8 µgm. per gm. rose to 2·9 µgm. per gm. (mean of six experiments) when the effect of the sensitizing substances was not controlled, though the rectus muscles were very sensitive and had been treated with optimal amounts of neostigmine.

In other experiments, excised brain tissue was divided into two equal portions, one of which was homogenized in acidified saline solution, while the other, after freezing in liquid air, was powdered and its acetylcholine extracted by contact with aqueous trichloroacetic acid for twenty minutes. The homogenized brain was found to contain 1·38 ± 0·03 µgm. acetylcholine per gm., the frozen brain 1·40 ± 0·11 µgm. per gm. (four experiments).

There is thus no evidence that freezing is associated with a loss of acetylcholine; it is possible that the results of Elliott and Henderson[5] were due to their allowing some thawing of their frozen tissue before its acetylcholinesterase had been completely inactivated, for acetylcholine disappears very rapidly from frozen tissue if even momentary thawing is allowed to occur[3].

Finally, the acetylcholine content of the brains of a series of sixteen adult rats, killed by immersion in liquid air, was found to be 2·52 ± 0·15 µgm./gm., while the excised brains of litter mates of five of these animals contained only 1·82 ± 0·02 µgm./gm. There seems to be no loss of acetylcholine from excised brain during the first few minutes after decapitation, and it would appear that the low content of acetylcholine in the excised brain resulted from the effects of the violent stimulation accompanying the process of decapitation. It is evident that such an effect could mask any but marked differences in the concentration of acetylcholine in the brains of animals subjected to different experimental procedures. For the detection of such differences, as well as for the determination of the absolute acetylcholine content of the brain, the use of liquid air would seem to remain the method of choice.

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## Passive Transfer of Transplantation Immunity

Passive transfer of transplantation immunity has never been successfully achieved in a simple way. Previous demonstrations of passive transfer have either employed special techniques giving results which are difficult to interpret[1,2], or else the nature of the immunity has been in doubt[3]. Here is reported a simple procedure for passively transferring transplantation immunity to a tumour.

The tumour used was lymphosarcoma *6C3HED*, described by Gardner, Dougherty and Williams[4]. Mice of Strong's *CBA* line are uniformly susceptible to the tumour, and mice of Strong's *C57* line, and the *Ai* line inbred in this laboratory, are uniformly non-susceptible. The survival of grafts of the tumour in non-susceptible mice has been measured by allowing grafts of the tumour to lie in these mice, and then regrafting them into susceptible mice, where growth of the tumour indicates that the tumour had survived in the non-susceptible host. In this way the median survival time of the tumour in *Ai* mice was found to be 9·9 ± 0·8 days. If the *Ai* mice had been previously immunized by inoculation with the tumour, the median survival time was then 2·1 ± 0·3 days. In order to demonstrate passive transfer of transplantation immunity, tissues were transferred from immunized non-susceptible mice into non-susceptible mice from the same line, and the proportion of test grafts of the tumour which survived after eight days in these hosts was measured. Approximately 70 per cent of the grafts survived this time in untreated non-susceptible mice, and after successful transfer of immunity this proportion was reduced.

Subcutaneous inoculations of serum and peritoneal exudate from immune mice both proved ineffective in transferring immunity, in experiments with *Ai* mice. However, evidence was obtained for transfer of immunity by intraperitoneal transplantation of 'immune' lymph nodes, and further investigations of this method of transfer were carried out in *C57* mice. Lymph nodes from immune mice were found to be highly effective in transferring immunity.

This method of transfer could be shown to be genuinely passive, and not merely a transfer with the lymph nodes of tumour cells or possibly of isoantigenic particles. Immune lymph-node mince was inoculated into *CBA* mice, but invariably failed to give rise to tumours. Furthermore, the duration of the immunity was estimated by leaving intervals between inoculation of immune lymph nodes and test tumour grafts. The immunity appeared to remain firm for four days, weaken after ten days, and disappear after twenty days. Lymph nodes taken from non-susceptible mice ten days after inoculation with the tumour were effective in transferring immunity, but after twenty days this power was lost. At this time all the tumour cells had been killed, and the nodes, which after ten days hypertrophy to approximately double their normal weight, have almost returned to normal. Only local lymph nodes were effective in transferring immunity; the corresponding nodes from the opposite side to the site of tumour inoculation were not effective. Neither spleen nor muscle from immunized mice was found to be effective.

This investigation, which will be published elsewhere in detail, shows that transplantation immunity shares with immunity to simple organic compounds[5] and immunity to tuberculin[6] the property of being transferred with greater facility by cells than by serum.

I wish to thank Prof. P. B. Medawar and Dr. K. B. Roberts for much helpful advice and discussion.

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## Hyaluronidase and Salicylates

It has been shown by Hechter[1] that, in the living animal, the spreading effect of hyaluronidase depends upon several factors. Inhibition of this effect such as has been reported to result from the administration of salicylates[2] may not therefore be due, necessarily, to depression of enzyme activity. The effect of hyaluronidase upon the permeability of connective tissue may be demonstrated on pieces of isolated fascia *in vitro*[3]. This method may be expected to give an indication of the action of hyaluronidase alone, since other factors which complicate the phenomenon of spread *in vivo* are excluded.

Three white stock mice, two male and one female, each weighing 25 ± 2 gm., were given 1 per cent sodium salicylate in their drinking water for 48 hr.; in addition, 0·5 ml. of 1 per cent sodium salicylate was injected intraperitoneally 24 hr. and again from between 1 and 6 hr. before the end of this period. The mice were then killed and fascia from each was immediately moistened with 1 per cent sodium salicylate, pH 6·1, and fixed as an occluding membrane to the end of a glass tube in the way previously described[3]. The membrane was immersed in the same solution, and more solution was passed through it at a pressure of 4 cm. water. After a few minutes the rate of flow was measured. A solution of Benger's 'Hyalase' in 1 per cent sodium salicylate was then perfused and after two minutes the rate of flow was measured again. Each mouse provided two membranes, one from each flank; but one membrane was damaged in dissection and not used. As a control, five membranes were obtained from three mice to which no salicylate had been given but which were similar in other respects. Rates of flow before and after perfusion of hyaluronidase were measured exactly as before, except that 0·85 per cent sodium chloride, pH 5·6, was substituted for salicylate. The results are shown in the accompanying table.

The table shows that the increase of flow produced by hyaluronidase is of the same order in both groups. In view of the very great increase in rate of flow brought about by the enzyme in the presence of salicylate and, moreover, through tissue from animals to which salicylate had been copiously administered, it is hard to believe that salicylates can have any

| | Experimental | | | | | Control | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |
| Initial rate of flow (µl./sec.) | 0 47 | 1·05 | 0·36 | 0·44 | 0 47 | 0·7 | 1·17 | 1 7 | 1·3 | 0·85 |
| Rate of flow after hyaluronidase (µl./sec.) | 10 0 | 16·0 | 6·6 | 13·6 | 10 0 | 20·0 | 20 0 | 20·0 | 20·0 | 11·0 |
| Increase (×) | 21 | 15 | 18 | 31 | 21 | 29 | 17 | 12 | 15 | 13 |

significant inhibiting effect upon the action of hyaluronidase on connective tissue. The explanation of their inhibition of the spreading phenomenon *in vivo* is therefore probably referable to their influence upon some other of the several factors upon which this phenomenon depends.

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May 29.

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## Position of Radical Attack during Oxidation of Long-Chain Paraffins

Much work has been done on the liquid-phase oxidation of hydrocarbons; but strangely enough very few experiments of a fundamental nature have included what would appear to be the simplest models, namely, straight-chain paraffins. Any suggestions made so far concerning the point of oxygen attack when there is no preferred tertiary or activated hydrogen atom have been largely speculative. Ivanov *et al.*[1] claim, on the basis of certain products isolated from the oxidation of *n*-heptane, that attack takes place predominantly at the 2-position. Asinger[2] found that in the chlorination of dodecane and cetane attack was equal on all methylene groups, and suggested that the same would hold for oxidation.

In our research on the mechanism of liquid-phase oxidation of paraffins, we have determined the proportion of attack on the different carbon atoms of *n*-decane.

Pure *n*-decane was autoxidized at 145° C. with oxygen until the hydroperoxide concentration had reached 2·5 per cent w/w. From previous work in these laboratories it was known that at this extent of oxidation more than 80 per cent of the decane oxidized retains its original carbon skeleton, the oxygen being present as hydroperoxy- and carbonyl-groups; of these functional groups, 80 per cent are present in mono-functional compounds, the isomer distribution of which indicates the points of attack.

The oxidate was first hydrogenated on palladium black to reduce the hydroperoxides to the corresponding alcohols. In one case the oxygenated compounds were then separated from the unchanged hydrocarbon by chromatography and treated with lithium aluminium hydride to reduce the ketones to alcohols, thus yielding a mixture (*A*) of the total isomers from which the diols had to be removed.

Samples of the same hydrogenated oxidate were also subjected to chromatography by two different operators to separate hydroperoxide-derived alcohols ($B_1$ and $B_2$) from ketones. The two ketone fractions, on reduction with $LiAlH_4$, yielded isomeric decanol mixtures ($C_1$ and $C_2$). During chromatography a partial resolution of the isomeric alcohols was noted.

The infra-red spectra of all five mixtures were recorded and the proportion of isomers determined by matching against standard mixtures of the pure decanols. In some cases, for example, $C_2$, traces of non-decanol material compromised accurate matching.

Mixture *A* should give the more accurate picture since fewer manipulations were involved in this case.

| Decanol isomer | Each isomer as percentage of total isomers in the fraction | | | | | Limits of accuracy of infra-red analyses |
|---|---|---|---|---|---|---|
| | Decanols from total oxidate | Decanols from peroxides | | Decanols from ketones | | |
| | *A* | $B_1$ | $B_2$ | $C_1$ | $C_2$ | |
| 1-ol | 3 | Detected | < 3 | Detected | Not detected | ± 2 |
| 2-ol | 31 | 28 | 29 | 25 | 23 | ± 3 |
| 3-ol | 25 | 28 | 28 | 22 | [35] | ± 3 |
| 4-ol | 22 | 22 | 17 | 25 | 22 | ± 5 |
| 5-ol | 19 | 22 | 23 | 28 | 22 | ± 3 |

The sum of *B* and *C* in the correct proportions is in reasonable agreement with *A*. Part of the ketones may have arisen from the hydroperoxide during hydrogenation; after allowing for this, and considering the limits of accuracy of analysis, we believe that the isomeric distribution of the ketones is substantially the same as that of the hydroperoxides.

By continuous counter-current extraction, decane monohydroperoxide of purity greater than 97 per cent was isolated from an *n*-decane oxidate prepared at 145° C. The isolated peroxide, which contained 20 per cent of the oxygen absorbed, was hydrogenated over Adams's catalyst and the product was an equimolar mixture of the four secondary decanol isomers with possibly a trace of decan-1-ol. No other products could be detected by infra-red spectroscopy.

Our results show that there is a small proportion of attack at the terminal methyl groups, but that the major attack is distributed almost equally on the methylene groups of the *n*-decane chain. Allowing for the limits of accuracy of the infra-red analysis, the preference for the methylene groups near the ends of the chain is only slight.

Our thanks are due to Messrs. Philpotts and Thain for the spectroscopic analyses. This work is part of a joint investigation by the Anglo-Iranian Oil Co., Ltd., and the Distillers Co., Ltd., into the liquid-phase oxidation of paraffins, and we thank our Directors for permission to publish it.

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## A Rapid Method for the Extraction of Radioiodide from Urine

The extraction of radioiodide from urine is important in radioiodide therapy, since without it the large quantities of highly radioactive urine which accumulate must be stored until the activity decays sufficiently to allow disposal.

Purves has described[1] a method for removing iodide from boiled, acidified and filtered urine, by passing it through a filter bed of asbestos impregnated with silver chloride, the iodide being retained in the filter bed, from which it can be afterwards removed as iodic acid by treatment with a solution of chlorine in $0 \cdot 1\,N$ sulphuric acid. Our experience with this method has been that in practice it fails because filtration of urine is a slow process, and also the asbestos mat invariably becomes clogged before 100 ml. of urine have passed through. Swiftness and simplicity of operation and an absolute minimum of handling are essential when dealing with highly radioactive solutions, and these considerations led us to evolve the following method, which is a practical improvement on that of Purves.

Silver chloride prepared by precipitation from silver nitrate was washed carefully with distilled water containing 1 per cent of nitric acid to free it from soluble salts. After drying in the dark at 100–110° C., it was fused in a silica dish at 465° C. The melt was allowed to solidify into a cake, removed from the dish by breaking the latter, and grated down with a coarse rasp. Silver chloride so prepared is effective in removing iodide from solutions. Varieties of silver chloride globules and sponges were also made by pouring the melt into cold water, but none of them was effective.

A glass tube of internal diameter 1 cm. and length 25 cm., wrapped in black paper, was filled with granules of silver chloride sieved free of dust. The packing was maintained in position by a plug of glass wool at each end. The urine, contained in the bottles used for collection, is drawn through the column by means of a water pump and discharged into a 2-lit. reservoir from which, after checking that the radioactivity has been removed by the column, it is disposed of down the sink. The extracted radioiodide is found almost completely within the first 2 cm. of the column.

The *p*H of the urine is adjusted to 2·8 with nitric acid using brom-phenol blue as indicator. If this is done as soon as possible after collection, neither boiling nor filtration of the urine is necessary and the extraction of iodide may be postponed, if desired, for 24–72 hr. The rate of flow through the column is limited only by the necessity of avoiding disturbance of the packing and of preventing channelling by gas bubbles produced by reduced pressure. Flow-rates of 100 ml./min. or more may be easily maintained.

The silver chloride preparation appears to be very stable. We have treated as much as 8 litres at a time without reducing the efficiency of the column, and there seems no reason why this figure should not be exceeded. In practice, however, the accumulation of dangerous quantities of radioactivity renders it advisable to decontaminate the column periodically as outlined above. This process also regenerates the silver chloride. We have so far passed more than 30 litres through the column without noticing any falling-off in its performance, as is indicated in the accompanying table. The column was decontaminated following passage of the volumes marked with asterisks.

| Volume of urine treated (ml.) | Flow-rate (ml./min.) | Delay before treatment (hr.) | Radioiodide extracted (per cent) |
|---|---|---|---|
| 1,500* | 100 | 24 | 97·8 |
| 800* | 100 | 48 | 78·4 |
| 1,000* | 25 | 72 | 88·9 |
| 1,600* | 30 | 72 | 82·9 |
| 8,000 | 20 | 48 | 80·8 |
| 1,400 | 70 | 48 | 78·8 |
| 8,000 | 10 | 48 | 88·9 |
| 750* | 100 | 24 | 78·9 |
| 1,600* | 100 | 24 | 78·9 |
| 8,000* | 125 | 48 | 97·1 |

It will be seen that the percentage extraction is considerably lower in some cases than others. Recirculating such urine through the column to remove the unextracted fraction is ineffective. This cannot at present be entirely explained, but is at least partially due to the presence of a variable quantity of protein-bound iodine which occurs in radioiodide–therapy urine, and which the column does not extract. This fraction is insignificant during the early hours of treatment, when the urinary output of radioactivity is at its greatest; and the column is, in fact, at its most efficient with such urine. We consider, therefore, that notwithstanding this limitation, the technique is of value as a practical expedient.

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Nov. 6.

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[1] Purves, H. D., *Nature*, 169, 111 (1952).

## Spontaneous and Induced Mutation

In his book "Bacterial Physiology" (New York, 1951), Dr. J. Lederberg writes, on page 94: "Not all workers have accepted the duality of adaptation mechanisms. Hinshelwood (1946), for example, has disregarded the selection of spontaneous mutants as an element of bacterial adaptations, apparently in order to bolster the applicability of his system of chemical kinetics to problems of bacterial growth".

The reference is to my short book, "The Chemical Kinetics of the Bacterial Cell" (which is described in its own preface as an "essay" and is not a reference work in any event). Nevertheless, it contains one chapter entitled "Variants" (that is, mutants) and another entitled "Selection" (one section of which is entitled "Superposition of Adaptation and Selection"). On page 193, in connexion with spontaneous and induced changes, it is stated: "It should be emphasized at the outset that one has not necessarily to do here with two competing or mutually exclusive hypotheses. Both types of mechanism may in fact operate in nature". On page 202 it is stated: "From this point of view the question would no longer be: what is the mechanism of variation and adaptation, but, which of the various mechanisms plays the more important part in any given example". On page 203 (in connexion with the same problem) it is stated: "Probably the correct interpretation varies from case to case". Ten pages later, still in the same connexion, it is stated: ". . . one is inclined to feel that a complete gradation of behaviour is probably to be detected, by the proper methods, among bacteria, just as it is known to exist in ordinary chemical reactions, where the relative importance of nucleation and growth of nuclei varies widely".

Experiments in this laboratory have led us to conclude that the induced adaptation mechanism operates in various particular cases. But we have never denied possible or even probable duality of mechanism in general.

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# FORTHCOMING EVENTS

(*Meetings marked with an asterisk * are open to the public*)

## Monday, February 9

British Society for the History of Science, Philosophy of Science Group (in the Joint Staff Common Room, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Dr. G. Kreisel: "On Formalization".

Pharmaceutical Society (at 17 Bloomsbury Square, London, W.C.1), at 7.30 p.m.—Prof. Gösta Edman: "Ash Pictures in the Identification and Assay of Vegetable Drugs".

Manchester Literary and Philosophical Society (at the University, Manchester)—Prof. W. A. Deer: "Trends in Petrology" (Percival Lecture).

## Tuesday, February 10

University of London (in the Anatomy Theatre, University College, Gower Street, London, W.C.1), at 1.15 p.m.—Mr. A. J. Arkell: "Toilet in Ancient Egypt".*

Zoological Society of London (at the Zoological Gardens, Regent's Park, London, N.W.1), at 5 p.m.—Scientific Papers

British Postgraduate Medical Federation (at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 5.30 p.m.—Dr. Honor B. Fell, F.R.S.: "Organ Culture in Biological and Medical Research" ("The Scientific Basis of Medicine", 11).*

Institution of Chemical Engineers (at the Geological Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Mr. S. R. Tailby and Mr. Muhammed Aly Saleh: "Heat Transfer from Luminous Gas Flames in Vertical Tubes".

Institution of Mechanical Engineers, Automobile Division (joint meeting with the Institution of Electrical Engineers, at Storey's Gate, St. James's Park, London, S.W.1), at 5.30 p.m.—Mr. A. H. Ball and Mr. W. Nethercot: "Ignition Interference with Television Reception"

## Wednesday, February 11

Royal Sanitary Institute (at 90 Buckingham Palace Road, London, S.W.1), at 2.30 p.m.—Dr. E. A. Parkin: "Problems of Insect Control in Large Kitchens".

Royal Society of Arts (at John Adam Street, Adelphi, London, W.C.2), at 2.30 p.m.—Mr. W. A. Stewart: "Increasing Beef Production"; Mr. W. R. Trehane: "Increasing Milk Production".

University of London (at the London Hospital Medical College, Turner Street, London, E.1), at 5 p.m.—Prof. A. Giroud (Paris): "Factors of Abnormal Development".*

University of London (at Bedford College, Regent's Park, London, N.W.1), at 5.15 p.m.—Mr. Eric Shipton: "The Recent Everest Expedition" ("Recent Exploration and Discovery", 2).*

Institution of Electrical Engineers, Radio Section (at Savoy Place, Victoria Embankment, London, W.C.2), at 5.30 p.m.—Prof. F. C. Williams, F.R.S., and Mr. G. B. B. Chaplin: "A Method of Designing Transistor Trigger Circuits".

British Institution of Radio Engineers, London Section (at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 6.30 p.m.—Mr. L. A. Thomas: "Modern Trends in Communications Materials".

Society of Chemical Industry, Food Group (at the Chemical Society, Burlington House, Piccadilly, London, W.1), at 6.30 p.m.—Dr. N. J. Berridge: "The Antibiotic Nisin and its use in the making and processing of Cheese"; Dr. Marie E. Coates: "The Mode of Action of Antibiotics in Animal Nutrition".

## Thursday, February 12

Royal Society (at Burlington House, Piccadilly, London W.1), at 4.30 p.m.—Dr. W. J. Pugh, F.R.S.: "The Research Work of the Geological Survey".

British Postgraduate Medical Federation (at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 5.30 p.m.—Prof. P. C. C. Garnham: "The Life Cycle of the Malaria Parasite" ("The Scientific Basis of Medicine", 12).*

Institution of the Rubber Industry (at the Royal Society of Tropical Medicine and Hygiene, Manson House, 26 Portland Place, London, W.1), at 5.30 p.m.—Mr. G. Lynch: "Practical Safety in the Rubber Industry"; at 7 p.m.—Dr. C. M. Blow: "Recent Developments in Chemical Derivatives of Rubber".

University of London (at King's College of Household and Social Science, Campden Hill Road, London, W.8), at 5.30 p.m.—Mr. Eric Shipton: "Mount Everest".* (Admission by ticket obtainable from the Secretary of the College.)

Birkbeck College (in the Assembly Hall, Institute of Education, Malet Street, London, W.C.1), at 6 p.m.—Prof. E. G. R. Taylor and Dr. Derek Price: A Discussion on the new Chaucer MS., "The Equatorie of the Planetis".*

## Friday, February 13

Institution of Mechanical Engineers (joint meeting with the Hydraulics Group, at Storey's Gate, St. James's Park, London, S.W.1), at 10.30 a.m.—Conference on "Hydraulic Servo-mechanisms".

Operational Research Club (joint meeting with the Ergonomics Research Society, in the Large Lecture Room, Royal Society, Burlington House, Piccadilly, London, W.1), at 2.30 p.m.—Discussion on "Men and Machines in Transport Systems".

Royal Astronomical Society (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Anniversary Meeting, followed by Annual General Meeting.

North-East Coast Institution of Engineers and Shipbuilders (at the Mining Institute, Neville Hall, Newcastle-upon-Tyne), at 6.15 p.m.—Mr. J. D. Hislop: "The Role of Non-Destructive Testing in Industry".

Royal Institution (at 21 Albemarle Street, London, W.1), at 9 p.m.—Dr. J. W. Mitchell: "Some Experiments on Photographic Sensitivity".

## Saturday, February 14

Bradford Chemical Society (at the Technical College, Bradford), at 2 p.m.—Research Colloquium.*

London County Council (at the Horniman Museum, London Road, Forest Hill, London, S.E.23), at 3.30 p.m.—Mr. R. D. Barnett: "Cyrene, a Greek City in North Africa".*

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# APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Deputy Coal Survey Officer (with a good honours degree, or equivalent, in chemistry, fuel technology, or geology, preferably with industrial experience and experience in laboratory control) at the Coal Survey Laboratory, Nottingham—The National Coal Board, Establishments (Personnel), Hobart House, Grosvenor Place, London, S.W.1, endorsed TT/584 (February 14).

First Grade Engineering Assistant (sewerage) in the City Engineer's Department, Port Elizabeth—Davis and Soper, Ltd., Agents to the City Council of Port Elizabeth, 52–54 St. Mary Axe, London, E.C.3 (February 14).

Graduate Assistant Science Mistress at the Lady Edridge Grammar School, South Norwood, to teach Physics throughout the school to advanced level of the G.C.E.—The Chief Education Officer, Education Office, Katharine Street, Croydon, Surrey (February 14).

Scientific Officer for research and development work on electronic instrumentation for use in trials of guided missiles (Ref. A.7/53A), an Experimental Officer for development and modification of electronic instrumentation used for trials of guided missiles and to supervise the field operation and maintenance of this class of equipment (Ref. A.8/53A), and an Assistant Experimental Officer to assist in development, operation, maintenance, calibration, etc., of telemetry equipment (Ref. A.9/53A), at Ministry of Supply Establishment at Aberporth, South Wales—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting the appropriate Ref. No. (February 14)

Scientific Technical Officer (Grade II or III) at the Central Laboratory, Shade House, Bolton Road, Pendlebury, interested in the investigational side of coal sampling and preparation—The Divisional Establishment Officer, National Coal Board, North-Western Division, 40 Portland Street, Manchester 1 (February 14).

Scientific Technical Officer (Grade II or III) (with a scientific background mainly in chemistry, and able to abstract and translate) as Technical Librarian at the Central Laboratory, Shade House, Bolton Road, Pendlebury—The Divisional Establishment Officer, National Coal Board, North-Western Division, 40 Portland Street, Manchester 1 (February 14).

Speech Therapist to the Wallington Clinic—The County Medical Officer, County Hall, Kingston-upon-Thames, Surrey (February 14).

Research Assistant (good honours degree in engineering or science, or its equivalent with a knowledge of aerodynamics and training and aptitude for experimental work essential) in the Department of Aerodynamics, to assist in experimental research—The Registrar, College of Aeronautics, Cranfield, Bletchley, Bucks (February 16).

Assistant Lecturer in Geography—The Secretary, London School of Economics and Political Science, Houghton Street, Aldwych, London, W.C.2 (February 20).

Director of Studies and Lecturer (or Assistant Lecturer) in Geography—The Secretary, Girton College, Cambridge (February 20).

Control and Switchgear Engineer in the Mechanical and Electrical Engineering Branch at London headquarters—The National Coal Board, Establishments (Personnel), Hobart House, Grosvenor Place, London, S.W.1, quoting TT/589 (February 21).

Geneticist for Poultry Research Centre, Edinburgh—The Secretary, Agricultural Research Council, 15 Regent Street, London, S.W.1 (February 21).

Research Chemist in the Soils and Plant Nutrition Section at Long Ashton Research Station—The Registrar and Secretary, The University, Bristol (February 21).

Chair of Physics applied to Medicine at Guy's Hospital Medical School—The Academic Registrar, University of London, Senate House, London, W.C.1 (February 25).

University Demonstrator in Agriculture (with a degree or postgraduate diploma in agriculture and, preferably, trained in field experimentation)—The Secretary, School of Agriculture, Cambridge (February 25).

Demonstrator and Research Assistant in Dental and Oral Pathology—The Registrar, The University, Sheffield (February 28).

I.C.I. Research Fellowships in Biochemistry, Chemistry, Engineering, Pharmacology, or Physics—The Secretary of University Court, The University, Glasgow (February 28).

Lecturer in Mathematics—The Secretary of University Court, The University, Glasgow (February 28)

Scientific Officer (with a good honours degree in mathematics and, preferably, specialized in mathematical statistics or analysis) to assist with mathematical problems arising from research on animal and plant populations—The Establishment Officer (S), Nature Conservancy, 91 Victoria Street, London, S.W.1 (February 28).

Structural Engineers in Government Departments—The Secretary, Civil Service Commission, Scientific Branch, Trinidad House, Old Burlington Street, London, W.1, quoting No. S.64–65/53 (February 28).

NUFFIELD FELLOWSHIPS AND SCHOLARSHIPS IN DENTISTRY—The Secretary, Nuffield Foundation, Nuffield Lodge, Regent's Park, London, N.W.1 (Fellowships, March 1; Scholarships, June 30).

LECTURER IN MEDICAL PHYSICS (graduate in physics with research experience and interested in medical problems)—The Registrar, The University, Manchester 13 (March 2).

ROBERT BLAIR FELLOWSHIP for advanced study or research in applied science and technology abroad—The Education Officer, (EO/H1/2), London County Council, County Hall, London, S.E.1 (March 2).

REGIUS CHAIR OF FORENSIC MEDICINE in the University of Edinburgh—The Private Secretary, St. Andrew's House, Edinburgh (March 15).

LECTURER IN PHILOSOPHY—The Dean of Arts and Science, University of Alberta, Edmonton, Alberta, Canada (March 31).

LECTURER IN VETERINARY BIOCHEMISTRY, and an ASSISTANT LECTURER or LECTURER IN VETERINARY MEDICINE (farm animals)—The Registrar, The University, Liverpool (March 31).

PUPILS and PROBATIONERS IN CIVIL ENGINEERING, and PUPILS IN MECHANICAL AND ELECTRICAL ENGINEERING (including telecommunications), in the Colonial Engineering Service, mainly in West, East and Central Africa, Malaya and the Far East—The Director of Recruitment (Colonial Service), Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting CDE/100/011 (March 31).

BIOLOGICAL SCHOLARSHIPS AND BURSARIES—The Secretary, Nuffield Foundation, Nuffield Lodge, Regent's Park, London, N.W.1 (April 1).

I.C.I. RESEARCH FELLOWSHIPS IN BACTERIOLOGY, BIOCHEMISTRY, BIOMOLECULAR STRUCTURE, BOTANY (plant biochemistry), CHEMICAL ENGINEERING, CHEMISTRY, CHEMISTRY OF LEATHER MANUFACTURE, CHEMOTHERAPY, COLOUR CHEMISTRY AND DYEING, ENGINEERING (civil, electrical or mechanical), FUEL AND REFRACTORIES, GEOLOGY (including geochemistry), METALLURGY, MINING (selective flotation and geophysical surveying), PHARMACOLOGY, PHYSICS, PHYSIOLOGY, or TEXTILE INDUSTRIES (protein chemistry)—The Registrar, The University, Leeds 2 (April 20).

I.C.I. FELLOWSHIPS FOR RESEARCH IN CHEMISTRY, PHYSICS and allied subjects—The Registrar, The University, Manchester 13 (April 30).

I.C.I. FELLOWSHIPS FOR RESEARCH IN PHYSICS, CHEMISTRY, BIOCHEMISTRY, ENGINEERING, METALLURGY, PHARMACOLOGY, CHEMOTHERAPY, or related subjects—The Secretary of the Board of Research Studies, The Old Schools, Cambridge (April 30).

I.C.I. RESEARCH FELLOWSHIPS IN BIOCHEMISTRY, CHEMISTRY, CHEMOTHERAPY, ENGINEERING, METALLURGY, PHARMACOLOGY, PHYSICS or allied subjects—The Academic Registrar, University of London, Senate House, London, W.C.1 (April 30).

MR. AND MRS. JOHN JAFFE DONATION for a studentship in original scientific research—The Assistant Secretary, Royal Society, Burlington House, Piccadilly, London, W.1 (April 30).

SOCIOLOGICAL SCHOLARSHIPS AND BURSARIES—The Secretary, Nuffield Foundation, Nuffield Lodge, Regent's Park, London, N.W.1 (May 1).

CIVIL ENGINEERS in Government Departments—The Secretary, Civil Service Commission, Scientific Branch, Trinidad House, Old Burlington Street, London, W.1, quoting No. S.64–66/53 (June 30).

ASSISTANT PHYSICIST—The Secretary, Board of Management for Glasgow Western Hospitals, 10 Park Circus, Glasgow, C.3.

BOTANIST (Plant Breeder) at Rokupr Rice Research Station, Sierra Leone—The Director of Recruitment (Colonial Service), Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting No. 27069/317.

CHIEF RESEARCH AND DEVELOPMENT OFFICER (with an honours degree in mining or science, and research and practical mining experience), Mines Department, Federation of Malaya—The Director of Recruitment (Colonial Service), Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting CDE.99/60/03.

CROP ECOLOGIST in the Department of Soil and Land Use Survey, Gold Coast, to collect yield data for various crops grown on different soils—The Director of Recruitment (Colonial Service), Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting CDE.79/13/03.

ELECTRICAL ENGINEERS and PHYSICISTS at the Ministry of Supply Telecommunications Research Establishment, Malvern: SCIENTIFIC OFFICER grade (Ref. A.5/53A) and EXPERIMENTAL and ASSISTANT EXPERIMENTAL OFFICER grades (Ref. A.6/53A) for research and development work on radio and electronic equipment in the Radar, Physics and Engineering Departments—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting the appropriate Ref. No.

ENGINEER (honours degree in mechanical engineering preferred) for research on new drives and designs for textile machines—The Wool Industries Research Association, Torridon, Headingley, Leeds 6.

EXECUTIVE ENGINEER in the Public Works Department, Uganda, to be responsible for construction and maintenance of roads, housing schemes, water supply, drainage, sewerage, and buildings—The Director of Recruitment (Colonial Service), Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting CDE.112/9/02.

EXPERIMENTAL OFFICER IN THE MECHANICAL ENGINEERING RESEARCH LABORATORY of the Department of Scientific and Industrial Research, East Kilbride, Glasgow, for research on plastic deformation of metals occurring in commercial processes, for example, rolling, drawing and forging—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.153/52A.

EXPERIMENTAL OFFICERS (with a pass degree in geology, mining, engineering or physics) for field work in Uganda, including supervision of examination of mineral deposits by pitting, trenching, shallow drilling and sampling; also some surveying and laying out of prospecting areas and collation of records—The London Director, Uganda Development Corporation, Ltd., 27 Regent Street, London, S.W.1.

EXPERIMENTAL OFFICERS IN THE RADIO DIVISION, Royal Aircraft Establishment, Farnborough, on development of electronic equipment, for radio frequency measurements, especially at centimetric wave-lengths, and for other detailed technical investigations—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting D.1/53A.

EXPERIMENTAL OFFICERS or ASSISTANT EXPERIMENTAL OFFICERS at the National Physical Laboratory, Teddington, for experimental work in the Ship Division—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting C.14/53A.

GEOLOGISTS (with a university degree in geology with first- or good second-class honours) in the Colonial Geological Survey Service—The Director of Recruitment (Colonial Service), Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting CDE.104/04.

LECTURER (with a good honours degree with some teaching or industrial experience, and preferably with a special interest in electronics or electroacoustics) IN THE PHYSICS DEPARTMENT—The Principal, Northampton Polytechnic, St. John Street, London, E.C.1.

METEOROLOGICAL OFFICER (with a first- or second-class honours degree in mathematics or physics, preferably with experience as a meteorologist) in Nyasaland—The Director of Recruitment (Colonial Service), Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting CDE.96/4/01.

METEOROLOGISTS in the British Caribbean Meteorological Service—The Director of Recruitment (Colonial Service), Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting CDE.57/26/01.

ORGANIC CHEMIST (Ph.D. preferred) in the Chemical Research Laboratory, Rheumatism Research Unit, to work with a team in the steroid field—W. Stansfield, Lyndhurst, Nether Edge Hospital, Sheffield 11.

PETROLOGIST (with an honours degree in geology with a specialist qualification in petrology, and one year's postgraduate study or experience) in the Gold Coast, for petrological investigations in field and laboratory, with chemical analysis of rocks and minerals—The Director of Recruitment (Colonial Service), Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting CDE.105/13/02.

PHYSICIST (with a good honours degree; an interest in statistical methods is desirable) for work concerned initially with the processing of textile fibres both from a practical and theoretical point of view—The Secretary, British Jute Trade Research Association, Kinnoull Road, Kingsway West, Dundee.

PHYSICIST (with a first- or second-class honours degree or equivalent in physics, and interested mainly in electromagnetic theory) in a Ministry of Supply establishment at Malvern, as theoretician on problems connected with design of high energy accelerators, with personal charge of a full-time computer—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.23/53A.

PHYSICISTS or ENGINEERS at the Royal Aircraft Establishment, Farnborough, to work on problems connected with either generation and distribution of electric power in aircraft, or on problems of electro-technology arising in design and development of aeronautical equipment (Ref. D.6/53A); ENGINEER with extensive electronic or electrical experience for development work on the application of electronic and electrical equipment to flight vibration testing of aircraft (Ref. D.7/53A)—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting the appropriate Ref. No

PHYSICS GRADUATE for research in the strength of paper and board—The Printing, Packaging and Allied Trades Research Association, Randalls Road, Leatherhead, Surrey.

POSTGRADUATE STUDENTSHIP IN PLANT BREEDING, ENTOMOLOGY AND PLANT PATHOLOGY—The Secretary, Empire Cotton Growing Corporation, 12 Chantrey House, Eccleston Street, London, S.W.1

PROFESSIONAL ENGINEERS in various Government Departments, in a wide variety of engineering duties—The Secretary, Civil Service Commission, Scientific Branch, Trinidad House, Old Burlington Street, London, W.1, quoting No. S.86/53.

SCIENCE or ENGINEERING GRADUATES for research in the CHEMICAL ENGINEERING DEPARTMENT on some aspects of flow of liquids through porous materials—The Registrar, Imperial College of Science and Technology, South Kensington, London, S.W.7.

SENIOR LECTURER IN CHARGE OF THE ELECTRONICS WORK OF THE DEPARTMENT OF ELECTRICAL ENGINEERING—The Secretary, Royal Technical College, George Street, Glasgow.

SENIOR SCIENTIFIC OFFICERS at Capenhurst, Chester, for analytical and vacuum technique development and work involving mass transfer in polyphase systems—The Ministry of Supply, Division of Atomic Energy (Production), Risley, Warrington, Lancs, quoting Ref. 410.

SENIOR TECHNICAL OFFICER (with a degree in horticulture or botany or equivalent qualification, with suitable practical experience in postgraduate training in research) for Seed Production of Vegetable and Root Crops—The Secretary, National Institute of Agricultural Botany, Huntingdon Road, Cambridge.

SURVEYORS in the Gold Coast Local Civil Service for geodetic, topographical and cadastral surveys and the supervision of junior staff—The Director of Recruitment (Colonial Service), Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting DE.103/13/01.

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# REPORTS and other PUBLICATIONS

*(not included in the monthly Books Supplement)*

## Great Britain and Ireland

Forestry Commission. Report on Forest Research for the Year ending March 1951. Pp. vi+139+4 plates. 4s. 6d. net. Bulletin No. 19: Poplars. By T. R. Peace. Pp. iv+50+24 plates. 7s. 6d. net. Leaflet No. 30: Sooty Bark Disease of Sycamore, *Cryptostroma corticale*. Pp. 8. 9d. net. (London: H.M. Stationery Office, 1952.) [2611

Southern Regional Council for Further Education. Fifth Annual Report, October 1952. Pp. 36. (Reading: Southern Regional Council for Further Education, 1952.) [2711

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# AUTONOMY OF UNIVERSITIES IN GREAT BRITAIN

THREE memoranda, dealing with the universities and government in Great Britain, with the University Grants Committee, and with Government grants-in-aid to universities in Great Britain, respectively, have been submitted to the Commission on Financing Higher Education, a private agency sponsored by the Association of American Universities. These memoranda have now been published*, with a foreword by J. D. Millett, the executive director of the Commission. The broad conclusion reached is that the British system is unlikely to be suitable for American conditions. On the Federal level, as Prof. Lindsay Rogers points out, the United States is so large and the number of institutions is so great that a single university grants committee would confront an impossible task. Apart from this, both Prof. Rogers and President Dodds are doubtful whether either the Washington atmosphere or local public opinion would be as favourable to the freedom and independence of the universities as both that of Whitehall and public opinion in general are in Great Britain. The risks of State interference are greater in the United States, primarily because of the financial control of the universities and colleges by boards of trustees which are not predominantly academic, and which may be less resistant to external pressure than academic staff would be.

Nevertheless, if this survey of the British system by three independent trained minds yields little by which the United States can profit directly, it is of real value for Great Britain. It is of the greater interest in that the surveys were made prior to the examination of the system conducted by the Select Committee on Estimates during February–March 1952. Its findings thus make an interesting counterpart to those of the Select Committee in its Fifth Report for the Session 1951–52 and also to Mr. H. B. Chubb's scholarly book, "The Control of Public Expenditure". Its importance lies principally in the independent analysis it provides of the conditions responsible for the past success of the system and the factors which may limit its functioning in future. It is accepted that the universities of the United Kingdom will continue to depend chiefly on the Government for financial support. All three authors agree that even with the greatest goodwill toward the universities and with the greatest respect for the tradition of academic freedom, the predominance of government financial support involves, at least indirectly, government guidance of academic policy. The system is one of compromise, the natural method by which toleration works. Toleration and compromise, as Sir Ernest Barker points out in his "Reflections on Government", are the basis of democratic government; and the continuance and the effectiveness of the University Grants Committee system depends accordingly on the continuance of that liberal tradition or spirit of accommodation.

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* Government Assistance to Universities in Great Britain. Memoranda submitted to the Commission on Financing Higher Education by Harold W. Dodds, Louis M. Hacker and Lindsay Rogers. (Published for the Commission on Financing Higher Education.) Pp. xiii+133. (New York: Columbia University Press; London: Oxford University Press, 1952.) 16s. net.

The implications of this situation are well brought out in these memoranda, particularly in those of Prof. Rogers and President Dodds. The system works well in Great Britain because of social and political customs and institutions which are peculiar to the country and may even be peculiar to the institutions concerned; they are not reproduced or reproducible in the United States. Nor can it be assumed that they exist in other institutions for which the adoption of a like device has been suggested. In brief, the independence of the British universities cannot be secured by administrative devices alone. It will last just so long as public opinion is willing that the universities should be autonomous, and how long that will be depends on the good sense and moderation shown by the universities themselves.

The potentialities of conflict between government and universities are recognized, and the memoranda give frank expression to some of the fears and misgivings entertained by the universities. Equally there are comments they would do well to note; particularly, for example, the query whether the agreements reached in private between the University Grants Committee and individual universities in regard to non-recurrent grants take sufficient account of the interests of the whole community, or again whether the amount of such grants may not be influenced too much by the skill or experience of one university rather than another in negotiating or presenting its case. That such a position could arise, particularly in regard to the newer departments, has already been adduced as a reason for continuing earmarked grants in the social sciences until such departments are able to present their case on equal terms with older established departments.

The memoranda support the argument already advanced by the Select Committee on Estimates and accepted by the Treasury in a Memorandum on the Select Committee's report that more information should be supplied to Parliament regarding the spending of these large sums of money. The practical problem is to determine what information is to be supplied, in what form and when. So far as Parliament is concerned, there is the question of supplying this at a stage when control can be effective without infringing the autonomy of the universities, and here President Dodds is inclined to suggest that the principle of greater accountability to Parliament will ultimately prevail.

Whether, in fact, such accountability will infringe the independence of the universities depends, however, on the extent to which the value of academic autonomy is understood and appreciated by Parliament and by the community as a whole. There is an aspect of political education involved here to which the universities might well give more attention. The wider and freer assumption of their regional responsibilities, as urged by Prof. B. Dobrée and 'Bruce Truscot', for example, could help; but so could alumni associations of the type which so impressed the Anglo-American Council on Productivity's team on universities and industry. The recommendation in the report of the latter that the desirability of extending graduate contacts in this way should be explored by British universities may well be even more important, from the point of view of maintaining and extending public understanding and support of the universities, than from that of obtaining financial support from sources independent of the Government.

If the broad conclusion of these studies is accepted, that the success of the University Grants Committee rests fundamentally upon unwritten conventions and the personal and social relations of a homogeneous community of university men, in and out of government, sharing common tastes and a common outlook, the importance of a more strenuous effort to extend the area of public understanding both inside and outside Parliament is obvious. President Dodds is on less certain ground in his remarks as to the effect of developments in secondary education on the universities. His suggestion that the British universities are more specialized than American universities is a little surprising.

University autonomy may be less fortuitous, however, in Great Britain than President Dodds inclines to think; but there can be no doubt that the general climate of opinion is scarcely as favourable to an extension of the device as it was to the initiation and early development of the University Grants Committee. Some of the weaknesses of the existing system emphasized in these studies, notably the staffing of its secretariat, are already receiving attention in consequence of the report of the Select Committee on Estimates; but it is clear that full weight should be given to the factors here emphasized as essential to the working of the system before any detailed proposals are formulated for its extension to other bodies.

The existence of a great reservoir of goodwill in public opinion is perhaps the most important factor, and with the comments in these studies as to the supply of further information about the working of the universities and the expenditure of the Parliamentary grant, the universities, individually and through the University Grants Committee, can scarcely fail to give closer attention to this question of publicity. In fairness, however, it should be pointed out that newsprint is one factor which renders such publicity difficult: full accounts of the development and activities of particular universities in national or local newspapers are likely to reach a much wider public than the most attractive accounts which the University Grants Committee could issue officially.

Such reports could not, of course, replace the official accounts for the purpose of informed discussion in Parliament, for example; but they could assist the growth of public understanding, particularly if well supported by broadcast discussions or talks. For it is a main weakness of the proposals for extending the device which has proved so successful in dealing with the universities to other institutions that, by and large, the necessary public understanding of the situation does not exist. Paradoxically, of course, the existence of such public understanding would minimize or even eliminate the need for some of these proposals.

# CAN ECONOMICS BECOME AN EXACT SCIENCE?

Econometrics

By Prof. Gerhard Tintner. (A Wiley Publication in Economics.) Pp. xiii+370. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1952.) 46s. net.

A STUDENT of economics is told, early in his theoretical courses, that his subject is distinguished from the natural sciences by the fact that economic experiments are virtually impossible. The lecturer heaves a sigh of regret and passes on with evident satisfaction to a domain wherein economic concepts are defined and their consequences developed with exquisite acuteness and skill, untrammelled by the awkward necessity of comparing theory with fact except in the end-product.

This is one reason why economics has difficulty in obtaining recognition as a branch of science; but there are several others. Economists almost universally prefer a literary method of exposition, and even the most mathematically minded of them write down an equation in their main text with evident reluctance, preferring to relegate the mathematics to the decent obscurity of an appendix. This not only encourages a degree of prolixity which would not be tolerated in any natural science; it also enables them, by the use of phrases like 'other things being equal', 'in the long run' and 'marginal increments', to avoid writing down their boundary conditions or to count the relations between their variables, and hence to make only the vaguest intuitive approach to questions of the uniqueness and stability of their solutions.

Now it has to be admitted that major experiments in economics are indeed impossible and that mathematical economics has not yet succeeded in telling economists much that they did not already know. There is, nevertheless, a growing feeling that if real progress is to be made the literary method is insufficient. One sees many signs of dissatisfaction with the present state of theoretical economics among economists themselves, as well as among those natural scientists who are drawn into an interest in the subject. There has, for example, been a movement away from the rather indefinite and unmeasurable quantity 'utility' towards the observable 'indifference', and a further movement towards the measurement of consumers' preferences through experimental studies of family budgets. Attempts are being made to measure the flow of production factors around the economic system by studies of national accountancy. Experiments in micro-economics are now possible; and although macro-economics experiments remain a dim dream, the methods of statistics, which are particularly appropriate to situations involving a complex of causation, are increasingly being tried out. The economic air is full of model-building, studies of stochastic equations, problems of identifiability and the like, all of them requiring a mathematical technique for their formulation and a statistical technique for their verification; and at last it is being appreciated that dynamic movements are an essential part of even the elements of the subject and that many apparently static properties, such as stable equilibrium, must be studied in the light of velocities. accelerations or time-lags.

The stage seems to be set for the emergence of a quantitative science of economics. (Whether we call it econometrics or not is a matter of taste.) But the actors seem rather reluctant to appear, and when they do they are not very successful. One reason is that they try to do too much; another is that there are not enough of them with a training in natural science; and a third is that they are apt to trail off on abstract mathematical arguments without holding themselves firmly in sight of the main objective. One cannot altogether blame them. A man with a career to make and a reputation to establish has to publish something, and it is easier to obtain positive results in pure mathematics than in the detection of economic patterns among the very imperfect statistical material which exists to-day.

The purpose of this preamble is to put Prof. Gerhard Tintner's book in a correct setting. It is entitled "Econometrics"; but it is not a text-book of econometrics, simply because in the present state of knowledge there cannot be such a thing; by this I mean that there cannot be a smooth development of a theory of quantitative economics from a set of postulates leading to experimentally verifiable conclusions. What Prof. Tintner has done is bring together a great many of the attempts made by econometricians to quantify parts of their subject and to expound the statistical techniques which are required. The book is in three parts: Part 1 (79 pages) is a non-technical introduction to econometrics; Part 2 (107 pages) is an introduction to multivariate analysis; and Part 3 (146 pages) is entitled "Some Topics in Time-Series Analysis". The relative lengths of these parts are themselves an illustration of the greater emphasis placed on statistical techniques than on the development of a quantified economic theory.

The main substance of Part 1 is contained in the third chapter (there are four altogether) on "Some Illustrations of Econometric Research", in which Prof. Tintner exhibits the type of problem which has been tackled econometrically: for example, Schultz's work on demand and supply analysis, Dean's on cost functions, Douglas's on production functions, Waugh's on utility functions, Leontieff's development of the *tableau économique*, and various models by Haavelmo, Tinbergen and Klein. They are all gallant attempts, and it is unfair to scrutinize the work of pioneers with too critical an eye; but it has to be admitted that they are subject to very severe limitations.

Part 2 consists of three chapters, on multiple regression and correlation, on some applications thereof to multivariate analysis and on stochastic models with errors in the equations. Wherever possible, Prof. Tintner quotes examples of econometric applications, and the chapter on errors-in-equations will be a useful introduction to the abstract treatments which have so far appeared in book form.

Part 3 is a review of developments in the theory of stochastic time-series which has taken place during the past twenty years—trend, Fourier analysis, autocorrelation analysis, stochastic difference equations, correlogram analysis and variate differences. There is an appendix on the elements of matrices and determinants and numerical computation.

One of the most useful features of the book is that Prof. Tintner, who has a very extensive acquaintance with the literature of statistics and econometrics, has given full references to original sources, so that his book is a useful introduction for anyone who wants to take his studies deeper. Personally, I would have preferred to see those references assembled in an appendix and not given in footnotes. There are so many of them that at times a layer of text seems to float on a heavy substratum of reference, leading to that heckling of the text by footnotes against which protests have been lodged in other spheres. But the references are given, which is the main thing.

Prof. Tintner would, I am sure, be the first to acknowledge the shortcomings of this book, some of which are due to the imperfections of the subject and some to the difficulty of expressing advanced statistical methods in terms which economists can assimilate, and a few of which are his own responsibility. But all students of econometrics will want to read it, and it should do much to widen interest in a frustrating but extremely important field awaiting scientific exploration. M. G. Kendall

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# PRINCIPLES OF QUANTUM THEORY

**Quantum Theory**

By David Bohm. (Prentice-Hall Physics Series.) Pp. ix+646. (New York: Prentice-Hall, Inc.; London: Constable and Co., Ltd., 1952.) 45s. net.

Dr. David Bohm has written a highly individual account of the non-relativistic quantum theory, his aim being to express the known results in terms of comparatively qualitative and imaginative concepts at an elementary level. The emphasis is mainly on the physical interpretation and logical structure of the theory, and the explanations given are unusually thorough. This is not to say that the mathematical development is neglected; the text contains neat derivations of most of the standard results. Altogether the book will be very valuable to the thoughtful student.

The first seven chapters develop the physical formulation of the quantum theory, which is built up rather inductively from the hypotheses of Planck and Einstein, the Bohr orbit theory and de Broglie's wave theory. This involves a careful discussion of the correspondence and uncertainty principles and of the changes produced by the process of observation. Dr. Bohm is successful in conveying the physical picture behind the quantum assumptions.

Chapter 8 is concerned with rather abstract matters. There are a discussion of the concepts of motion and of causes and an exposition of the difficult concept of complementarity. Dr. Bohm develops the interesting parallel between the uncertainties of quantum mechanics and the erratic nature of our thought processes; throughout the book are many biological analogies.

The second part of the book develops the mathematical formalism of wave functions, expectation values and probabilities, and the third part gives the usual solutions of standard problems. Proper importance is given to the classical limit, which is established by the W. K. B. approximation. There is a useful chapter on matrix methods, which are used effectively in various parts of the book, but the Dirac notation is not introduced. Three chapters are devoted to perturbation theory, both stationary and time-dependent. There is also an excellent chapter on scattering theory, which, in keeping with the rest of the book, contains an adequate discussion of the validity of the various approximation methods and of the equivalence of the time-dependent and stationary methods of solution. It is perhaps surprising, in a book of 640 pages, to find no account of relativistic electron theory or of second quantization; even the treatment of the symmetry properties of many-particle wave-functions is sketchy.

That the text is discursive may be judged from the fact that the theory of the hydrogen atom does not appear until p. 345. Wave mechanics is at best a queer business; some readers might be more willing to accept the concept that "the properties of matter are opposing potentialities which become precisely defined only at each other's expense and in interaction with an appropriate environment" if preceded, rather than followed, by the evidence that this point of view does at least lead to agreement with the very precise spectroscopic experiments.

The concluding chapters contain an account of the quantum theory of measurement and include a discussion of the famous paradox of Einstein, Rosen and Podolski which has played such an important part in clarifying our ideas on this subject. This leads on to Dr. Bohm's argument for the orthodox view, which he stresses in many earlier chapters, that the peculiarities of quantum mechanical behaviour cannot be attributed to the effects of hidden parameters acting classically. The argument gains greater interest as later papers show that Dr. Bohm now regards this view as open to question.

K. J. Le Couteur

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# ADVANCES IN PROTEIN CHEMISTRY

**Advances in Protein Chemistry**

Edited by M. L. Anson, Kenneth Bailey and John T. Edsall. Vol. 7. Pp. viii+411. (New York: Academic Press, Inc., 1952.) 8.50 dollars.

This latest volume of "Advances in Protein Chemistry" is a feast for the physical chemist, for five of the six articles deal with physical methods applicable to the study of proteins, or the results of such studies. This is inevitable, as three of the articles, comprising well over half the volume, deal with various aspects of the fibrous proteins (the structure of collagen fibrils; muscle contraction and fibrous muscle proteins; and the proteins of the mammalian epidermis), and these protein systems have been studied mainly by physical methods. Perhaps the volume is rather overweighted by these related topics.

The articles vary widely in their treatment and complexity. The review entitled "Infra-Red Analysis of the Structure of Amino-acids, Polypeptides, and Proteins", by G. B. B. M. Sutherland writing from Ann Arbor, should be compulsory reading for every honours student studying chemistry, biochemistry or physics; it gives an excellent survey of fundamental principles, methods, results and difficulties. On the other hand, the article on "Muscle Contraction and Fibrous Muscle Proteins" (H. H. Weber and H. Portzehl, of Tübingen) starts simply enough, "Muscle works by alternating between contraction and relaxation", and ends honestly, "Neither the study of the individual purified proteins of the myofibril, nor the brilliant investigations on the fine structure of the fibril, has led to any well-founded theory as to the nature and mechanism of the structural changes which take place in the contractile particles"; but most of the rest is for the expert only.

A splendid review on "The Arrangement of Amino-Acids in Proteins" is contributed by F. Sanger (Cambridge), who himself has devised and applied many of the methods he describes; the section on methods for the degradation of proteins and their inherent pitfalls is especially welcome. A discussion of nomenclature and symbolism for peptide chains and terminal residues is included. A new structure for vertebrate collagen fibrils, based on parallel, coiled, polypeptide chains (protofibrils) with transverse matching of corresponding chemical structures, is put forward by R. S. Bear (Massachusetts Institute of Technology). Work on the comparative structure and organization of mammalian epidermal cell proteins is discussed by K. M. Rudall (Leeds). Complementary to the article on infra-red spectroscopy, G. H. Beaven and E. R. Holiday (London Hospital) consider the "Ultraviolet Absorption Spectra of Proteins and Amino-Acids", especially the vibrational fine structures revealed by Holiday's 'moving-plate' spectrographic method, and the advantages and problems associated with analytical methods for proteins in terms of their aromatic amino-acid content.

It is a pleasure to see so many British authors featured in this volume—a welcome recognition of British contributions to protein chemistry. One suggestion may be made: the publishers should consider providing, in each subsequent volume, a cumulative list of titles in the whole series.

# DESCARTES: THE FATHER OF MODERNITY

## Descartes and the Modern Mind

By Prof. Albert G. A. Balz. Pp. xiv+492. (New Haven, Conn.: Yale University Press; London: Oxford University Press, 1952.) 63s. net.

MOST students of the seventeenth century will know the name of Prof. A. G. A. Balz. During the past twenty years, articles in learned reviews and a recent volume of essays, "Cartesian Studies", on the successors, both friendly and hostile, of Descartes have given us a foretaste of the scholarship and power of analysis which mark this distinguished volume, confessedly the fruit of many years of reflexion and study. Whether one agrees or disagrees with Prof. Balz's interpretation of Descartes, one cannot help being impressed by the sincerity and depth of his analysis, and it is refreshing to read a commentator who has meditated the texts of his philosopher and pondered them until he has wrought for himself and his reader a consistent meaning and interpretation. Prof. Balz does not close his eyes to the many difficulties and inconsistencies in the thought of Descartes, but the gaps he sees are not of his own making; they are, in one sense, inherent in the nature of the problems themselves. Towards the end of his book, he points out how fortunate the pursuers of inquiries concerning physical Nature are, in so far as their undertakings are relatively simple and they can avail themselves of the aid of the mathematicians. "They cannot quite conceal a certain disdain for those who conduct inquiries concerning that lesser mystery, man, whose baffling unity of composition is the very ground of their good fortune." Yet even the man of science may turn upon himself and experience some of the doubt and perplexity of the philosopher. "Those who pursue the physical sciences would do well to look with charity and humility upon those who seek to penetrate the mystery we confront because man is man, and because the conductors of inquiry are men." It is probable, at the present moment, that Descartes would obtain a more sympathetic and intelligent understanding of his problems from men of science than from the majority of philosophers, who would reject, out of hand, both solutions and problems as linguistic fallacies.

The title of this work is a little misleading. Except for the last four chapters, the author is not directly concerned with Descartes and present problems of science and philosophy. It is rather the beginnings and growth of the 'modern mind' which form the main subject of this work, and the concern is with Descartes as the father of 'modernity', at least as a first among equals. Prof. Balz is careful to point out that the transition from medievalism to modernity does not merely mean revolt but also conservation, not only change and destruction but also revision and redirection. The first four chapters are accordingly devoted to a discussion of the Augustinian and Thomistic doctrines, especially the famous distinction of Scientia and Theologia, which set the conditions under which Descartes must seek to launch the search for truth in the sciences. The next section describes this quest for certainty and is, in fact, together with the following section, a detailed analysis and exposition of the epistemological and metaphysical doctrines of the "Meditations". It is impossible, in the limits of a short review, to enter into the many points raised in these closely argued chapters. One original point of exposition may perhaps be mentioned. The name *Cartesius* is used to signify reason itself, and *René Descartes* used to describe the conductor of the inquiry who proposes to report what he has learned from Cartesius. This rhetorical device is used to avoid possible misconceptions which may arise from faults in Descartes's own method and devices of expression being confused with the logical structure and articulation of his philosophy. Given the patience requested by Prof. Balz, I was able to follow the elaborate discussion of the methodical doubt and the *Cogito* with comparative ease. Some readers may become slightly irritated.

The second part of the book is devoted to a discussion of the scientific doctrines of Descartes. It is as though the text commented upon was changed to the "Principia", but the emphasis is still upon the philosophical aspects. The mind–matter or soul–body problem is discussed in great detail, and this is one of the most rewarding sections of the whole work. The texts quoted are well known, but an original thinker throws new light on them without forcing or distorting their meaning.

The volume is magnificently produced, although it is somewhat expensive. Personally, I do not see the need for quoting the French texts in their old spelling, which may puzzle a few readers. Descartes himself was a careless speller and often expressed his complete indifference to orthography. Nothing is lost by modernizing the text. L. J. BECK

## Natural Gas and Natural Gasoline

By Prof. R. L. Huntington. (McGraw-Hill Chemical Engineering Series.) Pp. vii+598. (London: McGraw-Hill Publishing Co., Ltd., 1950.) 68*s*.

ONE of the earlier books on natural gas (Lichty, 1924) is still a favourite to consult on this subject. It is none the less instructive to read a new and up-to-date treatise, in this case extending to natural gasoline, for so much has happened in the evolution of this technology in the intervening time. The author is professor of chemical engineering in the University of Oklahoma where, incidentally, the other book was written. Naturally, appeal is to engineering students taking courses in the production of natural gas from crude oil, condensate, dry-gas fields, and the manufacture of various products from such new materials.

A wide range of cognate subjects is considered. The approach is to some extent academic; but practical field applications are by no means neglected. The course of instruction includes the estimation of gas and gasoline reserves; elements of plant location and design; gathering of raw gas and residue gas; a useful account of cycling efficiencies in the Cotton Valley (La.) gas-condensate reservoir; elements of natural-gas processing; and absorption, distillation, fractionation, dehydration, storage and transportation. That difficult subject, high-pressure pipe-line research, is treated with all the mathematical background necessarily entailed, and then the book concludes with a number of useful and practical appendixes, ranging from current specifications to methods of test.

This is a text-book which can be confidently recommended to oil technologists, both in the making and of ripe experience.

## Statistics for Medical and other Biological Students

By L. Bernstein and M. Weatherall. Pp. xii+180. (Edinburgh and London: E. and S. Livingstone, Ltd., 1952.) 18*s*. net.

THE introduction of statistical methods in medicine has to some extent been uphill work, so many practitioners by occupation, tradition and inclination being more concerned with the individual case-study than with the broad survey. It is now generally recognized, however, that the medical curriculum should include some elements of statistics. Drs. L. Bernstein and M. Weatherall have written this text-book on the basis of lectures and practical classes given by them to medical students in the first year of preclinical studies.

The development of the book follows fairly standard lines. Two chapters on scientific method and probability precede a set on frequency distributions and measures of location and dispersion. There follow three chapters on sampling, two on regression and correlation, and introductory chapters on transformations, the analysis of variance, experimental design, therapeutic experiments and the interpretation of observations. Much has had to be omitted, and a great deal more dealt with by passing reference, but these limitations are presumably imposed by the size of the book.

The authors have rightly concentrated on the logic of statistical methods and their use in medicine. The mathematics involved in the derivation of these methods have either been omitted or reduced to the point where they can be mastered by the use of elementary algebra. The result is very readable, and if the book does not carry the medical student as far along the path as a statistician would like to see him go—or as he must go if he needs to use statistical methods himself—it at least points his feet in the right direction and gives him a useful introduction to the statistical problems he will have to face.

## Practical Pharmacology

By Prof. J. H. Burn. Pp. viii+72. (Oxford: Blackwell Scientific Publications, 1952.) 12*s*. 6*d*. net.

IT would not be easy to invent at short notice a course of practical work for medical students. The experiments must arouse interest and have some relation to practical medicine; but they must also be fairly simple to perform and not take too long. Such courses grow gradually as the years go by; active teachers try out new methods and add the best of them to their repertoire in the place of older methods which have lost their original importance. The result of this process of evolution is an elaborate set of instructions which is issued to the students and contains the results of the accumulated experience of many years. These courses evolve on parallel lines in different places; but those who are responsible for them are always anxious to profit by the experience of others, and every teacher of pharmacology will be glad to have the chance of learning exactly what is done in the pharmacological laboratory in the University of Oxford, which is justly famous for its technical skill and the variety of its experiments.

Prof. J. H. Burn has written a clear account of eleven experiments on isolated organs, seven experiments on mammals with their circulations (but not their brains) intact, two on frogs and one on man. These experiments are all described in full detail, with clear drawings by Dr. E. M. Vaughan Williams, and a number of beautiful figures showing the results. A few of these experiments have been in all practical courses for a long time; but many of them are quite new, and it is clear that the Oxford pharmacologists have not been resting on their laurels. The book is so beautifully printed on glossy paper that it is a little sad to think that many copies of it will soon be exposed to all the dangers of the laboratory.

## Technical Publications, 1947

Pp. xi+499. (New York: Standard Oil Development Co.; London: Esso Development Co., Ltd., 1950.) n.p.

THIS second annual volume of papers, by members of the Standard Oil Co. (New Jersey) and five affiliated organizations in the United States, which were contributed to technical magazines during 1947, bears testimony to the talent and diligence, and also to what the president of the Company in his foreword picturesquely describes as the "aggressive research" of the scientific workers and engineers concerned. The volume is divided into papers on geology and production research, manufacturing research, production quality research, and analysis. The subjects range over the determination of oil in place and connate water; oil in Florida; ambiguity in gravity interpretation; palæogeography of South America; consolidation of sands in oil wells; retorting oil shale by fluidized solids; testing cracking-catalysts; liquid—and vapour—liquid extraction; naphthas from fluid catalyst cracking; butadiene resinous polymers; polymers and viscosity index; pour-depressant treated oils; butyl inner pneumatic tubes and tyre life; heat conduction in rubber-like polymers; synthetic elastomers as plasticizers for polyvinyl resins; infra-red spectroscopy in analysis of liquid hydrocarbons; determination of aromatics and naphthenes in complex mixtures containing olefins; Deniges reagent test for *tert*butyl and *iso*propyl alcohols; short-cut methods of infra-red analysis; and determination of antioxidants in gasoline. The book includes a challenging essay on the stake of business in American education, and closes with the mention of ninety-five other publications published in 1947 by members of the group.

## Journal of the Institute of Metals

Vol. 76, 1949–50. Editor: N. B. Vaughan. Pp. xxvi+796+113 plates. 30*s*. Vol. 77, 1950. Editor: N. B. Vaughan. Pp. xxiv+676+83 plates. 30*s*. (London: Institute of Metals, 1950.)

THESE two volumes contain fifty papers and (Vol. 76) a symposium of eight papers on metallurgical aspects of the hot working of non-ferrous metals and alloys, together with the presidential address, and the Autumn and May Lectures of the Institute of Metals. The range of subjects is wide, and all those connected with the science of metals will find much of interest.

It is instructive to examine the sources of the papers, which may be summarized as follows: British Non-Ferrous Metals Research Association, fourteen; universities of Great Britain, ten; Commonwealth Dominions, six; industrial, six; National Physical Laboratory, four; other British government laboratories, three; and research institutions, two. The symposium contains six papers from industrial sources, and one from the British Non-Ferrous Metals Research Association. When compared with the volumes of pre-war years, the increased output of this last-named Association is remarkable. The growth of the Dominion schools is encouraging, but the relatively small number of papers from British government laboratories is regrettable and may well affect the recruiting of first-class men for these institutions. The universities have maintained their position in difficult circumstances; but I feel that the Institute is failing to secure its proper share of papers dealing with the real fundamentals of the science of metals.

W. HUME-ROTHERY

## Smithsonian Logarithmic Tables to Base e and Base 10

Prepared by George Wellington Spenceley, Rheba Murray Spenceley and Eugene Rhodes Epperson. (Smithsonian Miscellaneous Collections, Vol. 118: Publication 4054.) Pp. xiii+402. (Washington, D.C.: Smithsonian Institution, 1952.) n.p.

THIS volume is divided into two equal parts, each consisting of two hundred pages. Every page is divided into three parallel columns containing, respectively, the logarithms of $n$, $1 + n.10^{-7}$ and $1 + n.10^{-11}$, where $n$ ranges through all integers from 1 to 10,000. Those to base $e$ (denoted by ln) appear in the first part, and those to base 10 (denoted by log) in the second part, all entries being given to twenty-three decimal places. In the tables of common logarithms the characteristics are omitted.

A four-page introduction exemplifies the methods of factorization which are most convenient for use in looking up the logarithm or antilogarithm of any given number. To quote a typical example, in which it is assumed that the computer has access to a calculating machine, one can express $\pi$, correct to twenty-three decimal places, as

$$3141 \times 1.0^{3}1886 \times 1.0^{7}8307 \times 1.0^{11}5638,\ 28195,\ 88209 \times 10^{-3}.$$

The first three factors can be converted into logarithms immediately, and the fourth factor is dealt with by replacing $\ln(1 + x)$ by $x - x^{2}/2$, and converting, if necessary, to a common logarithm in the usual way. By this method a result for $\ln \pi$ or $\log \pi$ is obtained which contains an error of one unit only in the twenty-third decimal place. In computing antilogarithms, it is, broadly speaking, only necessary to reverse the above procedure.

Finally, it may be said that the book is well bound and that the printing, though sometimes a little irregular, is always legible; there seems little doubt that, in the words of the preface, "the tables should be a welcome addition to those already in existence".

J. H. PEARCE

## Tensor Analysis

Theory and Applications. By Prof. I. S. Sokolnikoff. (Applied Mathematics Series.) Pp. ix+335. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1951.) 48*s*. net.

IN the first two chapters of this book, Prof. I. S. Sokolnikoff proceeds by way of vectors, linear transformations and matrices to the theory of tensors. The third chapter fulfils a dual purpose: it applies tensor methods to differential geometry, thus enabling the reader to assimilate the technique by applying it in a familiar field, and also collecting geometrical results which will be needed in the last three chapters. These deal with general dynamics, relativity and the mechanics of continuous media. The general dynamics is treated fully; the relativity is intentionally merely a sketch, since so many good accounts are already available. The author's deep interest in the theory of elasticity makes the final chapter exceptionally valuable. First he gives an analysis of deformation, based on the work of Brillouin and Murnaghan; but then, instead of assuming a linear stress–strain relation, he uses thermodynamical ideas to infer a general theory in which the classical linearized theory appears simply as a special case. A very brief note on fluid mechanics ends the chapter.

The exposition is clear and readable, and some exercises for the reader to work on are included.

## A New School Biology

By Dr. F. J. Wyeth. Part 1. Pp. viii+310+xvii. 9*s*. Part 2. Pp. viii+311–587. 8*s*. 6*d*. (London: G. Bell and Sons, Ltd., 1952.)

THESE two volumes are stated to be for pupils taking the Ordinary level of the General Certificate of Education; but it is to be regretted that the author has not considered the content nor the spirit of the syllabus, the time allocation nor the age of the pupils.

A book full of heavy type and italics is to be deprecated, since it indicates what must be learnt without reference to understanding. Facts abound, from the mechanism of the jaws of a snake to the minute structure of a diatom; digestion in some detail (with formulæ of proteins) but not a word about diet; everywhere there are details of structure and function, but little attempt to link any of it up with human affairs or make it stimulating.

On the whole, this book provides too much and too strong meat for children.

D. M. REID

# STRUCTURE OF ALGAL FLAGELLA

By Prof. W. T. ASTBURY, F.R.S., and Dr. N. N. SAHA

Department of Biomolecular Structure, University of Leeds

As a natural development of our work on the molecular structure of bacterial flagella, we have for some time now been engaged also in a similar study of algal flagella. Since this is likely to be long and involved, we believe it will be of value to set down without further postponement some of the findings, which have turned out to be so different from what was rather hoped from the relatively clear-cut results of the bacterial investigation. It will be recalled that the latter placed the essential substance of bacterial flagella (*Proteus vulgaris* and *B. subtilis*) in the keratin – myosin – epidermin – fibrinogen group of fibrous proteins and correlated the motility mechanism with the well-known folding and unfolding of polypeptide chains which is the basis of the long-range elastic properties of the group[1]. It was suggested, in fact, that bacterial flagella can be described as monomolecular hairs or muscles, a conclusion that has since been refined by the deduction from detailed analysis of the X-ray data that a more apt description still would be monomolecular *muscles*[2]. There is a large gap in size and apparent level of complexity between bacterial and algal flagella, as is at once evident from Fig. 1, an electron micrograph of a flagellum of *Euglena gracilis* showing also (inside the loop) a short length of a typically wavy bacterial flagellum about 120 A. thick; but even so, considering the much greater jump between bacterial flagella and hairs and muscles, it seemed not unreasonable to expect that algal flagella too might be found to fit just as readily into the scheme. However, present indications, while not of course ruling out the common broader molecular principles of biological elasticity and movement, are against the idea of any direct conformity with hairs and muscles, as will appear in what follows.

The algal flagella we have examined so far are of *Polytoma*, *Polytoma* 13, *Polytoma 2a*, *Polytomella magna*, *Chlorogonium elongatum*, *Euglena gracilis* and *Chlamydomonas*, pure strains of which, together with much valuable advice for which we are greatly indebted, were supplied by Dr. E. G. Pringsheim, of the Botany School, Cambridge. The flagella were detached, purified and collected by a combination of Gard's[3] shaking technique and centrifugation, and yields were obtained of about 5 mgm. per litre. These have been sufficient for our exploratory purposes; but a total of some 200 mgm. proved a severe limitation in the end, and it becomes necessary to work on a larger scale, as indeed we are now doing.

There are wide structural differences among the various kinds of algal flagella as seen in the electron microscope; but in spite of these differences, their X-ray diagrams are all more or less of the same type, revealing a main component common to them all. It was not found possible to make thin coherent films like those given by sols of bacterial flagella; the films obtained by deposition and drying of algal flagella, though hygroscopic, are brittle and only slightly oriented. Fig. 2, of *Chlorogonium* flagella, is an example of the best we have been able so far to accomplish in this respect—it is unfortunately little better than a powder diagram, albeit a surprisingly good one from such material.

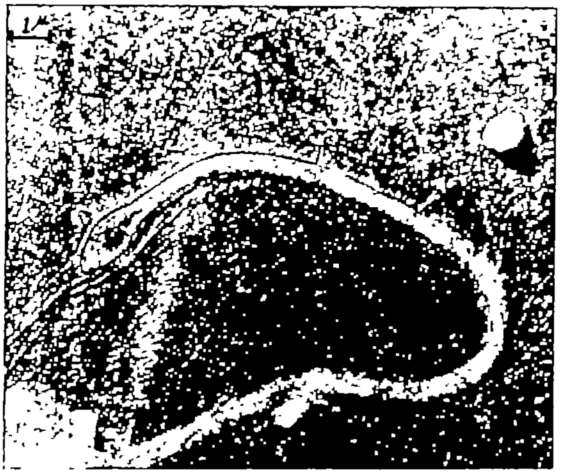

Fig. 1. Electron micrograph of a flagellum of *Euglena gracilis*, showing also, for comparison, a short length of a wavy bacterial flagellum

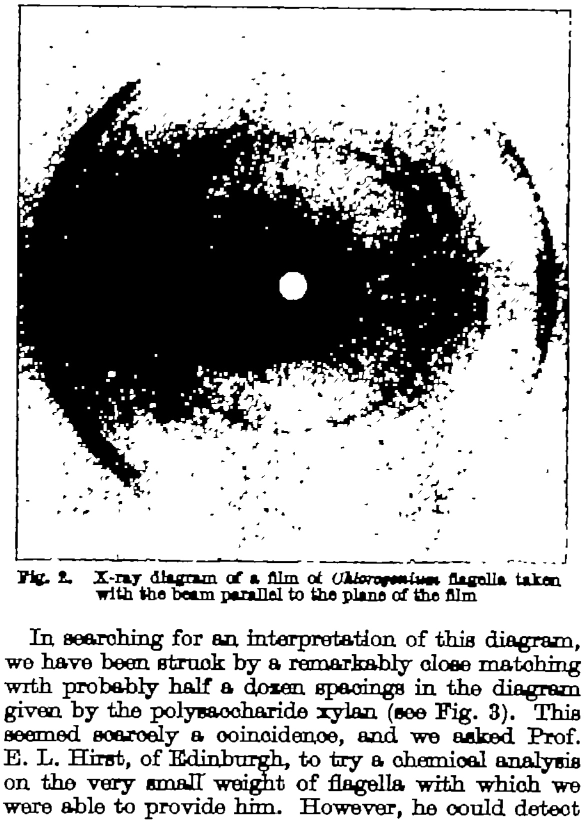

Fig. 2. X-ray diagram of a film of *Chlorogonium* flagella taken with the beam parallel to the plane of the film

In searching for an interpretation of this diagram, we have been struck by a remarkably close matching with probably half a dozen spacings in the diagram given by the polysaccharide xylan (see Fig. 3). This seemed scarcely a coincidence, and we asked Prof. E. L. Hirst, of Edinburgh, to try a chemical analysis on the very small weight of flagella with which we were able to provide him. However, he could detect no xylose nor any other carbohydrate in appreciable amount; but on the other hand, he reported that paper chromatography disclosed the presence of plenty of amino-acids. Dr. W. R. Middlebrook of this Department then repeated the analyses for protein and confirmed the presence of aspartic acid, X-RAY REFLEXIONS FROM ALGAL FLAGELLA

| Spacing (A.) Obs. | Spacing (A.) Calc. | Intensity | Proposed indices |
|---|---|---|---|
| 14·3 | (14·3) | s | 001 |
| 7 | (7) | vw–w | 010, 002 |
| 5·3 | 5·21 | vw | 111 |
| 5 | 5·0 | vw | 012 |
| 4·65 | (4·65) | s | 200 |
| 4·1₄ | 4·24 | w | 103 |
| 3·9 | 3·87 | s | 210 |
| 3·5 | (3·5) | m | 020 |
| 3·1₄ | 3·15 | w | 022 |
| 2·9₆ | 2·98 | m | 122 |
| 2·8₅ | 2·80 | s | 220 |
| 2·6₅ | 2·69 | w | 123 |
| 2·4₀ | 2·41 | w | 223 |
| 2·3₅ | 2·33 | w | 030, 400 |
| 2·0₅ | 2·09 | m | 230 |
| 1·9₅ | 1·93 | m | 420 |

glutamic acid, lysine, arginine, glycine, alanine, valine, leucines, phenylalanine, methionine, serine and threonine; the acidic amino-acids predominating over the basic. He too was unable to demonstrate any carbohydrate, though it is felt that this is not a final verdict because of difficulties associated with the simultaneous presence of protein breakdown products. Dr. Middlebrook made also a couple of preliminary estimations of the nitrogen content, but he found only about 8 per cent; so very probably it requires something in addition to simple protein to account for the whole of the flagellar mass.

Our best X-ray diagrams (from *Polytoma* and *Chlorogonium*) show reflexions at the spacings given in the first column of the accompanying table.

These do not appear to correspond particularly closely with anything already familiar in either the protein or polysaccharide field, but in view of the largely protein nature of the flagella and present doubts about polysaccharide, we should like to suggest that the X-ray data accord best with a β-protein structure in a rectangular unit cell of dimensions: $a = 9\cdot3$ A., $b = 7$ A. (fibre axis), and $c = 14\cdot3$ A. It will be seen from the table that the agreement is quite good. The proposed structure diverges from that of β-keratin and denatured proteins in having (like silk fibroin) an amino-acid spacing of 3·5 A. instead of 3·33 A., and an unusually large side-chain spacing of 14·3 A. instead of 9·8 A. We have, of course, tried to substantiate this choice of axes by repeated efforts to produce sufficient orientation in the flagellar films, but so far with little greater success than to concentrate the 14·3-A. reflexion on the equator of photographs taken with the X-ray beam parallel to the plane of the film—a result which is by no means conclusive on its own, but which is distinctly favourable in combination with another observation made on a thin film that had been dried at 105° in the course of intramolecular swelling tests (see below). When this film was photographed with the beam first perpendicular and then parallel to its plane, it was noticed that the reflexion at 4·65 A. was a little stronger, and that at 14·3 A. a little weaker, in the former diagram, suggesting that the 4·65-A. spacing tended to lie parallel to the film, whereas the 14·3-A. spacing tended to stand perpendicular to it.

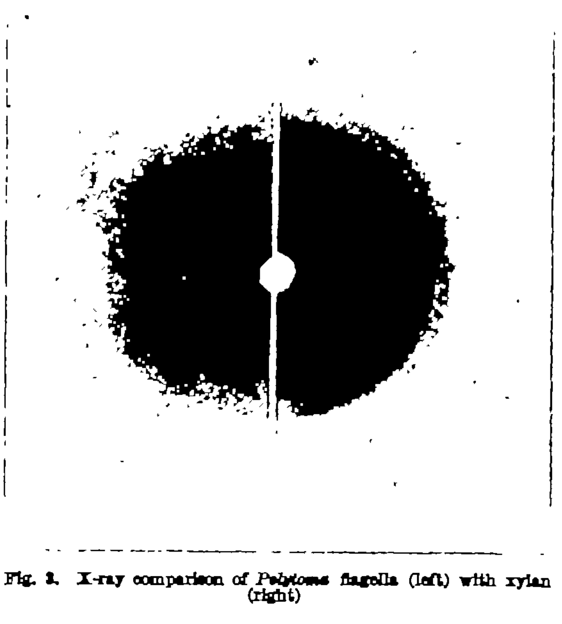

Fig. 1. X-ray comparison of *Polytoma* flagella (left) with xylan (right)

As just mentioned, we have also tried to demonstrate differential intramolecular swelling of the postulated side-chain spacing, but again without success. Contrary to expectation, no change at all could be detected in this respect between dry and wet flagella.

A considerable part of the flagellar substance is soluble in aqueous ammonia (0·1 *M* was used), and it was found then, after centrifuging, that preparations made from the supernatant gave once more practically all the original reflexions; while the insoluble residue gave a much poorer diagram, still similar though, but with greatly weakened side-chain and backbone reflexions and a moderate new reflexion at about 9·6 A.

Complementary experiments to those with ammonia were carried out by adding a few drops of *N* hydrochloric acid to a small amount of flagella on a glass slide and leaving to dry. The X-ray photograph of this sample now showed two kinds of reflexions, one very 'spotty' such as may be obtained from salts and other substances of low molecular weight, and the other continuous rings which proved on closer examination to be strengthened counterparts of certain extremely weak reflexions in the original flagellar diagram. On adding ammonia, this change brought about by acidification tends to be reversed, the 'spotty' rings gradually disappearing and those of the ammonia-soluble structure coming back again.

Another curious result was obtained after heating a sample of wet flagella to about 95° to see whether the orthodox β-diagram of heat-denatured proteins would be produced. What happened was that certain 'spotty' rings appeared quite close to the positions of some of the original continuous rings, as if there were being generated a product of small molecular weight structurally related to the β-protein.

From the above tests (all performed on quantities of material too small for anything like completeness) we have gained the impression, first, that the full diffraction diagram possibly arises from more than one component, and secondly, that the protein side-chains are probably combined with, and perhaps cross-linked through, accessory atoms or groupings. Actually, the 'spotty' (low molecular-weight) lines found after the action of hydrochloric acid show a fair correspondence with the strongest lines in the powder diagram of $CaCl_2,2H_2O$, so it may be that the acid liberates carboxyl groups cross-linked through calcium or other divalent ions. An alternative explanation that the acid hydrolyses the protein seems excluded by the reversibility of the effect when ammonia is added.

We are indebted to Mr. K. D. Parker of this Department for a number of helpful observations made by infra-red spectroscopy. The absorption spectrum of a thin film of *Chlorogonium* flagella shows the expected general resemblance with that of dried stretched horse-hair (β-keratin); but it is at once apparent that additional factors have to be invoked to account for the former in detail (see Fig. 4). For example, in the region where β-keratin gives the bands at 1,625 cm.$^{-1}$ and 1,650 cm.$^{-1}$ associated with the C=O stretching mode, and the bands at 1,520 cm.$^{-1}$ and 1,550 cm.$^{-1}$ probably due to the NH deformation mode, the flagella give a relatively smooth hump together with a strong band at about 1,400 cm.$^{-1}$. On acidification with hydrochloric acid the latter is eliminated, a depression appears round about 1,600 cm.$^{-1}$ with the result that the CO and NH bands are now unmasked, and a strong band appears at about 1,730 cm.$^{-1}$ together with increased absorption in the region 1,250 cm.$^{-1}$. Strong absorptions at 1,740 cm.$^{-1}$ and 1,250 cm.$^{-1}$ are known to be associated with un-ionized COOH groups, in contradistinction to bands at 1,600 cm.$^{-1}$ and 1,400 cm.$^{-1}$ associated with ionized COO$^-$ groups; so one difference at least between the flagellar protein complex and β-keratin would seem to lie in a relative abundance of carboxyl groups in the former (cf. the predominance of acid amino-acids in the chromatogram after hydrolysis). This inference was further strengthened by comparisons with sodium alginate and alginic acid, which showed very strikingly the change-over just mentioned from ionized COO$^-$ groups to un-ionized COOH groups[4]. A small effect of a similar kind was also observed on treating horse-

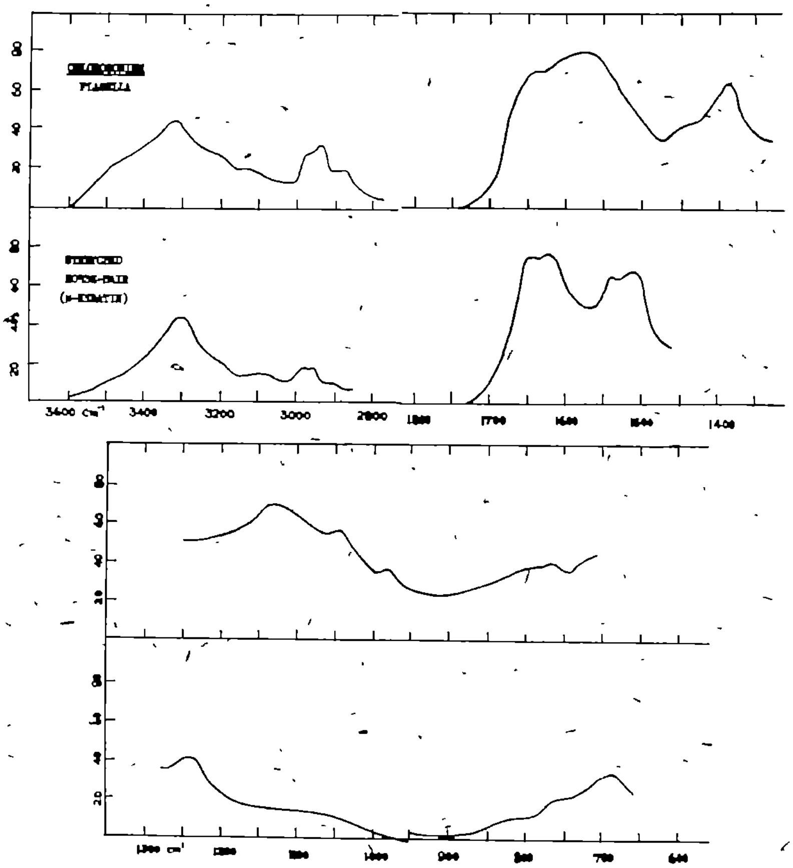

Fig. 4. Infra-red absorption spectrum of *Chlorogonium* flagella compared with that of stretched horse-hair (β-keratin)

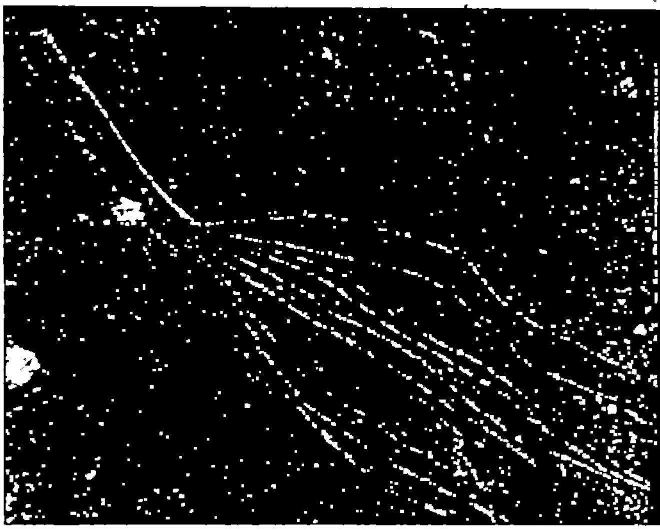

Fig. 5

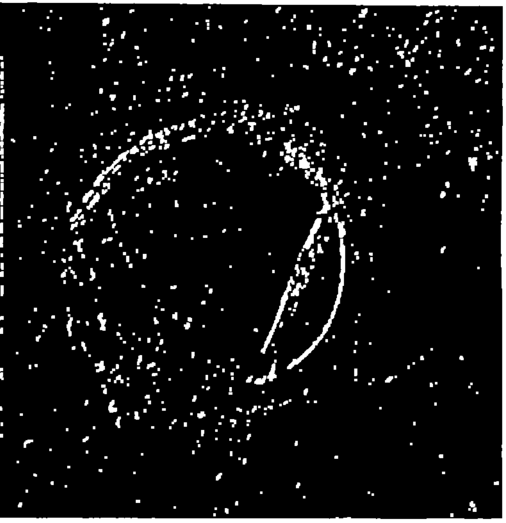

Fig. 6

Fig. 5. Electron micrograph of a flagellum of *Polytomella magna* splitting longitudinally into nine fibrils, with incipient transverse disintegration also

Fig. 6. Electron micrograph of a coiled-up flagellum of *Polytomella magna*

hair with hydrochloric acid. Incidentally, the flagellar spectrum was found to have little in common with that of xylan except for absorption in the region 950–1,200 cm.$^{-1}$, where xylan has strong bands characteristic of carbohydrates. This might be an additional suggestion of the presence of sugar rings of some kind in the flagella. Another noteworthy observation in what looks like the same connexion was made in a comparison of the ammonia-soluble component with the insoluble residue: as with the X-ray comparison described above, the infra-red spectrum of the soluble product was similar to that of the original material, but the insoluble residue showed an increased absorption from about 950 cm.$^{-1}$ to 1,200 cm.$^{-1}$ relative to the absorption from about 1,500 cm.$^{-1}$ to 1,700 cm.$^{-1}$.

Several workers have reported already on electron microscope studies of various flagellates[5], and we ourselves, with the help of Mr. A. Millard, have been content so far with a limited number of micrographs largely for purposes of guidance in the preparative techniques and in relation to the deeper molecular aspects. As noted near the beginning of this article, there are seen in the electron microscope differences in gross morphology that must be secondary to the essential molecular unity indicated by X-rays. An important feature frequently observed is, of course, the longitudinal splitting characteristic of fibre structure. Fig. 5, for example, shows the disintegration of *Polytomella magna* into nine principal fibrils (the original flagellum being about 2,500 A. thick and each fibril about 350–375 A. thick), though this is soon accompanied also by transverse breakage. In some pictures of *Polytoma* the longitudinal splitting is seen to be proceeding to finer threads still; and another common observation is of the tight bending, illustrated in Fig. 6, that appears to be brought about particularly on washing with distilled water. Altogether, what with this coiling-up and eventual longitudinal splitting and transverse disintegration too, it is not surprising that films of such flagella should be so brittle and unresponsive to orientation techniques.

It is tempting to speculate on the molecular basis of the motility mechanism; but the data are not enough yet for any really convincing argument, especially in view of the seeming wide dissimilarity from bacterial flagella. There is nothing in the available evidence in favour of a quasi-rigid flagellum beating about a hinge near its insertion, and we have to find some counterpart to the transition between the α- and super-contracted states to which we have ascribed the bending movements of bacterial flagella. Probably the best guess for the present is that there is a β-structure normally stabilized by cross-linkage of carboxyl groups through calcium or other divalent ions, and that the cross-linkage is periodically broken down, for example, by exchange with monovalent ions. This would give the chains a freedom of movement that could result in an entropic shortening, as in the experiments described by Mongar, Wassermann and MacArthur[6]. These authors observed contractions of up to 20 per cent when calcium alginate fibres were treated with solutions of sodium or other monovalent metal salts. To cause a flagellum to bend into the required form, the interchange between extended and shortened chains would, of course, have to be suitably distributed, in both time and place, among sub-units of the structure; but there is no obvious difficulty about that, considering the way each flagellum is built up from finer fibrils. Sufficient of the latter are recognizable in some kinds of flagella to provide a framework not merely for a side-to-side beating movement but also, if necessary, for a continuous spiral wave.

The idea of chain-molecules normally held straight by cross-linkages is supported by the sharpness of the supposed side-chain reflexion, its unusually high spacing, its unchanged character on wetting, and the chemical evidence for something in addition to simple protein; while the X-ray suggestions of calcium already mentioned are strengthened by spectrochemical tests kindly carried out for us by Dr. R. L. Mitchell, of the Macaulay Institute for Soil Research, Aberdeen. He found, among traces of other metals, a fair amount of sodium, calcium and magnesium, with a relatively small amount of copper, though unfortunately the sample of flagella we were able to send him was too tiny for reliable quantitative estimations.

We are now proceeding to remedy this trouble of having too minute quantities of material, and we hope to be in a position shortly to re-investigate with much more thoroughness all the points and possibilities raised in this preliminary article. At the least, however, it will be granted that we have caught a glimpse of a most fascinating new field in molecular biology that invites exploration with all the intensity and resources at our command.

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[3] Gard, S., *Arkiv Kemi*, 19, A, No. 21 (1944).

[4] cf. also Rowen and Plyler, *J. Res. Nat. Bur. Stand.*, 44, 313 (1950).

[5] See, for example, Manton, I., and Clarke, B., *Nature*, 166, 973 (1950), together with other references there quoted.

[6] Mongar, J. L., and Wassermann, A., *Nature*, 159, 746 (1947). MacArthur, I., Mongar, J. L., and Wassermann, A., *Nature*, 164, 110 (1949). MacArthur, I., and Patnaik, B., *Proc. Leeds Phil. Soc.*, 5, 254 (1949).

# CHINESE SCIENCE REVISITED (2)

By DR. JOSEPH NEEDHAM, F.R.S.

IN the second of these two articles, the attempt will be made to indicate some of the particular emphases which exist in the Chinese scientific world of to-day. There is, in the first place, an emphasis on practical tasks. In a country where so much modernization has been needed, this is inevitable; but it does not mean that theoretical studies are being neglected, for they are fed by practical experience, and the latter alone, it is felt, can keep them along the right lines. Secondly, there is an emphasis on teaching, since the need for properly qualified specialists (or 'cadres' as they are called) is so pressing. Thirdly, there is an emphasis on popular enlightenment, and the bringing of science and the scientific outlook to the vast masses of the people. Lastly, something should be said about the philosophy of science and the kind of researches which have been noteworthy in the past three years.

At the end of the last article there was mention of geological survey parties—eighty-three of these were in the field during 1951. But the geologists have also given essential service in the physio-topographical surveys of areas where railway construction and river conservancy work are progressing. Without them the Lunghai railhead would not have reached Lanchow ten months ahead of schedule, as it did; without them the astonishing progress could not have been made with the Huai River Project. In this scheme, which will solve the problem of a great river (between the Yangtze and the Huang Ho) for generations to come, sixteen large retention-basin dams are being constructed on the upper tributaries in the provinces of Honan and Anhui. Some are already finished, and the whole project will be at least on the scale of the famed Tennessee Valley Authority.

In other cases, parties of scientific men of very varied specialities have taken the field. For example, a party of no less than fifty experts proceeded to Lhasa to see what could be done to assist the Tibetans in improving their conditions of life. This group included agronomists, soil scientists, geologists, geographers, meteorologists, sanitary engineers and medical men, ethnologists (for example, Li An-Chê) and historians. Another large party, including gynæcologists and child welfare experts, visited the minority peoples of Sinkiang.

The current emphasis on practical tasks can be seen in all fields. In some, the results produced can be spectacular. The cotton aphid (*Aphis gossypii* Glover) has long been a great pest in the cotton-growing regions of southern Hopei and the newly-formed province of P'ing-Yuan. But its life-cycle was not well understood. After several months of travel and research in the regions concerned, Chu Hung-Fu and his colleagues of Academia Sinica were able to ascertain that this aphid passes the winter attached underground to the roots of a common weed *Lactuca* or *Ixeris chinensis versicolor*. It is now possible, therefore, to eradicate it almost completely; this is all the more important a discovery because the pest is rather resistant to known insecticides. While I was visiting the Academy's Entomological Laboratory, reports came in of the first successful large-scale use (1951) of gamma benzene hexachloride against locusts, spread from aeroplanes in southern Hopei and Anhui. Many of the new substances for insect control, such as *E*-605,666, 'Gammexane', etc., are now made in China.

As for the emphasis on teaching, it can be seen in all fields. For the time being, research is concentrated rather in the institutes and laboratories of the Academy, though it goes on to a minor extent in university laboratories; this is regarded as a passing phase, for the general principle that the latter should also be active research schools is fully admitted. Planned expansion in geology, for example, is remarkable—where there were 35 students in 1951, there were 120 last year, and for this year 1,000 are being planned for. The Medical College of Peking University, and the National Medical College at Shenyang (Mukden), formed by the additional absorption of the former Scottish and Japanese schools, are indeed impressive in their size and vitality. According to Dr. Hu Chuan-Kuei, principal of the Peking University Medical College, which has forty years of history, the student numbers rose from 400 in Kuomintang times to 1,400 at the present day. This includes 260 students in pharmacy, 160 in dentistry, 140 in public health, 40 in nursing and 40 in midwifery. The total number of qualified medical men in China is of the order of 50,000; but ten times this number are urgently needed to give one per thousand of the population. Of the 2,300 hsien cities in China, however, already more than 1,800 have their own State clinic or hospital. Besides the mobilization of old-style practitioners as auxiliaries, already mentioned, there has been a cutting down of the total time needed to qualify. The full qualification will still take five years; but medical assistants are being turned out after a two-year course, and technicians of various kinds need even less. The compression of the curriculum has been done by omission of matters which are unlikely to be met with by the Chinese medical man, for example, the tropical diseases of South America. All teaching is now done in the Chinese language. I saw, as evidence of recent developments, a finely produced new text-book of general pathology based mainly on Chinese material, and in Chinese, by Hu Chêng-Hsiang and others. Of course, the Peking University Medical College is not the only one in the capital; the Peking (now the Chinese) Union Medical College is also functioning intensively.

Both for research and teaching, Chinese scientific workers now have facilities incomparably greater than those which used to be available during the confusion and blockade of the Second World War. A great many instruments are now being made in the big cities such as Shanghai. In Academia Sinica laboratories, I saw excellent incubators and refrigerators, a variable-temperature insect-behaviour chamber, vacuum pumps, mechanical stirrers, shaking machines, ball mills and glassware, all made in China. A kind of 'Pyrex' ware is also locally available. Microtomes have been constructed by the Chinese Union Medical College workshops. At the Shenyang Medical School a consignment of two hundred teaching microscopes from East Germany had just come in during one of my visits, and my friends in the National Academy were making much use of East German catalogues. If normal conditions of trade can be restored, as all must hope, China would doubtless be glad to receive British scientific instruments. Heavier kinds of equipment are often Soviet in origin, and the Chinese are making excellent use of them.

Another emphasis which must be mentioned is that on popular education. There is a touching and genuine thirst for scientific knowledge among the Chinese people. Shops which sell anatomical models and geological charts have a crowd around the windows all day. If the visitor from the West wanders into one of the modern bookshops on a Sunday, he will almost have to step over rows of children and boys and girls of various ages sitting on the floor and against the bookcases reading popular science, and not paying the slightest attention to him. The assistants never insist on readers buying books, though they usually do, as they are relatively extremely cheap. I visited a popular exhibition of astronomy in the beautiful Pei Hai Park in Peking. It was packed with ordinary people, to say nothing of the usual large proportion of school-children, who were delighted with a simple form of planetarium. Most justifiably there were special panels accurately relating the ancient and medieval contributions of the Chinese to astronomy, such as the invention of the equatorial mounting by Kuo Shou-Ching in A.D. 1279; and the young man who was demonstrating these was delighted that a Western visitor was already familiar with these contributions and could even elaborate on them. Of great interest also was an exhibition of army education set up in the buildings surrounding the exquisite Temple of Heaven; here there were many pieces of simply constructed apparatus for demonstrating fundamental principles of physics, optics and the like; or, to take another example, out-patients passing through the corridors at China Union Medical College would pause to look at illuminated model scenes inset into the walls, which explain the cycles of transmission of the chief helminthic infections known in the Chinese countryside. Will it not make some difference to the world that five hundred million people are awakening to the significance of natural science and all that that implies ?

Next, something may be said of a few of the researches which have been proceeding during the past three years. Stimulated by the importance of ethyl mercury chloride as a fungicide, the Institute of Physical Chemistry of the Academy has been studying the role of catalysts in the formation of this and similar compounds. The Institute of Organic Chemistry has been working on plant hormones and possible new antibiotics derived from certain plants traditionally used in Chinese medicine. From the point of view of economy it would obviously be of advantage to use as many of these as possible, and they are now undergoing more extensive study by modern methods than ever before ; the China University Medical College, for example, has a special department for the investigation of Chinese materia medica. In physiology there has been work on micro-analysis of potassium, sodium and phosphorus in nerve tissue during activity. The Laboratory of Developmental Physiology has completed researches on the structure and mode of action of the eye-stalk hormone of Crustacea, and has isolated an active substance in the form of its cadmium complex. Systematic botany and zoology are being actively pursued by many workers ; often in connexion with important practical problems, such as forestry, fisheries, and the epidemiology of rodent-borne plague. The palæontologists have been studying fossils of dinosaurs and their eggs at Laiyang in Shantung Province. They have also conducted large-scale excavations in the Choukoutien area near Peking in connexion with *Sinanthropus pekinensis*, the precious specimens of which were lost during the confusion of the Second World War, and are widely believed to be still in American hands. Palæobotanists have been concentrating on the mesozoic fossils of the Szechuan basin, and the redwood fossils in the coal beds of Fushun in southern Manchuria. Important work has been done by the Metallurgical Institute on new kinds of nodular graphite cast iron with superior strength and properties favourable to mechanical treatment. Its Kunming branch laboratory has been occupied with problems relating to the bauxite deposits of Yunnan province, and similar local needs. In so short a review as this it is, of course, impossible to do more than allude to a few of the subjects on which research is proceeding.

In conclusion, a few words may be said regarding the philosophical point of view of Chinese science to-day. In accordance with the world-outlook which has triumphed in China, Chinese scientists are greatly interested in dialectical materialism. The fact that there is very little opposition to it is noteworthy, and arises from several causes. There was never any strong strain of metaphysical idealism, such as that represented by Eddingtonian views, in Chinese thought. On the contrary, its finest formulation by the school of Chu Hsi in the Sung dynasty (twelfth century A.D.) was remarkably congruent with dialectical materialism, for this school worked with but two concepts : *ch'i*, matter, including its most tenuous forms, and *li*, the pattern or organization of things. These patterns were explicitly recognized to be arranged in levels of organization. For this world-picture dialectical materialism may readily be considered a continuation. In other words, the age-old and refined conceptions of Chinese humanism are fusing with dialectical materialism without that stress and strain felt in a Europe which has so long been the battlefield of irreconcilable opposites—either theological spiritualism, or atoms and the void.

# OBITUARIES

## Prof. F. E. Weiss, F.R.S.

The death of Frederick Ernest Weiss on January 7 at the age of eighty-seven severs one of our last direct links with the great men who, in late Victorian times, created the science of biology in Britain. The son of parents who were outstanding for their strength of character and high principles, he was born in Huddersfield on November 2, 1865. When he was seven years old his father died, and his mother with five young children moved, first to Heidelberg and later to Neuchâtel, to obtain a good education for her family.

Returning to England, Weiss entered University College, London, in 1884, with the object of taking a degree in botany ; but in his first year he came under the spell of Ray Lancaster and devoted much of his time to zoology. He learned his botany from Prof. Daniel Oliver, D. H. Scott and, in his third year, from Prof. Frank Oliver, who had just come from Cambridge to succeed his father in the chair. After graduation, Weiss spent some time at Naples in research on *Amphioxus*, but returned to the study of botany as Quain student and lecturer in botany at University College. Three years later he was appointed professor of botany in Owens College, Manchester—now the University of Manchester—in succession to W. C. Williamson, the famous palæobotanist. Weiss held this chair until his retirement in 1930, and was responsible for the erection of new laboratories, and for the creation of a notable school of botanical study and research from which many well-known botanists originated.

Weiss followed his predecessor at Manchester in carrying on research on the structure of Carboniferous plants, especially on their root systems ; but he also carried out investigations on pollination, seed dispersal, genetics and on graft hybrids. He took a keen interest in the study of vegetation, assisting in the work of the British Vegetation Committee and later in the foundation of the British Ecological Society, of which he was president during 1924–25. He devoted much of his time to the development of the botanical department of the Manchester Museum, and for many years gave a course of popular lectures in connexion with the Museum. His services to his University were considerable. Besides long periods of membership of its Council, he often acted as pro-vice-chancellor and served as vice-chancellor during two critical years, 1913–15. The appreciation of his work was shown by the award of the honorary degree of LL.D. He was a faithful supporter of the British Association, and was president of Section K (Botany) in 1911. He became a Fellow of the Royal Society in 1917, and served on its council.

After retiring from his chair at Manchester, Weiss moved to the neighbourhood of Guildford and spent much of his time at the garden of the Royal Horticultural Society at Wisley, where he was chairman of the Scientific Committee. He was a member of the Council of the Society for two periods between 1935 and 1946 and served on its Library and its Scientific Committees, as well as on its Examinations Board. His service to horticulture was recognized by the award of the Victoria Medal of Honour in 1947. He also devoted much time to the Linnean Society, serving as its president during 1931–34. In 1937 he was president of the South Eastern Union of Scientific Societies.

Weiss was a man of exceptional charm and kindness, combining wisdom and experience with modesty and tact; he was loved and respected by all who had the privilege of knowing him. He had wide interests, not only in science and education, but also in social betterment and in the improvement of Manchester and its surroundings. He took and maintained an unfailing interest in the welfare of his students and younger colleagues; he was always ready to give them help and advice. In all his many interests and projects he was helped by his wife Evelyn, third daughter of the Right Hon. Dr. Robert Spence Watson, whom he married in 1898, and who, with their three daughters, survives him.

H. Hamshaw Thomas

## Sir James French

We regret to record the death of Sir James Weir French, which occurred at his residence in Glasgow on January 14, at the age of seventy-six. James Weir French was born in Glasgow in April 1876 and was educated at Bearsden Academy and the University of Glasgow, where he graduated as B.Sc. in 1898; the degree of doctor of science was conferred on him some years later. While still at the University he entered the firm of Barr and Stroud and was appointed a director when the firm became a limited company in 1913. He was chairman of the firm from 1938 until he retired in 1949.

Sir James French had travelled widely and had gained considerable technical experience abroad. After the First World War, he was attached as an expert to the Inter-Allied Control Commission in Germany. He was knighted in 1941 in recognition of his contribution to the equipment of the Fighting Services.

Among important offices held by Sir James French in academic and scientific institutions and societies, he had been chairman of the governors of the Royal Technical College, Glasgow, president of the Royal Philosophical Society of Glasgow and lay chairman of the Glasgow Art Club.

Sir James's main energy was devoted to the design and development not only of the scientific instruments manufactured by Barr and Stroud, but also to the special optical machinery and materials necessary for their manufacture. During the First World War, when supplies of optical glass became critical, he was associated with the late Prof. Barr in the development and production of optical glass suitable for the highest standard of optical instruments. The subsequent large-scale production for the firm's instruments was largely due to his energy and initiative in devising the manufacturing processes and designing and constructing the necessary plant and equipment.

Sir James French published many scientific papers, chiefly on optical subjects; but his wide and detailed knowledge of the history of glass and porcelain, including those of ancient Egypt, made his papers on this subject of particularly wide interest.

## Prof. J. S. S. Brame, C.B.E.

John Samuel Stafford Brame, who died on December 10 at the age of eight-one years, was an authority on fuels and lubricating oils. He was educated at St. Thomas Rich's School, Gloucester, and commenced his scientific studies and training at the Royal College of Science. In 1897 he joined the staff of the Royal Naval College, Greenwich, as an assistant to Prof. V. B. Lewis, who held the chair of chemistry. The latter so greatly influenced Brame that under his guidance he specialized in oil technology and combustion, especially that of oils in furnaces; Brame here laid the foundation for his life's work. This association with Prof. Lewis, a founder member of the Institute of Petroleum Technology, finally brought him to the highest position in this field, namely, president of the Institute.

When Prof. Lewis resigned from the chair of chemistry in the Royal Naval College in 1914, Brame was appointed as the first professor of chemistry and metallurgy, a position which he held until his retirement from the College in 1932. During the whole of this period he lectured upon petroleum in all its aspects, and carried out investigations connected with lubrication, combustion, etc. When it was proposed to use oil as a fuel for the Royal Navy, Prof. Brame took a keen interest in this proposition; he carried out experiments on the numerous oil-burning locomotives of the (then) Great Eastern Railway, and from this experience was able to indicate certain conditions for the burning of oil on ships.

On leaving the Royal Naval College, he was appointed a director of Messrs. Alexander Duckham and Co., Ltd., lubrication oil specialists, and held the position of technical adviser until 1939.

For many years Prof. Brame lectured at the Sir John Cass College, London, on oil technology. These lectures were considered a very important part of the educational system devised and financed by various oil companies for the training of their staffs.

During his activities at the Royal Naval College and at the Sir John Cass College, Prof. Brame held many important posts, including the chairmanship of the Standardization Committee of the Institute of Petroleum Technologists, a subject in which he was always interested. He was a Fellow of the Royal Institute of Chemistry, and of the Chemical Society. He was made a Commander of the Order of the British Empire in the New Year's Honours, 1930.

F. A. Ruddock

We regret to announce the following deaths:

Prof. Paul Niggli, professor of mineralogy and petrology in the University of Zurich and in the Swiss Federal Institute of Technology, Zurich, and also *correspondant* for the Mineralogical Section of the Paris Academy of Sciences, aged sixty-four.

Lieut.-Colonel J. S. Vorley, C.B.E., director of national parks, Southern Rhodesia, and formerly of the Indian Forest Service, on January 2, aged fifty-four.

# NEWS and VIEWS

## Institution of Electrical Engineers : Awards

Sir Harry Railing has been elected to honorary membership of the Institution of Electrical Engineers for his services to the electrical engineering profession and to the science, and for his services to the Institution. The Faraday Medal of the Institution has been awarded to Sir A. Stanley Angwin for his outstanding contributions to the development of telecommunications in Great Britain and in the international and inter-continental fields.

### Sir Harry Railing

Born in 1878 and educated at the University of Munich, Sir Harry Railing received his early training and practical experience on the Continent of Europe and in the United States. In 1905 he went to the Witton Engineering Works of the General Electric Co., Ltd., to take charge of the test department and laboratories, and in 1911 he was made a director and placed in charge at Witton, where he remained for twenty years, a period of rapid expansion and development. In 1933 he left Witton for London, although he continued to control the organization of the Witton Works, and in 1941 was appointed joint general manager of the Company, becoming successively vice-chairman and then chairman and joint managing director. He was knighted in 1944. Sir Harry became a member of the Institution in 1912 and has held numerous offices, including the presidency (1944). He was also chairman of the Council of the British Electrical and Allied Manufacturers' Association during 1944–45 and was elected president last year.

### Sir Stanley Angwin, K.B.E.

Sir Stanley Angwin was born at Penzance in 1883 and was educated at Queen Mary College, London. After being a pupil of Messrs. Yarrow and Co., engineers and shipbuilders, he joined the Post Office Engineering Department in 1906. During the First World War he served in the Middle East and France in the 52nd (Lowland) Divisional Signals and was awarded the M.C. and D.S.O. He then returned to the Post Office Engineering Department, joining the wireless section, which at that time was being expanded, and played a major part in the design and construction of the Leafield, Cairo and Rugby radio stations and in the inauguration of the trans-Atlantic telephone service. Sir Stanley became assistant engineer-in-chief of the Post Office in 1932, deputy engineer-in-chief three years later, and then engineer-in-chief during 1939–46. During the tenure of this last-named post, for the most part held during the stress of war, many significant technical developments took place, including the introduction and expansion of the short-wave overseas radio-telephone services which have given Great Britain so important a position in world telephony, and the adoption of the coaxial cable system as a normal method of providing trunk-line communications. Sir Stanley was knighted in 1941 and received the K.B.E. in 1945. He was president of the Institution of Electrical Engineers in 1943.

## Experimental Physics in University College, Dublin: Prof. T. E. Nevin

Dr. T. E. Nevin, who has succeeded the late Prof. J. J. Nolan in the chair of experimental physics in University College, Dublin, graduated in the National University of Ireland in 1927. His first research was done on atmospheric electricity, under Prof. Nolan. In 1929, however, he was awarded an 1851 Exhibition, and during the tenure of this, under Prof. A. Fowler at the Imperial College of Science and Technology in London, and afterwards in Dublin, he has made many important analyses of band spectra. University College possesses a 21-ft. Rowland grating which has been used by him to unravel some very complex spectra, including negative bands of oxygen and bands of manganese hydride and deuteride. Prof. Nevin has also constructed a very large vacuum spectrograph, which is likely to come into use shortly. In recent years he has made experimental investigations of cosmic rays, in association with Prof. C. B. E. McCusker, of the Dublin Institute for Advanced Studies. Prof. Nevin has been a member of staff of the Physics Department of University College since 1931. He was elected to membership of the Royal Irish Academy in 1942, and has twice been a member of its Council. Since 1943, he has been a member of the governing board of various schools of the Institute for Advanced Studies, Dublin, and has delivered lectures on special topics under the auspices of the Institute.

## Mathematics at the Royal Technical College, Glasgow : Dr. D. C. Pack

The governors of the Royal Technical College, Glasgow, have appointed Dr. Donald Cecil Pack, lecturer in mathematics in the University of Manchester, to the chair of mathematics in the College. Dr. Pack won an open scholarship in mathematics to New College, Oxford, and took his B.A. with first-class honours in mathematics in 1941. The degree of D.Sc., for a thesis on a subject in the field of compressible flow and shock waves, was conferred on him by the University of St. Andrews in 1951. In the Second World War he served with the Ordnance Board during 1941–43, working on ballistics and the trajectories of shells. Later, as a scientific officer with the Ministry of Supply, he was engaged in research on gas dynamics with particular reference to supersonic flow and the effect of shock waves. He was also concerned with researches on problems relating to the penetration of armour. When the War ended Dr. Pack spent some time on supersonic research at the German supersonic station at Volkenrode. He is the author of numerous publications in the field of gas dynamics, supersonic flow, propagation of shock waves and related problems. During 1947–51 he was a lecturer in mathematics in the University of St. Andrews, and during 1951–52 was a visiting research associate professor at the University of Maryland.

## Atomic Energy for Industrial Power and other Uses

In reply to a question from Mr. Hector Hughes in the House of Commons on January 26, as to what progress had been made in British national research stations towards solving the problem of using atomic energy for industrial, travel and other peaceful purposes, the Minister of Supply, Mr. Duncan Sandys, said that the novel problems raised in the production of electrical power from atomic energy have been studied in the light of experience gained with the graphite piles at Harwell and at Windscale. Valuable discussions have also been had with Canadian experts about the results obtained in the operation of their heavy-water reactor at Chalk River, Ontario. The most certain method of generating power from atomic energy would be to build an improved type of natural uranium reactor enclosed in a pressure shell, the heat produced being transferred by a gas under pressure through a heat-exchanger to a conventional electric-power generator. As a by-product, this would yield plutonium, which could be used as fuel for further reactors. The potentialities of such a reactor are being studied, and, if the prospects prove favourable, the construction of an experimental atomic-power station of this kind would be considered. At the same time, continued Mr. Sandys, it is hoped to develop reactors of a more advanced type, known as 'breeder-reactors' by reason of the fact that they are designed to produce more fissile material than they consume. To facilitate the study of these methods, a small experimental reactor of this kind is being built at Harwell. This should be completed in a few months time, and work is proceeding meanwhile at Harwell and Risley on the design and development of a full-scale breeder reactor, capable of producing substantial amounts of electricity. A suitable site for the construction of this plant is being sought.

A natural-uranium reactor moderated with heavy water is also being built, which will produce a much more intense flow of neutrons than is possible with the present equipment. This reactor is for research work and will not be used to generate power. It will, however, greatly expand the quantities and variety of radioactive isotopes which can be produced for industrial, scientific and medical purposes. This project will take about four years to complete. It is not proposed to undertake work on the application of nuclear energy to propulsion until more experience has been gained in the development of stationary nuclear power plants. Mr. Sandys pointed out that it is too early to say with any precision how soon electricity generated from atomic energy will be available on a significant scale for industrial purposes. Nuclear reactors will certainly not supersede existing methods of producing electric power in the near future; but if the technical problems are solved and the new methods prove to be economical, there is no reason why nuclear reactors should not, before very long, provide a useful additional source of industrial power.

## Increased Expenditure for Research and Development by the Ministry of Supply

IN presenting a Supplementary Estimate for the Ministry of Supply in the House of Commons on January 26, the Minister, Mr. Duncan Sandys, said that the need for the Estimate arises mainly from the increased rate of expenditure on research and development: expenditure for that purpose is expected to exceed by about £21 million the £128 million originally provided. Some of the increased expenditure is due to rises in prices and wages, but in the main it provides evidence that the progress of the technical and scientific establishments of the Ministry, and of the industries working with it, has been more rapid than was expected. A special effort has been made to accelerate the development of new types of air-frames, aero-engines, electronic equipment and improved methods of jet propulsion. Further encouraging progress has been achieved in work on guided rockets, and Mr. Sandys added that there is no doubt that the guided rocket is one of the decisive instruments and will come to dominate the military scene. To hold back our scientific workers or technicians in this vital field would, he said, be false and dangerous economy. The successful atom-bomb test at Monte Bello, continued Mr. Sandys, completed an important phase in our programme of atomic research and opens a wider horizon for further scientific activity. With the progress made in studying the peaceful applications of atomic energy, it justifies an expansion of our development programme in this field, and the unexpectedly rapid progress with processes of extracting uranium as a by-product from gold-mining in South Africa and the encouraging developments in uranium production in Australia have also increased expenditure on atomic energy. About £5 million out of a Supplementary Vote of £5·85 million under "Works Services" relates to research and development establishments and arises out of this programme.

In the debate on the Supplementary Estimate, numerous questions were pressed for further information, more particularly in regard to the expenditure on research. In his reply on the debate, the Parliamentary Secretary to the Ministry of Supply, Mr. A. R. W. Low, while declining to break down further the figures for the expenditure on research, particularly the £9·9 million under Subhead *B*3 for research and development work by industry, extra-mural research at universities and the like, agreed that the Vote would include some research work for civil purposes as well as some on atomic energy. He said that he is satisfied that, where there are overlapping problems, there is consultation with all those concerned. No answer was given to Mr. Emrys Hughes's request for a clearer indication as to what is understood by research, or to Mr. F. Lee's inquiries as to the steps taken to facilitate the application to industry of the results of research at the earliest possible moment or as to the numbers of scientific workers and technologists engaged in research and the capacity of the universities to supply them.

## National Institute of Sciences of India: Presidential Address, 1952

IN his presidential address to the National Institute of Sciences of India, given on October 4, 1952, at the Museum House, Calcutta 13, Dr. Sunder Lal Hora dwelt on a number of topics pertaining to science in India. He first mentioned his pleasure that the three scientific Surveys of India—Geological, Zoological and Botanical—should recently have been grouped under one Ministry, that of National Resources and Scientific Research; also to this Ministry there now falls the care of the seven administrative units of the Indian Museum. Turning to the Institute itself, Dr. Hora discussed the publishing of original papers in the Institute's *Proceedings*, forty-four of the fifty-six submitted during 1951 having been published. The delay at present is seven to nine months, but by various means, including the printing of routine business in a new regular journal, the *Bulletin*, and in the Institute's "Year Book", it is hoped to find more space in the *Proceedings* for original work and at the same time to reduce the delay to not more than six months. As regards the quality of the English in the papers submitted, Dr. Hora pointed out that the standard is noticeably deteriorating, and he suggested that this fact should be borne in mind by the Government when formulating any plans about the place of the English language in its educational curricula. Dr. Hora did not flinch from making other critical comments. Thus, he said that he was disturbed at the apathy shown towards the activities of the Institute, even by its Fellows, and he went on to indicate that this is but one facet of a general failure by Indians to appreciate the merits of their country's scientists, as shown by the relatively poor salaries paid to those working in academic circles and also by the tendency to employ foreign scientific advisers in preference to local talent. In conclusion, Dr. Hora discussed the stepping-up of the biological sciences in India, and in this connexion the Institute has decided to recommend that departments for the special study of certain subjects should be established as follows: a marine biological station at Bombay; a central freshwater biological station at Mettur, Madras State; animal genetics at a cancer research centre in Bombay, a cytogenetics research wing at the University of Calcutta and a cytochemistry research wing at the University of Mysore; and plant genetics at the Indian Agricultural Research Institute, Delhi.

## Electron Microscopy of Plant Cilia

Further observations on the structure of plant cilia, by a combination of visual and electron microscopy, are given by I. Manton, B. Clarke, A. D. Greenwood and E. A. Flint in the current issue of the *Journal of Experimental Botany* (3, No. 8, 204; 1952). The cilia of zoospores of *Saprolegnia ferax, Chlorosaccus ulvaceus, Allomyces arbuscula* and *Olpidium brassicæ* are illustrated by some excellent photographs at magnifications ranging from × 2,000 (visual light under an oil immersion objective) to × 20,000 (electron micrograph). The flagella of these micro-organisms (three fungi and a yellow-green alga) showed eleven component strands, these usually being clearly differentiated into a central pair and nine others. These strands are observable in specimens which are undergoing fibrillar disintegration. Similar strand numbers have also been observed in ferns and in green and brown algæ. Stained and unstained specimens of *Saprolegnia* and *Chlorosaccus* have been closely compared in the electron microscope and the nature of the artefacts produced by staining investigated. Visual and electron micrograph records of one and the same stained cell have also been compared. Observation of the very distinctive but closely comparable flagellar character in brown algæ, yellow-green algæ and certain fungal and flagellate groups has led the authors to the conclusion that these groups are phyletically more nearly related to each other than they are to other groups, for example, green algæ (see also p. 280 of this issue of *Nature*).

## General Principles of University Research

In *Research for Industry* (4, No. 5; July 1952), the news bulletin of Stanford Research Institute, Dean Ernest R. Hilgard, of the Graduate Division of Stanford University, writing on "Fundamental and Applied Research in relation to the University", lays down three criteria for the choice of possible research projects by a university, including research grants or contracts offered by industry or government. First, the project should be in line with the professor's special interest and training; second, it should preferably be of a kind to make good use of the students and to provide them with a rounded training in research; third, it should normally lead to scholarly publication. These criteria do not exclude applied research, since it can meet these standards provided the inquiries are conducted in the true scientific spirit. Examining the kinds of research which normally should be less favoured by a university, Dean Hilgard lays down four further criteria. First, projects serving the immediate aims of industry or government but lying outside the scholarly interests of the staff and not in the direction of intended development; second, those requiring a pace of development best served by non-teaching scientists and full-time technicians; third, specialized projects requiring a staff so large as to disturb the equilibrium of the university; and fourth, research which requires excessive travel away from the university.

## Latin-American Course in São Paulo on Radio-isotope Methodology

A course on radioisotope methodology, the first of its kind ever to be held in Latin America, has been organized by the Faculty of Medicine of the University of São Paulo, Brazil, under the direction of Prof. A. Wormall, who has been temporarily seconded from the Department of Biochemistry and Chemistry, St. Bartholomew's Hospital Medical College, London, assisted by Dr. Tede Eston, Dr. Veronica Rapp de Eston, Prof. P. B. Smith and Miss Constancia Pagano, of São Paulo. The course, which started on January 14 and is a full-time one, lasting for six weeks, consists of two whole days of practical work each week together with theoretical lectures on the experiments to be made; in addition, four theoretical lectures are being given weekly and seminars held in connexion with the laboratory work. Those taking the course are graduates in science or medicine, and thirty men and women are at present participating, nineteen being from Brazil and eleven being holders of Unesco fellowships from other Latin-American countries; the limitation in numbers is due to the difficulties of accommodating the practical work, but there is no restriction on the numbers who may attend the lectures, and, in fact, four others are doing so. Most of the participants hold responsible positions in universities, research institutions or hospitals, and it is hoped that the course will enable them to make profitable use of radioactive isotopes for research and for clinical medicine. Further details can be obtained from the Laboratório de Isótopos, Faculdade de Medicina, Caixa Postal 2921, São Paulo, or the Divisão de Difusão Cultural, Reitoria da Universidade de São Paulo, rua Helvetia 49 a 55, São Paulo.

## Physical Society's Annual Exhibition

The thirty-seventh annual exhibition of scientific instruments and apparatus arranged by the Physical Society will be held during April 13–17 in the Imperial College of Science and Technology, Imperial Institute Road, London, S.W.7. A return has been made to the practice of former years of placing the whole of the exhibition in the main buildings of the College (except for one heavy exhibit housed in the Mathematics Department of the Huxley Building, Exhibition Road, for which tickets of entry will not be required. Three discourses, each lasting approximately forty-five minutes, will be given at 6.45 p.m. in the Large Chemistry Lecture Theatre as follows: April 14, Dr. E. C. Bullard (National Physical Laboratory), "Seismic Study of Ocean Basins"; April 15, Dr. L. A. Jordan (Paint Research Station), "Particles, Pellicles; Pigments, Paints and Physics"; April 16, Prof. W. V. Mayneord (Department of Physics, Royal Cancer Hospital), "Scintillation Counting and its Medical Applications". A handbook giving details of the exhibits will be published early in March and will be available at the exhibition or ordered from the Physical Society (price 6*s*., or

7*s.* 3*d.* by post). The exhibition will be open at the following times: April 13, 10.30 a.m.–8 p.m. (Fellows and Press only, 10.30 a.m.–2 p.m.); April 14–16, 10 a.m.–8 p.m.; April 17, 10 a.m.–5 p.m. Application for tickets, which are of various types, available for part or all of these times, should be made as soon as possible to the Exhibition Secretary, Physical Society, 1 Lowther Gardens, Prince Consort Road, London, S.W.7, from whom all further particulars can be obtained.

### Electronic Instruments in Atomic Energy: Course at Harwell

A specialized course on the design, use and maintenance of electronic instruments used in nuclear physics, radiochemistry and in work with radioisotopes will be held at the Isotope School of the Atomic Energy Research Establishment, Harwell, during March 16–20. The course will be limited to twelve people who are physicists or electronic engineers holding a degree or equivalent qualification, and will include lectures and practical work on counters, D.C. and pulse amplifiers, coincidence units, scalers and rate-meters. The instructional staff will be drawn from the Atomic Energy Research Establishment, but the Isotope School is outside the security fence and the subject-matter will be entirely unclassified. The fee for the course is 12 guineas, and living accommodation (at Buckland House, near Faringdon, which is one of the senior staff hostels of the Establishment), transport and morning and evening meals will be provided at a charge of 7 guineas. Application forms can be obtained from the Electronics Division, A.E.R.E., Harwell, near Didcot, Berks.

### Royal Society Lectures for 1953

Royal Society Lectures for 1953 will be delivered as follows: Croonian Lecture, on June 11, by Sir Ronald Fisher, professor of genetics, University of Cambridge; Bakerian Lecture, on May 7, by Prof. N. F. Mott, professor of physics and director of H. H. Wills Physics Laboratory, University of Bristol; Ferrier Lecture, on December 10, by Dr. F. M. R. Walshe, consulting physician to University College Hospital and to the National Hospital for Nervous Diseases; Wilkins Lecture, on March 5, by Sir Harold Hartley; Leeuwenhoek Lecture, on November 5, by Dr. K. M. Smith, director of the Plant Virus Research Unit (Agricultural Research Council), Molteno Institute, University of Cambridge.

### Announcements

The Council of the Royal Society has appointed Sir James Chadwick as the Rutherford Lecturer for 1953; he will deliver the Lecture at McGill University, Montreal, in the autumn. This is the second Rutherford Lecture to be given under the terms of the Rutherford Memorial Fund, the first having been delivered last year in New Zealand by Sir John Cockcroft.

The Guthrie Lecture of the Physical Society, which is given annually in memory of the founder of the Society, will be delivered on March 13 in the Lecture Theatre of the Science Museum, Exhibition Road, London, S.W.7, at 5 p.m., by Prof. M. Born, who will speak on "The Conceptual Situation in Physics and its Prospects of Development".

A Centenary Lecture of the Chemical Society will be given by Prof. A. Tiselius, of Uppsala University, at 7.30 p.m. on February 26 in the Lecture Theatre of the Royal Institution, Albemarle Street, London, W.1. The subject of the Lecture will be "Some Applications of the Separation of Large Molecules and Colloidal Particles".

A Centenary Exhibition of prints from the Royal Photographic Society's Permanent Collection and photographic apparatus collected by the Society and the Science Museum has been arranged at the Science Museum, Exhibition Road, London, S.W.7, and in the Society's House, at 16 Princes Gate, London, S.W.7. The Exhibition will be open from February 17 until March 28.

At the general monthly meeting of the members of the Royal Institution, held on February 2, Mr. Stanley Robson was elected secretary to fill the vacancy caused by the resignation of Prof. A. O. Rankine.

Mr. A. B. Duncan, chairman of the finance committee and a member of the Scottish committee of the Nature Conservancy, has been appointed chairman of the Conservancy in succession to Sir Arthur Tansley.

Mr. M. W. Thring has been appointed an assistant director of research of the British Iron and Steel Research Association. He will continue as head of the Physics Department of the Association.

Mr. F. E. Bruce has been appointed to the University readership in public health engineering tenable at the Imperial College of Science and Technology, London. The degree of *D.Sc.* (Engineering) of the University of London has been conferred on Mr. Stanley Whitehead.

The third annual conference of the Ergonomics Research Society will be held in the Department of Human Anatomy, University of Oxford, during April 13–16, and will take the form of a symposium on "Human Performance: its Measurements and Limitations". The conference will be under the chairmanship of Prof. W. E. Le Gros Clark. A fee of 30*s.* is charged for those who are not members of the Society. Limited accommodation is available in Brasenose College. Enrolment forms (to be completed at the latest by March 31) and further information can be obtained from H. Murrell, Spinneys, Marlpit Lane, Headless Cross, near Redditch, Worcs.

A conference marking the twenty-fifth anniversary of the Sub-Committee on Dust Technology of the Verein Deutscher Ingenieure will be held in Essen during March 26–27. After an introduction by the chairman, Robert Meldau, a number of papers will be read, including one by Prof. P. Jordan (University of Hamburg) on the distribution of fine dust in new theories on world creation, another by Prof. Correns (University of Gottingen) on dust in the formation of sedimentary rocks, and seven other papers dealing with various aspects of dust technology.

The first Marjory Stephenson Memorial Lecture will be given by Dr. D. D. Woods at the Royal Institution, Albemarle Street, London, at 6 p.m. on April 13, his subject being "The Integration of Research on the Nutrition and Metabolism of Micro-organisms". The Lecture is open to the public. The Marjory Stephenson Memorial Fund is administered by the Society for General Microbiology, and the Lecture will be given during the sixteenth general meeting of the Society. Further details can be obtained from the general secretary of the Society, Dr. J. G. Davis, 52 London Road, Reading, Berks.

# HYDROBIOLOGY AND INLAND FISHERIES OF AFRICA

THE principle of the symposium as a means of taking stock and stimulating new work in science may be said to have a value which is in direct proportion to the isolation of the workers concerned. Thus symposia have special value in the more remote parts of the world where many workers are to-day striving towards common objectives in small institutes or organizations hundreds or even thousands of miles apart. A good example was the symposium on African hydrobiology and inland fisheries which was held during October 14–17, 1952, under the ægis of the Scientific Council for Africa South of the Sahara. It brought together more than forty workers in these subjects from sixteen different territories in Africa, including Belgian, French, Portuguese and British Colonies, the Union of South Africa and Southern Rhodesia. The site was Entebbe in Uganda, appropriate in that it is near the centre of Africa and is lapped on three sides by Africa's largest lake.

The symposium was opened by Sir Andrew Cohen, Governor of Uganda, in an erudite speech in French and English. He mentioned the progress in African scientific co-operation which is being achieved by the Commission for Technical Co-operation in Africa and by the Scientific Council for Africa South of the Sahara, and pointed to the importance of the development of fisheries in solving a major nutritional problem of Africa, particularly in a country like Uganda, which has more than its fair share of lakes and swamps. He referred particularly to the need for scientific background: "It is a commonplace," he said, "so great that it need not be repeated publicly, that one of the main keys to agricultural development lies in the knowledge of soils. In the development of fisheries the water is the soil, and yet we know too little about our waters".

The contributions and discussions inevitably covered a wide range, including comparison of the organizations in the various territories, information services, fish and fisheries of natural waters, fish farming, trout fisheries, hydrobiology in relation to disease, legislation, and the co-ordination of fishery interests with those of agriculture and other subjects in the use of Africa's meagre water supplies. From the Belgian Congo, C. Halain described the successful results of the campaign for establishing numerous fish farms in native areas, and Dr. A. F. de Bont described scientific results achieved in that connexion, these being compared with experience in fish farming contributed by Dr. D. Hey and Dr. S. S. du Plessis from South Africa, J. L. Lemasson and others from the French territories, H. C. Copley and Dr. V. van Someren from Kenya, O. E. Symes from Nigeria, and others. The fish farming industry of Africa is being built mainly on the numerous local species of *Tilapia*, and this led to discussion on the transportation of fish from one drainage basin or fish region to another. It was generally agreed that, while economic development cannot be held up, it is more important during the next few years to learn more about the local endemic species in their natural waters and under conditions of culture, than to distribute widely those few species which have already proved themselves useful under domestication.

Sessions devoted to natural waters included some important contributions on production biology from the East African Fishery Research Organization's laboratory at Jinja, which has now been in existence for several years. R. S. A. Beauchamp and G. R. Fish, for example, threw considerable light on the highly complex hydrology of Lake Victoria. Dr. J. Rzoska, from the University College of the Sudan, described hydrobiological researches on the White Nile, particularly the influence of the reservoir contained by the Gebel Aulyia barrage near Khartoum.

An academic note was sounded in discussions of the ecology of tropical swamps introduced by Prof. L. C. Beadle, of Makerere College, and on the biology of speciation in African lakes introduced by Dr. E. B. Worthington. This turned around the debatable problem of sympatric and allopatric speciation, which was argued particularly, by P. H. Greenwood from his studies of *Haplochromis* flocks in Lake Victoria, Miss R. Lowe on the associations of *Tilapia* species from Lake Nyasa and elsewhere, and Dr. G. S. Carter, who is spending a year at the Jinja Laboratory on sabbatical leave from Cambridge.

Much new information was brought to light on a variety of African fishes in relation to their environments, particularly those of economic importance and including the introduced species of trout in the highland areas. A feature of the meeting was an account of research on fish-eating birds and on the ecology and economic status of the crocodile by another visiting worker from Cambridge, Dr. H. B. Cott. His results promoted discussion on the policy which should be adopted by Governments in applying some control to the industry in crocodile skins, which in some waters may threaten the very existence of crocodiles. Whereas views were expressed that the crocodile is an animal which could well be dispensed with in areas of economic fisheries, particularly on account of the destruction which it causes to fishing nets, it was generally admitted that its influence on food chains is yet inadequately known and might sometimes be beneficial. For example, an experience was recounted from Madagascar that the destruction of crocodiles had been associated with an increase in the incidence of rabies: crocodiles no longer eliminated rabid dogs which were drinking.

Prof. J. Millot (of the Muséum d'Histoire Naturelle, Paris, and of Madagascar), who was chairman of the symposium, remarked in his concluding speech that the meeting as a whole had provided the opportunity for a thoroughly useful exchange of experience and views from a very wide region, and the contributions and discussions had achieved a high scientific standard. The fact that the hydrobiology of Africa is achieving a considerable importance and is less isolated than formerly is illustrated by the fact that no less than ten of the participants at this symposium expect to attend the Twelfth International Limnological Congress, to be opened during August at Cambridge. The language problem, which is so apt to impede international meetings, was solved by simultaneous interpretation at the symposium. A full record will appear as an official publication in due course. E. B. WORTHINGTON

# SIGNIFICANCE OF RACIAL DIFFERENCES

DR. G. M. MORANT'S informed and clearly reasoned pamphlet on "The Significance of Racial Differences"* makes an important contribution to the series of publications on the question of race published by the United Nations Educational, Scientific and Cultural Organization. Racial differences, their extent and their significance, are burning questions to-day when racial stresses are rampant. What has been established by a century of scientific inquiry should be more widely known, and the methods of approach to such questions more widely understood. "Popular views of the matter are still nebulous enough to be swayed by anyone who chooses, for his own ends, to spread 'racial' dogmas which cannot readily be proved true or false."

Racial differences, physical and mental, have indeed been a subject for literary discussion for two thousand years and more. But a fundamental weakness is that it has no agreed systematic method of considering such questions of group difference. The classes of evidence chosen for emphasis and the choice and interpretation of items in those classes are usually such as best fit some general theory of the writer's; they offer a wide field for bias and produce many contradictory conclusions. But certain tendencies are general: to regard as 'racial' many differences that are environmental or cultural; to reduce, for simpler thinking, the variety that every group exhibits to the uniformity of a single type; to endow that type with the more extreme and striking attributes of a few, rather than with those of the group as a whole; and to assume that groups which are markedly different in regard to some obvious physical attribute must have certain marked differences in mental make-up.

Scientific inquiry, on the other hand, whether into the physical, physiological or mental constitution of human groups, has the same agreed basic method of approach, which the author describes. By techniques of analysis which compare groups as a whole, it has established for many attributes (or 'characters'), especially physical, the actual extent of racial differences. "The ways in which men differ are of small account compared with the ways in which they are alike, but the former make up the class defining individual and group distinctions."

Though the physical differences between groups may often have little practical importance—apart from the influence on attitudes and intercourse of any that make very obvious distinctions between peoples—the results of the study of the physical characters have this advantage: that most characters of form, size or colour are mainly (and blood groups are believed to be entirely) determined by hereditary factors; whereas the outward manifestations of mental characters are determined to a considerable extent by experience and social environment. In both cases it is the hereditary, the racial, factors that are in question, and the ampler findings in regard to physical characters can throw light on the more complex question of the mental differences between racial groups.

Within all racial groups for which there are adequate records over the past seven thousand years, physical variation as recorded is of much the same order: rather less, as a rule, in the earlier series than the later, but not much; rather more in modern Europe than elsewhere, but with exceptions. There is considerable variation in group averages; but for very few 'continuous variables', apart from characters of colour and hair form, can groups be found the distributions of which do not overlap. Even in stature, and taking groups at opposite ends of the range, the tallest Congo pygmy is about as tall as the shortest Dinka; and in pairs of racial series selected at random about one in three would differ in average height by less than 4 cm. Dr. Morant, by a slip, says "about one in 130" (p. 32), a figure contradicted by the evidence of his distributions; also, in stating (p. 41) that no other measurement is known to differentiate racial populations as effectively as stature and cephalic index, he overlooks nose-breadth, which differentiates more effectively than either—hand-breadth probably too (*Man*, 50, No. 14). These errors do nothing to weaken his argument. For almost all metric characters, inter-racial variation is less than intra-racial, and the distributions for even the most divergent groups overlap widely, so that a large proportion of the individuals belonging to one could belong to either.

Valid comparisons between group averages for innate, hereditary, mental ability and disposition are difficult to make for racial groups whose mental experience is very different; but mental tests have at least shown a wide range of variation in any group tested, and—allowing for differences of background—wide overlap in group distributions. A rule found to apply to all forms of life is that variation within inter-breeding groups is associated with variation between such groups; and it is improbable that man's mental characters, unlike his physical, are an exception. "The general inference is that there are racial differences in mentality, although clear demonstration of them—regarding particular characters and particular pairs of populations—is not available yet". The differences are not likely to be all in favour of the same groups. Nor does it necessarily follow that a wide average difference in some physical trait is associated with a wide average difference in some mental trait. Also, the average mental differences may be small: existing evidence suggests "that group diversity tends to be less in degree for mental tests than for body measurements"—if less, not less significant.

Dr. Morant points out an aspect of group difference that, for mental characters, may make a distinction of importance. Two overlapping distributions of which the mean values are not far apart are yet likely to differ considerably in their relative frequencies of individuals having extreme values of the character. "There may be almost equal proportions of stupid, mediocre and able people in two populations; even so, exceptional ability may be found with a frequency of 1 in 1,000 in one group and with a frequency of 1 in 10,000 in the other. Having a larger proportion of exceptionally able members may be a factor which tells decisively in favour of a population in the course of centuries or milleniums." One might go further than does Dr. Morant in this informative and thoughtful pamphlet: at turning points in a nation's history it may tell decisively, though briefly, on its whole future course.

M. L. TILDESLEY

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* "The Significance of Racial Differences". (The Race Question in Modern Science.) By Dr. G. M. Morant. Pp. 48. (Paris: Unesco; London: H.M.S.O., 1952.) 1s. 6d.; 25 cents; 75 francs.

# NEW ZEALAND FOREST SERVICE

## REPORT FOR THE YEAR 1950–51

THERE is a breezy directness about the annual forestry reports of New Zealand* which should invite public attention. Yet under the heading "Purpose of Annual Report", the Director of Forestry writes: "Practically without exception the annual reports of the Director of Forestry have been used consistently since 1934 to review forest policy. There have been few if any facets of policy that have not been reviewed on numerous occasions. Primarily, these reviews have been intended to inform Parliament on the Department's discharge of its responsibilities under the various Forest Acts and their amendments. Equally, they have been directed at the public in the expectation that, the annual reports being public documents freely available both to the press and to interested bodies, the public would be adequately informed of the evolution of forest policy. That expectation has proved illusory. A month seldom passes without there being some definite evidence that policy reviews are either not consulted or completely ignored. Clearly, annual reports are insufficient in themselves to promulgate forest policy". In forestry matters the Director is not alone in this discovery.

One of the chief troubles in New Zealand, as elsewhere in both the Old and New Worlds, is fire damage. The Director contrasts New Zealand with Scandinavia where, he says, fire protection work is much less costly because the people have become forest-minded. This is true of the peoples of other parts of Western Europe, and we have yet to acquire this attribute in Great Britain. In New Zealand, on the other hand, says the report, there is a tradition of land-clearing to make farms, and most of the people of the cities are out of touch with forests and forestry. In order to improve fire publicity, the campaign against fire is now to be merged in public relations affairs.

In the annual report for 1948–49, under forest policy, it was announced that the decision had been taken by the Government to establish a saw mill and a pulp and paper mill at Murupara on the Rangitaiki River in the Rotorua Forest Conservancy —the first of its type in the Dominion (see *Nature*, 165, 966; 1950). There was afterwards considerable hesitancy in embarking on this great scheme to exploit the extensive forest in question. The proposed development is of high interest in its novel departure. Later in the year the Government finally took the momentous decision to proceed with the project, and in order that the resources of this great forest may be exploited without further delay, the Government effected, during the 1950 session, the passage of legislation empowering the construction of the Edgecombe–Murupara Railway and granted financial authority for the work.

On the subject of soil conservation, about which so much is talked and written nowadays, the report correctly says: "The joining of soil conservation with river control has served to cloud the fundamental issue that in the final analysis both soil and water problems are essentially land and not engineering problems". The example is given of the failure of the British groundnuts scheme, and allusion is made to serious fears that all is not well with the much-advertised Tennessee Valley Authority scheme. As is well known, the necessary protection of the head-waters of the various waters upon which the scheme is based was ignored.

It is estimated that 80 per cent of the erosion and flooding troubles of New Zealand would ultimately disappear if land and forest fires could be entirely eliminated; a further 15 per cent would be rectified if overgrazing by wild life and by farm animals could be stopped, and other better farming practices universally instituted. E. P. STEBBING

* New Zealand State Forest Service. Annual Report of the Director of Forestry for the Year ending 31st March 1951. Pp. 79. (Wellington: Govt. Printer, 1951.) 1s. 6d.

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# METEOROLOGICAL OFFICE

## REPORT FOR THE YEAR 1951–52

THE principal feature of the report of the Director of the Meteorological Office for the year ending March 31, 1952*, is the attention which is being devoted to the study of the atmosphere in the region between about 30,000 and 50,000 ft. in height—roughly the top of the troposphere and the lowest part of the stratosphere. This region is particularly important because jet aircraft fly in it at a fuel consumption which for the distance covered is less than at lower levels. The winds there are sometimes very strong, having been known to exceed 150 knots (about 280 km./hr.), and the air is sometimes bumpy for no visible cause (such as thunderclouds) which would give warning to pilots. The forecasting of wind-speed and -direction and turbulence in this region is an important meteorological problem. The increased attention given to the upper atmosphere is partly shown by the formation during the year of a new Branch of the Office for detailed study of the Climatology of the Upper Air; previously, this work had been the function of a section of the Overseas Climatology Branch. Research into the forecasting of winds at high levels has continued during the year, and analysis of occasions of clear-air turbulence has confirmed earlier indications of an association between turbulence and the presence of marked variation in wind-speed in the vertical and horizontal directions. The work on turbulence included observations by the Meteorological Research Flight of the behaviour of smoke trails emitted by aircraft.

The forecasting of radiation fog is a major meteorological problem of importance to all forms of transport. A special organization was set up at Cardington (Bedford) to examine the development of fog. The work includes observations with the aid of instruments which can be carried by kite-balloon to more than 2,000 ft. Experimental forecasts for four days ahead were prepared twice weekly in the Forecast Research Division. A measure of success was attained; but the reliability of the forecasts was not sufficient to enable a decision to be made to devote additional staff to this work. Among other subjects of research described in the report are the study of cloud structure by radar, icing on aircraft, and the development of instruments, such as the radar theodolite, for measuring upper winds.

The meteorological services provided for the Royal Air Force and Army, civil aviation, the general public and industry continued to expand. A large meteorological exhibition was set up in the Dome of Discovery of the Festival of Britain Exhibition in

* Annual Report of the Director of the Meteorological Office presented by the Meteorological Committee to the Secretary of State for Air for the Year April 1, 1951, to March 31, 1952. (M.O. 562.) Pp. 56. (London: H.M.S.O., 1952.) 2s. net.

London. The exhibition included a weather-forecasting unit at which a special souvenir weather report and forecast was compiled, and more than 150,000 copies were sold to visitors. The overall strength of the Office staff decreased from 2,601 to 2,589 during the year; but the scientific officer class increased from 160 to 165. A number of university students, mainly of physics and mathematics, worked in the research centres of the Office during vacations.

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## DRYING OF HIDES AND SKINS

It is twenty years since experimental work in Kenya yielded results which established principles for the correct drying of hides; the experience gained since that time has now been described by J. R. Furlong, principal of the Colonial Products Advisory Bureau (Plant and Animal) (*Colonial Plant and Animal Products*, 2, No. 4; 1951).

To obtain the best possible leather from a hide, it is desirable to proceed to the tanning operations without reducing the hide to a dry state. Many countries, however, have insufficient native hides for their needs, and it is necessary to bring supplies from overseas or long distances to the tanneries. The distance which green or lightly salted hides can safely travel without damage caused by putrefaction is very limited, and it is essential to submit the hides to some process of curing in order that they may be transported and stored without deterioration. The curing may consist of salting the hide and transporting it in a wet-salted condition—an expensive method applicable to the best qualities of hides, or the material, after salting, may be dried out and sent to the market in a dry-salted condition. In many countries, however, salt is scarce and the use of the imported material would be too costly. Recourse is therefore made to the procedure of air-drying as a method of preservation. This is practised in many hot countries, particularly in the African continent. Dry hides represent a large proportion of the production of the entire output of such countries as Nigeria, East Africa, South Africa, the Sudan and Abyssinia, while India and South America are also large producers of dry hides.

Dry hides are an important class of raw material for the tanneries of the world to-day. In the decade before the War many tanners had developed a technique for producing leather of the highest quality from this class of hides, and during the War a still larger number of tanners in the United Kingdom were forced to use Colonial dry hides for the first time. While Continental tanneries had always handled Colonial hides, it is the great advance which has been made in this connexion in the United Kingdom, as a result of war-time experience, that is of significance. Tanners have learnt how to obtain good results, and it is to Colonial sources that English tanneries now look for increasing supplies of their raw materials.

The article describes methods which are now being used in the suspension-drying of cattle, goat and sheep skins, and emphasizes that the old method of drying hides and skins on the ground is liable to cause serious damage, and should never be employed. Drying hides and skins on the ground should be prohibited in areas where the improved processes of suspension-drying are practicable.

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## HANDLING OF RADIOACTIVE AND TOXIC SUBSTANCES

An edited report of the proceedings of the symposium on the handling of radioactive and toxic substances, which was organized by the Chemistry Division of the Atomic Energy Research Establishment, Harwell, and which was held in two sessions on September 10–11 and 13–14, 1951, at Buckland House, near Faringdon, Berks, has recently been issued*. Sixty-four representatives from the chemical industry, universities, hospitals, government research establishments and the atomic energy projects of Western European countries attended. A list of the various representatives and their respective organizations is included in the report. The chairman, Dr. R. Hurst, welcomed the representatives, and mentioned that the original suggestion to hold such a symposium came from Dr. R. Spence, the head of the Chemistry Division at Harwell.

The contributed papers and subsequent discussion centred around three topics: the use of glove boxes, remote control of chemical operations and laboratory housekeeping and decontamination. Dr. Hurst, who spoke first, described the various improvements and requirements in the design of glove boxes which experience of their use at Harwell has indicated. He stated that glove boxes provide the simplest means of confining a chemical operation so as to prevent the spread of radioactivity, or to exclude oxygen, dust or harmful organisms. Suitable gloves developed for use in these boxes were described and shown. The use of heat-sealed polyvinylchloride bags for the transfer of active material or apparatus into or out of glove boxes was recommended. Mr. J. G. Bell then gave details of a glove box design with double-wall protection for work on alpha-active materials which require a protective atmosphere, and Mr. W. G. Busbridge discussed the requirements of filters for use with glove boxes. The disadvantages of wool-resin filters were pointed out, and a new type of filter employing a mechanical filter of wool and asbestos was briefly described.

On the subject of remote control of chemical operations, the discussion centred on two general methods: systems of tongs, manipulators and periscopes, by which conventional apparatus can be used by an extension of the hands; and systems by which liquids can be transferred, precipitates removed and similar operations conducted by vacuum-lifting or by pumping from vessel to vessel. In this section papers were read by J. Dean and A. B. Ritchie, G. B. Cook, G. N. Walton, G. Wortley, and Dr. W. J. Arrol. Finally, Dr. G. L. Miles reviewed the general problem of laboratory management in radiochemical work, the housekeeping techniques which are essential to prevent and restrict the spread of radioactivity and to keep the working-space clean and free from contamination. It was emphasized that hoods, glove boxes and apparatus should have hard smooth surfaces, that detergents are generally satisfactory as decontaminants and that certain radioisotopes may need special treatment. Recommendations on the disposal of active waste were also made.

The report makes interesting reading and is amply illustrated by photographs and diagrams.

* Atomic Energy Research Establishment. Symposium on the Handling of Radioactive and Toxic Substances, held in Two Sessions on September 10–11 and September 13–14, 1951, at Buckland House, near Faringdon, Berkshire. (A.E.R.E., C/R 958.) Edited by G. R. Hall. Pp. iv+37+31 pl. (London: H.M.S.O., 1952.) 12s. 6d. net

# HISTOCHEMISTRY OF SUCCINIC DEHYDROGENASE

By Dr. H. A. MALATY and Dr. G. H. BOURNE
Department of Histology, London Hospital Medical College, London, E.1

KUHN and Jerchel[1] synthesized various substituted tetrazolium salts and showed that their aqueous solutions stained living tissues (for example, yeast and bacteria). Various other workers confirmed this (see Smith, ref. 2). Tetrazolium is a compound which becomes coloured when it is reduced, and this suggested that the effect of its solutions in colouring living tissues may be due to the effect of reducing substances or to dehydrogenases present in them. Jerchel and Kohle[3] showed that it was possible for these tetrazolium compounds to act as hydrogen acceptors for some pyridine-nucleotide dehydrogenases. Tynen and Underhill[4] first used tetrazolium (triphenyl tetrazolium chloride) as a histological reagent, demonstrating subcutaneous fat with it. They found that injection of a 1 per cent aqueous solution of triphenyl tetrazolium chloride into mice stained neutral fat a bright orange-red in 5–10 min. They suggested that the fatty tissue caused reduction of the tetrazolium to a formazan pigment. Black and Kleiner[5] also used the same compound for measuring the respiration of tissue slices, and Kun and Abood[6] appear to have been the first to use it specifically for the estimation of succinic dehydrogenase activity.

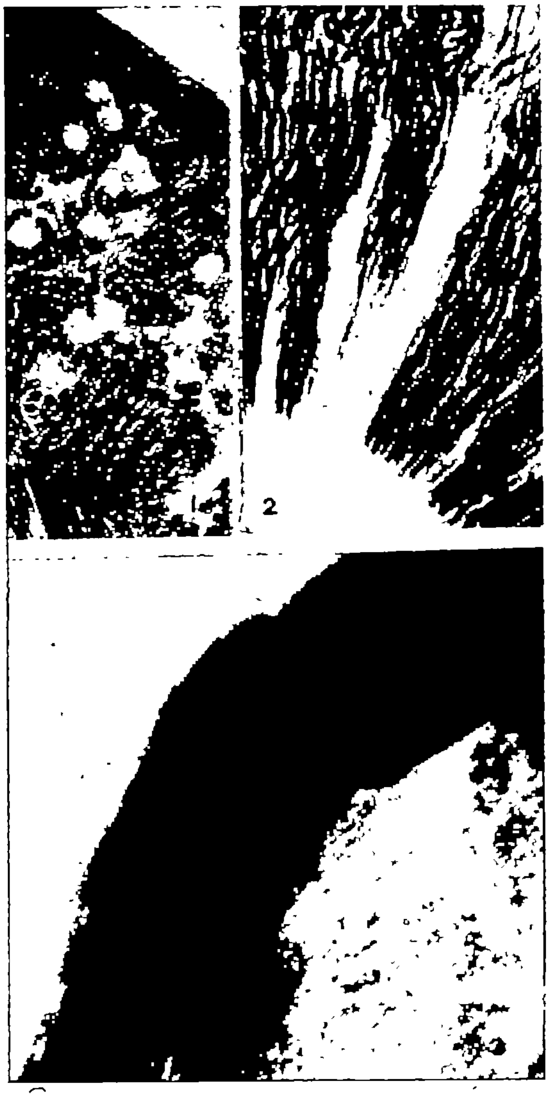
Rutenberg, Gofstein and Seligman[7] described the synthesis of blue tetrazolium and its use for estimating succinic dehydrogenase activity in tissue homogenates. Afterwards, Seligman and Rutenberg[8] showed that this enzyme could be demonstrated histochemically using blue tetrazolium. An analysis of the specificity of tetrazolium compounds for the histochemical detection of succinic dehydrogenase has been given recently by Shelton and Schneider[9].

The rationale of the technique is as follows. Blue tetrazolium is ditetrazolium chloride and is pale yellow in aqueous solution; it is a hydrogen acceptor and becomes reduced to a blue water-insoluble pigment (diformazan). Fresh-frozen sections are placed in a substrate[8] containing 1 part of water, 1 part of 0·2 *M* sodium succinate, 1 part of 0·1 *M* phosphate buffer (*p*H 7·6) and 1 mgm. of blue tetrazolium per ml. The reaction develops in about two hours. We have found that by this time the maximum colour has developed, and that even leaving the sections over-night does not intensify the colour further. The succinic dehydrogenase in the tissues is, of course, responsible for the splitting of hydrogen from the succinate, and this reduces the tetrazolium to diformazan which, being insoluble, is precipitated at the site of enzyme activity.

We have investigated this reaction in guinea pig, rabbit, mouse and rat tissues. Technical points which we have found affecting the reaction are as follows.

(1) *Method of killing the animal.* Some animals were killed by anaesthetizing with chloroform, some by ether, some by 'Nembutal' injection and some by a blow on the head. In animals killed by the use of anaesthetics, it was difficult to obtain a satisfactory reaction for the enzyme, particularly with the liver and cardiac muscle. The reaction in kidney, brain and nerve appeared to be unaffected by the method of killing the animal except in the case of the rabbit, when it was almost impossible to obtain a result from any of the tissues after anaesthesia. A blow on the head appeared to be the most satisfactory way of killing the animal.

(2) *Thickness of sections.* Seligman and Rutenberg found that sections of 8 μ or less gave no reaction, and that sections 20 μ thick gave optimum results even though about one section in five gave no result. Presumably these negatives are due to oxidation of the diformazan, since a greater number of positive sections is obtained if oxygen is excluded from the system. Seligman and Rutenberg found that thicker sections than this were unsatisfactory. Shelton and Schneider agree with Seligman and Rutenberg in this respect. We have, however, obtained poor results with 20-μ sections, but have been able to obtain excellent and consistent results with sections of 50–100 μ.



Succinic dehy rogenase preparations
(1) Kidney (rabbit); note positive reaction in convoluted tubules; negative reaction in glomeruli. × 35
(2) Kidney (rabbit); note positive reaction in Henle's loops; negative reaction in lower collecting tubules. × 35
(3) Striated muscle (rabbit); note positive reaction given by rows of sarcosomes between muscle fibrils. × 1,000

(3) *Fixation.* We obtained our best results from sections which were not treated with any fixative—even acetone proved unsatisfactory. Seligman and Rutenberg hardened their sections after incubation by treatment with 10 per cent formalin for 30 min. The sections should be mounted in glycerine jelly or in Apathy's medium.

(4) *Freshness of buffer.* We found that it was essential to use freshly prepared buffer.

(5) *Sectioning the tissue.* We found that freezing the tissue in a drop of water for sectioning was less satisfactory than freezing it on its own and dropping the sections directly into the substrate solution.

Shelton and Schneider tested four tetrazolium compounds as indicators of dehydrogenase activity. These were neo-tetrazolium, blue tetrazolium, tetrazolium violet and 2,3,5-triphenyltetrazolium chloride. The first two of these were found to be satisfactory, the last two unsatisfactory. Neo-tetrazolium gave the most rapid reaction. These authors found that fresh tissues had some endogenous ability of reducing tetrazolium salts; but that this ability was for some unknown reason lost when the tissues were frozen. They found that crystalline lactic and alcohol dehydrogenases did not reduce tetrazolium salts in the presence of their substrates, but that purified xanthic oxidase and diphosphopyridine nucleotide–cytochrome c-reductase were able to reduce these salts. Nevertheless, under the conditions of the histochemical test when carried out on frozen sections, they consider the reaction reasonably specific for succinic dehydrogenase, although they do not deny that mediation by other enzymes may be involved. In our own experiments no reaction was obtained when the succinate in the reaction mixture was replaced by malate, fumarate, citrate or cysteine.

In the animals we have examined, we have investigated the distribution of the reaction in peripheral nerve, liver, heart muscle, skeletal muscle, kidney and cerebellum.

Like Seligman and Rutenberg, we found the kidney very rich in this enzyme, but we did not, as they did, find cardiac muscle to have greater activity: we found it to have less. We found kidney to have the highest activity, then cardiac muscle, skeletal muscle, cerebellum, liver and peripheral nerve. Our results with kidney agree with those of previous authors in that we found the cortex of the kidney very rich in activity but the medulla almost completely negative; in other words, as with alkaline phosphatase, the enzyme was localized in the metabolically active part of the kidney (the convoluted tubules and Henle's loops) and only in the beginning of the collecting tubules. Glomeruli were almost completely negative. Like Shelton and Schneider, we found little evidence of diffusion in our preparations, when the blue granular reaction was given. We were not able, however, to decide upon the significance of the diffuse purple reaction given by some tissues which Seligman and Rutenberg find accompanies regions of low activity.

In cerebellar tissue, the outer (molecular) layer of the cortex showed this diffuse coloration, which increased in intensity and reached its maximum colour at the junction with the inner (granular) layer. The Purkinje cells were of the same intensity as the surrounding tissue. In the granule layer the cells and processes stained a diffuse purple colour (the white matter of the cerebellum was completely negative), but in addition the cells contained blue granules. In some cases these were evenly distributed in the cytoplasm and in some cells there was a juxta-nuclear or peri-nuclear aggregation of granules which linked together to give a network-like appearance resembling the Golgi apparatus.

The liver, in addition to a diffuse purple background, showed blue granules in the cells and in some cells bright blue rods and filaments.

Peripheral nerve also gave a diffuse purple reaction, and faint blue granules could be seen in places; but it was not possible to be certain whether these granules were between or within the nerve fibres. The cells of the perineurium showed blue granules in many places.

The intra-cellular distribution of succinic dehydrogenase is of considerable interest since differential centrifugation studies have shown that the large-granule fraction (presumably composed chiefly of mitochondria) contains practically all the succinic dehydrogenase activity of the tissue. Shelton and Schneider found that the large-granule fraction reduced tetrazolium salts when incubated with them. They found that the mitochondria and masses of reduced tetrazolium (formazan) crystals formed a *matte*, but they were not able to see whether individual mitochondria were stained. These results support the view that considerable succinic dehydrogenase is localized in the mitochondrial fraction; and it suggests that a good deal of activity is localized in, or possibly adsorbed on, the surface of the mitochondria, but gives no information whether any further activity is present inside the mitochondria.

Our preparations of kidney and liver showed a granular formation in many of the cells which was identical with mitochondria; but much more striking were our preparations of skeletal muscle. Here we found closely packed chains of granules between the muscle fibrils which gave an intense positive reaction. There is no doubt that these granules, from their form and localization, are sarcosomes—elements which are known to be mitochondrial in origin and to contain enzymes identical with those present in the mitochondria of liver cells. We have found a similar localization of activity in the sarcosomes of heart muscle. Seligman and Rutenberg publish a photograph of heart muscle which also shows this; but they simply refer to it as granular and homogeneous deposits in the myocardial cells. Parts of our preparations (liver, kidney and muscle) show large amorphous granules and some show structures which are strikingly mitochondrial in shape and form. High-power observation of the amorphous granules suggests that these may represent mitochondria, on the surface of which a mass of formazan crystals has accumulated. The same thing occurs in a few of the sarcosomes of muscle. On the other hand, some mitochondrial-like bodies and most sarcosomes seem to be stained an intense dark blue with no obvious signs of formazan crystals on the surface. This appears to suggest that the enzyme causing this reduction is present within the mitochondria, although it may, of course, be associated with the mitochondrial membrane.

One of the criticisms of the work on the localization of respiratory enzymes in mitochondria as demonstrated by the technique of differential centrifugation is that the enzymes may be adsorbed on to the mitochondria from the homogenate; however, the papers of Seligman and Rutenberg and of Shelton and Schneider, together with the results of the present study, present strong evidence that succinic dehydrogenase activity is closely associated with the mitochondria in the intact cell.

Since this paper was written, an extensive study of the histochemical reaction for succinic dehydrogenase has been published by Padykula[10]. In general, we agree with her results. She found also that, if sections were incubated in an atmosphere of nitrogen, much more consistent results were obtained.

We are indebted to Prof. E. W. Dempsey, of Washington University, St. Louis, for a supply of blue tetrazolium which was used in this work; also to Drs. Schneider and Shelton, of the National Institutes of Health, for a supply of neo-tetrazolium with which some of this work was confirmed.

[June 9.

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# TRAVELLING-WAVE LINEAR ACCELERATOR FOR X-RAY THERAPY

By C. W. MILLER

Research Department, Metropolitan-Vickers Electrical Co., Ltd., Manchester 17

DURING the past three years a linear accelerator having a design energy of 10 MeV. has been undergoing development for the Medical Research Council. The work has been performed by the Metropolitan-Vickers Electrical Co., Ltd., in conjunction with the Atomic Energy Research Establishment, Harwell, and the Medical Research Council. The machine, which is the first of its kind to be built specifically for X-ray therapy, has now completed its performance tests and has been installed at the Hammersmith Hospital, London.

Brief descriptions of the construction of this machine have already appeared[1,2], and the design of the accelerating tube itself follows closely the theory published by members of the linear accelerator team from Harwell[3,4], much of the computation being carried out by them. The corrugated waveguide is 3 m. in length, has $a/\lambda = 0{\cdot}168$ and operates at a free-space wave-length of 10·0 cm. The corrugation pitch is 1 cm. over the first 40 cm., and 2 cm. over the remaining length of guide. The ratio of phase velocity to that of light is approximately 0·4 at the input end, increasing to 0·992 at 1 m. along its length and thereafter remaining constant at 0·996. Electrons are injected into the accelerator from a gun operating at 45–50 kV. The electron dynamics require a power flux of some 3·6 MW., and, as the radio-frequency power source provides pulses of 2 μsec. duration and 2 MW. peak power, feedback as described by Harvie and Mullett[5] is used.

In much of the experimental work the machine was operated with a target mounted directly on the end of the accelerating tube. For clinical use an X-ray head is fitted in which the electron beam is deflected through a right-angle before hitting the target. This head can be rotated about the axis of the accelerator to change the direction of the X-ray beam.

The first length of corrugated waveguide was manufactured to dimensions calculated from the theory given by Walkinshaw[4]. Low-power measurements on this section of guide showed that the phase velocity at the design frequency was in error by some 5 per cent. Dimensions for a second length of guide were determined by scaling from the experimental results, and this new guide was found to have the required velocity characteristics. The discrepancy between theory and the experimental results has been found, and Walkinshaw and Bell have, in as yet unpublished work, derived an alternative method which not only avoids this error but also gives more rapid convergence.

The accelerator was operated for the first time in December 1950 and has from the first given a very large X-ray output. Measurements have been made of beam current and power, electron energy and X-ray output, and the variation of these quantities as functions of the operating conditions, such as radio-frequency power and frequency, focusing field and electron injection current, has been investigated. By modification of sections of the guide, the performance of the machine with several different phases of electron bunching was determined. The variations obtained in these tests were qualitatively in agreement with theory, and from the curves obtained it was possible to determine the best arrangement for installation. For clinical operation, not only is it desirable that high current and energy be provided but also that, owing to the change in direction of the electron beam in the X-ray head, a narrow spectrum of electron energy is required, and variation of energy with input power and frequency must be minimized. Typical performance curves are shown in Figs. 1 and 2. By running at a somewhat higher power-level and increasing the recurrence-rate beyond the nominal maximum of 500 pulses/sec., greater outputs can be obtained. At 600 pulses/sec. the X-ray output may be increased to 1,000 r./min. at 1 m., while at 700 pulses/sec. an output of 1,250 r./min. has been achieved. Short-term stability of the equipment is good, while long-term stability is ensured by means of a servo-operated phase shifter[6] in the waveguide feedback circuit, to correct for frequency drift and temperature changes of the corrugated waveguide. X-ray output stabilization at a preset value is obtained by variation of the gun-filament current. The width of the X-ray beam produced, using a thick gold target, has been found to be 24·5° at half intensity. A beam-flattening filter is incorporated to give uniform intensity at 1 m. over a circle 26 cm. in diameter. The treatment area, normally rectangular, can be adjusted by means of sliding diaphragms down to a minimum of 3 cm. square, and for circular fields special diaphragms may be inserted. The diameter of the electron beam is approximately 3 mm., and the consequent small spot-size and stability of its position ensures an adequately small penumbra. In clinical use it is intended to operate at dose-rates up to 200 r./min. at 1 m. from the target, a normal single treatment thus requiring an exposure of the order of two minutes. This output is considerably below the maximum shown in Fig. 2 and allows for stabilization and losses in the X-ray head, including the beam-flattening filter.

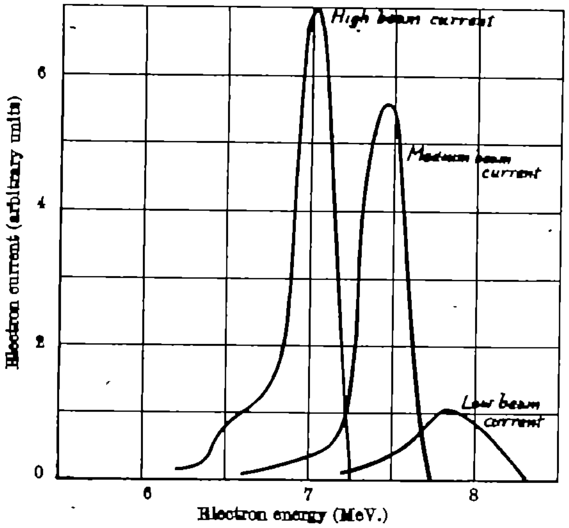

Fig. 1. Typical performance curves of linear accelerator, showing electron energy spectra

The conversion from electron current to X-ray output is 18·2 r./min./μA. at 1 m. for an energy of 8 MeV., while the exponent for the variation of this figure with energy is 2·87.

In general, the performance of the equipment has shown a close agreement with theory, with the exception that the electron energy is lower than was expected. An explanation which reconciles theory and measurement has been found as follows. In the design the relationship between accelerating field and power flux has been evaluated using the theory given by Walkinshaw[4]. In this the fields in the corrugated guide ($E_\rho$, $H_\varphi$ and $E_z$) are given as an expansion in Bessel functions with coefficients $A_0$, $A_1$, etc. It is only the term with coefficient $A_0$ in the expansion for $E_z$ which gives acceleration. Power flux is determined by the integration of the Poynting vector, $E_\rho \times H_\varphi$, and this, of course, leads to a further expansion. Following Walkinshaw, it had been assumed that only the term from the product of the two terms with coefficients $A_0$ was of significance, and from this assumption the relationship between the accelerating field and power flux was obtained. Further investigation shows that the assumption was not justified and that an appreciable part of the power flow is attributable to other terms in the expansion. The exact evaluation becomes difficult and has only been carried far enough to show that the effect can qualitatively explain the low energy. In order to obtain a quantitative relationship, measurements were made using a perturbation method based on the work of Maier[7] and Hansen and Post[8]. In these experiments the resonant frequency of a cavity constructed from a short length of corrugated guide is changed slightly by means of a metallic bead or piston. The fractional change in frequency together with the group velocity, determined by dispersion measurements, enables the relationship between the axial field and power flux to be calculated. Values obtained in this way confirm that the expected energy of the accelerator should have been approximately 8 MeV.

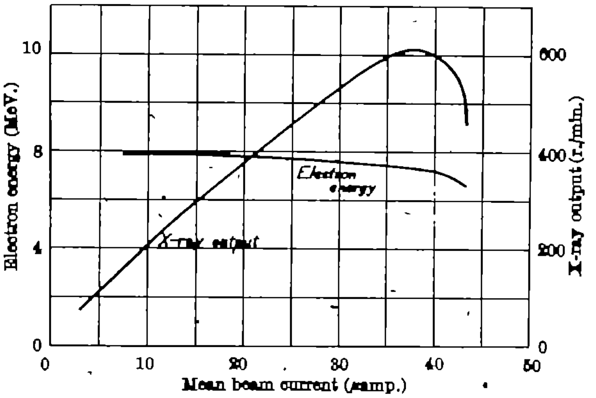

Fig. 2. Typical performance curves of linear accelerator at 500 pulses/sec. operation. Electron energy is that at the peak of the spectrum; X-ray output is measured without the clinical head

In the light of experience gained in this development, a 4-MeV. accelerator for clinical use has been designed, and several of these machines are at present being constructed. In this design the length of the corrugated guide is only 1 m., and the whole of the accelerator is mounted on a rotatable support. Considerable attention has been given to the simplification of the controls and of the facilities for the setting-up of the patient.

It is a pleasure to acknowledge the contributions of colleagues, and also the collaboration of the Atomic Energy Research Establishment and the Medical Research Council.

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# HOMOLOGY OF THE LAYERS OF THE EPICUTICLE OF INSECTS

By Prof. R. DENNELL and Dr. S. R. A. MALEK
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THE insect epicuticle is known to be a complex structure, and the different views that have been put forward regarding its constitution have been difficult to reconcile. Wigglesworth has indicated the presence in *Rhodnius*[1], *Tenebrio*[2] and *Periplaneta*[3] of four epicuticular layers—the cuticulin, polyphenol, wax and cement layers. In contrast, Richards and Anderson had been able to demonstrate by different methods only two in *Periplaneta*[4], and later Dennell described a two-layered epicuticle in blowfly larvæ[5]. Neither of the two layers described by these authors appeared to have its obvious counterpart in the description given by Wigglesworth. Now, however, comparison is aided by more detailed information on the epicuticle of *Periplaneta* and of the larva of *Calliphora*.

The innermost layer of the epicuticle of *Periplaneta* is the chitin-free cuticulin layer readily recognizable by its mosaic appearance[3]. When fully hardened, it shows no affinity for stains, and takes up sudan black *B* only after treatment with 'Diaphanol'. It gives a strongly positive argentaffin reaction, and fuses into oily droplets on heating with chlorated nitric acid. On the other hand, the newly formed cuticulin layer stains red with Mallory's triple stain, and takes up sudan black without previous treatment due to the presence of lipoid now found to be of sterol type. The argentaffin reaction is positive but less intense than in the fully hardened cuticle. As Wigglesworth found in *Rhodnius*[6], hot concentrated solution of potassium hydroxide causes complete dissolution. The newly formed cuticulin layer therefore bears a striking resemblance to the inner layer of the epicuticle of blowfly larvæ. In *Sarcophaga* the 'inner epicuticle' or 'protein epicuticle' stains red with Mallory, dissolves in hot concentrated potassium hydroxide solution, and gives only a slight argentaffin reaction and sudan black staining[5]. In *Calliphora*, however, it is strongly argentaffin[5], and on re-examination has been found to contain a sterol. It seems, therefore, that the inner epicuticle must be regarded as homologous with the cuticulin layer of the cockroach, the differing properties that have been ascribed to this layer being due to the observation of differing degrees of impregnation of a basal protein matrix with steroid and further protein and their subsequent polymerization, and to tanning in the hard cuticle. A further indication of homology is that both the inner epicuticle of blowfly larvæ[7] and the cuticulin layer of the cockroach[9] contain a polyphenol oxidase at the time of hardening.

Overlying the inner epicuticle of blowfly larvæ is the very thin but resistant outer epicuticle or 'lipoid epicuticle'[5]. Its disruption into oily droplets on strong heating in chlorated nitric acid caused it to be wrongly regarded as cuticulin[10]. Like the inner epicuticle, it does not contain chitin. Isolated as already described[5], it has been further studied in *Calliphora*. It shows a strong X-ray diffraction pattern of paraffin-chain type and, in spite of the method of preparation, a weak diffuse protein pattern. The infra-red spectrum shows great C—H absorption with strong evidence of the presence of fatty acid esters. Micro-chemical analyses show that the nitrogen content amounts to only about 1 per cent. The outer epicuticle differs then from the cuticulin layer in containing not a steroid but a straight-chain paraffin.

Does such a thin layer of great stability occur also in hard cuticles? As is to be expected, it is found in puparia, and may be isolated by its persistence after treatment with 'Diaphanol' followed by hydrochloric acid. Richards and Anderson[4] found a resistant outer layer in the cockroach, and this observation has been amply confirmed in the present work. The soft cuticle of the newly moulted cockroach has been macerated and a very thin non-mosaic membrane lifted here and there from the underlying cuticulin layer. Where it remains in contact with the cuticulin layer, it is not histologically distinguishable, but a uniformly lifted cement layer is clearly seen. In the adult cuticle a thin stable membrane has been isolated by the treatments used for blowfly puparia. It is noteworthy that Wigglesworth[1] also has shown the presence in *Rhodnius*, before the secretion of the cement layer, of a superficial layer of greater resistance than the underlying cuticulin layer. Both cuticulin and the superficial layer, however, yielded oily droplets on dissolution in chlorated nitric acid, and Wigglesworth did not regard the two layers as chemically different. But the paraffin-containing outer epicuticle of *Calliphora* also yields oily droplets, and it is suggested here that the thin resistant layer of the cockroach cuticle is a paraffin-containing layer homologous with that of *Calliphora*. Unfortunately, sheets of this layer from the cockroach are not sufficiently robust to be examined by X-ray diffraction and infra-red absorption methods.

Turning now to the polyphenol layer of Wigglesworth's scheme, this is said to be formed as a discrete layer by the spreading and fusion of argentaffin droplets secreted at the tips of the pore canals[1,2]. But later the areas reducing ammoniacal silver nitrate are less prominent[3], and Wigglesworth's observations seem to permit the view that the argentaffin secretion may impregnate underlying layers in preparation for the hardening process. This is further suggested by the fact that these layers, when first laid down, do not give the argentaffin reaction[1,2], whereas at the time of moulting the test is positive before the general tanning of the cuticle begins. With regard to the nature of the argentaffin droplets it seems unlikely that a polyphenol is involved. The ferric chloride test is negative[9], and the argentaffin test is not specific for polyphenols. It has been shown in the cockroach cuticle[9] that, during preparation of the outer procuticle for tanning, a protein giving the argentaffin reaction is passed into a zone already occupied by a steroid, and it is suggested here that the 'polyphenol' secretion is a protein which similarly impregnates the sterol-containing cuticulin layer as a preliminary to the tanning process. Richards[8] admits the possibility that the polyphenol layer may be dispersed by, and modify, the underlying layers. In the view presented here, then, the polyphenol layer is not regarded as a constituent layer of the epicuticle.

To summarize, the insect epicuticle is regarded, in the light of our present knowledge, as basically comprising an innermost layer, the protein epicuticle, which during development of the cuticle is impregnated first by a steroid and then by an additional protein. It may then undergo quinone tanning to become the fully formed cuticulin layer described by Wigglesworth. The impregnating protein of the cuticulin layer may be secreted by the tips of the pore canals. Overlying the cuticulin layer is a very thin, chemically stable, paraffin-containing layer, the lipoid epicuticle. In some cuticles a cement layer may protect or be embedded in a wax or grease layer. In the accompanying table this view of the epicuticle is compared with that of Richards[8] and of Wigglesworth[1].

| Richards | Wigglesworth | Dennell and Malek |
|---|---|---|
| Tectocuticle | Cement layer | Cement layer |
| Lipoid epicuticle | Wax layer | Wax layer |
| Quertal | Polyphenol layer | Not recognized as a discrete layer |
| Lipoprotein layer | More resistant surface of cuticulin layer | Lipoid or paraffin epicuticle |
| Basal protein layer | Main mass of cuticulin layer | Protein epicuticle which may be impregnated with steroid and protein to form cuticulin layer |

We are indebted to Dr. K. M. Rudall for kindly making the X-ray diffraction and infra-red absorption observations for us. A more detailed account of the observations which form the basis of the views presented here will be given elsewhere.

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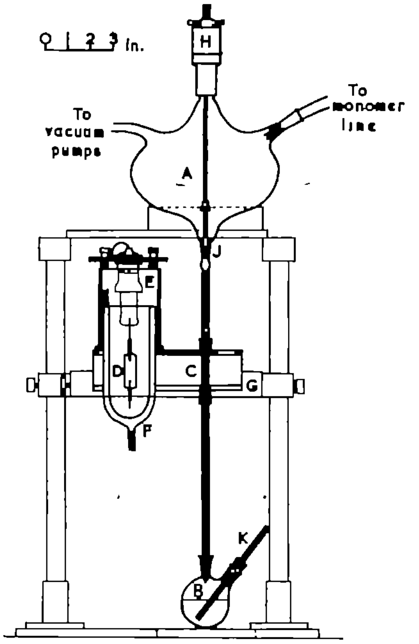
# LETTERS TO THE EDITORS

*The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications*

## A Flow Method for the Synthesis of 'Block' Copolymers

Two methods of synthesizing 'block' copolymers have been reported in a recent communication from these laboratories[1]. Whereas both these methods involve a static system, it has now proved possible to conduct a similar kind of synthesis using a flow technique. Polymer radicals derived from one monomer are introduced into a second monomer; their continued growth leads to the production of block polymer. The type of apparatus used for these experiments is shown in the diagram.



Monomer containing photo-sensitizer (1-azo-1-*bis*-*cyclo*hexanoic carbonitrile) flows down a vertical capillary (*C*) into a receiver (*B*). The rate of flow can be varied by means of a stainless steel valve (*J*) at the top of the capillary. Since oxygen is an inhibitor of vinyl-type polymerizations, all operations are carried out *in vacuo* and the valve is controlled externally from a vacuum-tight metal bellows attachment (*H*). Very high concentrations of free radicals (up to $10^{-4}$ mole/litre) are produced at any desired point inside the capillary by focusing into it a large proportion of the radiation from a 125-W. high-pressure mercury lamp (*D*). This is achieved by using an elliptical cylinder of stainless steel strip (*G*), highly polished on its interior surface to act as a reflector, the lamp being housed at one focus of the ellipse and the capillary at the other. The input rate, as determined by uranyl oxalate actinometry, is $2 \cdot 8 \times 10^{-7}$ Einsteins/sec. in the region of absorption by the sensitizer; the volume of liquid under illumination is only 0·03 ml.

In order to test the feasibility of introducing polymer radicals into the receiver, butyl acrylate was chosen as monomer since it has an unusually low rate coefficient for termination ($1 \cdot 8 \times 10^4$ litre mole$^{-1}$ sec.$^{-1}$ at 15° C.)[2]; at the rates of more than 100 per cent polymerization per hour inside the capillary, the life-time of the radicals is of the order of one second. The concentration of radicals attained inside the capillary depends on the length of the zone of illumination, the concentration of the sensitizer and the rate of flow of the monomer. It is essential in this method that the radicals emerging from the capillary should be dispersed immediately in the monomer contained in the receiver, thus increasing their life-time. Forced vibrations set up in a spring-steel strip (*K*) prove efficient for this purpose. Under these conditions the amount of polybutyl acrylate formed in the receiver is highly dependent on the number of radicals reaching it, namely, on the rate of flow and the distance of the mirror from the receiver. This may be seen from the accompanying table, in which $v$ is the velocity of the monomer, $P$ the concentration of polymer radicals at distance $d$ from the mirror, $F_1$, $F_2$ the calculated amounts of 'dead' polymer formed in the illumination zone and the capillary respectively, and $F$ the total amount of polymer formed.

| | | | | | |
|---|---|---|---|---|---|
| $v$ (cm./sec.) | 30 | 18·5 | 15·3 | 9·9 | 7·2 |
| $d$ (cm.) | 20 | 9 | 10 | 10 | 10 |
| $P \times 10^4$ (moles/lit.) | 0·42 | 1·0 | 1·4 | 2·2 | 2·5 |
| $F_1 + F_2$ (gm./lit.) | 0·04 | 0·07 | 0·15 | 0·48 | 0·83 |
| $F$ (calculated), gm./lit. | 0·75 | 1·29 | 1·91 | 2·45 | 3·25 |
| $F$ (obtained), gm./lit. | 0·9 | 1·12 | 1·95 | 2·5 | 3·4 |

The calculations are based on the theory of the non-stationary phase of chain reactions[3] and on general considerations of flow systems. It is possible to calculate $F_3$, the amount of polymer formed in the receiver; if a value of 40 sec. is assumed for the time required for polymerization in the system to cease, then the calculated values for $F$ are in agreement with those obtained from refractometric, measurements. The amounts of polymer formed in the system are given by:

$$F_1 = \frac{k_p}{k_t} . \ln \left( \cosh \frac{t_1}{\tau} \right), \quad F_2 = \frac{k_p}{k_t} . \ln \left(1 + k_t . P_M t_2\right)$$

$$\text{and } F_3 = k_p \int_0^{u} P . dt,$$

where $k_p$ and $k_t$ are the rate coefficients for propagation and termination, $t_1$ and $t_2$ are the times spent by the monomer in the zone of illumination and afterwards in the capillary, $\tau$ is the life-time of the radical in the stationary-state treatment, and $P_M$ is the maximum concentration of radicals attained in the system. The table also shows that $(F_1 + F_2)$ is much less than $F$, that is, most of the polymer radicals are terminated in the receiver and not inside the capillary. It should be possible to control the chain-lengths of the polymer radicals before they react with the second monomer, and the only restriction on the preparation of 'tailored' block polymers from a variety of monomer pairs is that the radicals from one monomer must react with the second monomer.

So far, two types of block polymer have been synthesized by this method. After running polybutyl acrylate radicals into styrene monomer, the polymer was isolated under such conditions that further thermal copolymerization was negligible. These runs were carried out at high rates of flow, so that the amounts of pure polybutyl acrylate formed and the percentage of this polymer in the block polymer were small. Ultra-violet analysis indicates a polystyrene content of approximately 72 per cent by weight.

The second type was made by running polyacrylonitrile radicals into styrene monomer, analysis indicating 76 per cent polystyrene in the product. It was soluble in chloroform only with difficulty. None of the turbidity usually associated with the heterogeneous polymerization of acrylonitrile was observed in the capillary. Since it has been demonstrated in a blank experiment that the polymer formed cannot be due to sensitizer radicals reaching the styrene, it appears that the initial stages of acrylonitrile polymerization may be homogeneous.

J. A. Hicks
H. W. Melville

Chemistry Department,
University of Birmingham. Nov. 10.

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[3] Burnett, G. M., *Trans. Farad. Soc.*, 46, 772 (1950).

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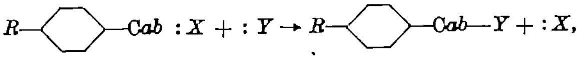
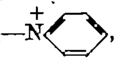
## Effects of Alkyl Groups in Nucleophilic Substitution

This communication refers mainly to the polar effects of alkyl groups in $S_N2$ reactions, in structural circumstances in which steric factors are absent. Rate comparisons showing the effects of methyl and *tert.*-butyl substituents are summarized in the accompanying table. Reactions (1) to (7) and (9) are of the type



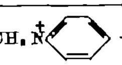
where $Cab—X$ is, for example, $CH_2$—hal., $CH_2—\overset{+}{N}$, CO—OEt, or CO—hal., and $:Y = \bar{I}$, $\bar{O}H$ or $\bar{O}R$ (the dots represent electrons). Reactions (1)–(6) are of the second order, being of the first order with respect to each of the reactants specified. In the solvolytic process (7), the reagent (ethanol) is in large excess and the reaction is of the first order. It is probable, however, that this change is also substantially bimolecular[1]. Reaction (9) is a first-order replacement at a saturated carbon atom under conditions especially conducive to a unimolecular mechanism[2]. It was included in order to obtain a comparison of the effects relating to the two main substitution mechanisms, $S_N2$ and $S_N1$. Reaction (8) is a second-order nucleophilic replacement; but it should be noted that, in contrast to the other changes, it occurs at an aromatic carbon atom.

The polar requirements of the unimolecular mechanism (reaction 9) are clear. The rate-determining process consists of the separation of the expelled group with the electrons of the $C—X$ bond, and it should be facilitated unconditionally by electron release to the reaction centre. Consistently, it is observed that the *p*-alkyl substituents in reaction (9) give rise to a large increase of rate. The results show that *p*-Me has a greater capacity for electron-release than *p*-Bu$^t$, and they thus confirm a previous demonstration of C—H hyperconjugation influences in suitably situated alkyl groups[3].

In the bimolecular mechanism, the polar requirements are not so clear-cut. In this single-stage process, bond formation occurs simultaneously with bond fission; and, while bond fission should, as before, be facilitated by electron-releasing alkyl groups, the approach of the nucleophilic reagent, which is necessary for bond formation, should be hindered by these substituents. The net result is a difference effect; and, while it is not possible in general terms to make a simple prediction of its direction, the magnitude of the effect of a given substituent in $S_N2$ reactions may be expected to be smaller than the corresponding influence in $S_N1$ replacements. In reactions (1)–(4), alkyl groups increase the rate of substitution; but in examples (5)–(8) these substituents decrease the rate. In all cases, the observed effects are considerably smaller than the corresponding influences in unimolecular substitution (reaction 9). In the first set of bimolecular processes, bond-fission requirements are dominant, and the facilitating electron-release effects from the methyl substituents are greater than those from the *tert.*-butyl groups. In the second set, bond-forming requirements are dominant and the (now inhibiting) electron-releasing power of Me is again greater than that of *t*-Bu. The rate sequence *p*-H > *p*-Bu$^t$ > *p*-Me has also been observed for the reaction of 2-nitrobromobenzenes with pyridine, and confirmatory results have been obtained for reaction (6)[4].

The results, as a whole, show that C—H hyperconjugation effects, which are available in the *p*-methyl derivatives but not in the *p*-Bu$^t$-compounds, are of importance in bimolecular nucleophilic substitution under the conditions used. It should be emphasized that, because of the marginal requirements of $S_N2$ reactions, coupled with the dual

Reaction Rates showing Polar Effects of Alkyl Groups
($k_2$ in sec$^{-1}$gm.-mol.$^{-1}$lit.; $k_1$ in sec.$^{-1}$)

| Reaction | Solvent | Temperature (° C.) | Rates for various *p*-substituents | | H | Me | Bu$^t$ |
|---|---|---|---|---|---|---|---|
| 1. $(p)R.C_6H_4.CH_2.Br + I^-$ | $Me_2CO$ | 0·0 | $k_2 \times 10^3$ | = | 2·89 | 4·23 | 3·92 |
| 2. $(p)R.C_6H_4.CH_2.Br + EtO^-$ | EtOH | 25·1 | $k_2 \times 10^4$ | = | 1·84 | 2·73 | 2·64 |
| 3. $(p)R.C_6H_4.CH_2.Br + Bu^tO^-$ | Bu$^t$OH | 60·0 | $k_2 \times 10^3$ | = | 3·75 | 5·03 | 4·46 |
| 4. $(p)R.C_6H_4.CH_2.Cl + EtO^-$ | EtOH | 25·1 | $k_2 \times 10^5$ | = | 3·72 | 5·85 | 5·45 |
| 5. $(p)R.C_6H_4.CH_2.\overset{+}{N}$ $+ EtO^-$ | EtOH | 20·0 | $k_2 \times 10^4$ | = | 4·01 | 2·02 | 2·77 |
| 6. $(p)R.C_6H_4.CO.OEt + OH^-$ | 85 per cent (wt.) EtOH—$H_2O$ | 25·1 | $k_2 \times 10^4$ | = | 7·18 | 3·13 | 4·42 |
| 7. $(p)R.C_6H_4.CO.Cl + EtOH$ | EtOH | 0·0 | $k_1 \times 10^5$ | = | 7·89 | 4·49 | 5·26 |
| 8. $(p)R.C_6H_2(NO_2)_2.Cl + EtO^-$ (2 : 6-dinitrochlorobenzenes) | EtOH | 50·0 | $k_2 \times 10^6$ | = | 14·7 | 2·59 | 4·55 |
| 9. $(p)R.C_6H_4.CH_2.Br + H_2O$ | $H.CO_2H$ | 25·1 | $k_1 \times 10^7$ | = | 3·68 | 213 | 103 |

behaviour of alkyl substituents, changes in experimental conditions (for example, temperature, solvent) may produce different rate sequences. Our extensions of these investigations will include a study of the Arrhenius parameters of the reactions under various experimental conditions, and we postpone further discussion of the effects until additional observations are available.

*Note added in proof* (*cf. ref.* 4). See *J. Amer. Chem. Soc.*, 74, 4940 (1952); because of differences in experimental conditions the absolute rate coefficients, for identical esters in the parallel investigations, are appreciably different, but the rate ratios, $p$-$R$/$p$-H, are in closer agreement.

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E. D. HUGHES
C. K. INGOLD

University College,
London, W.C.1. Oct. 23.

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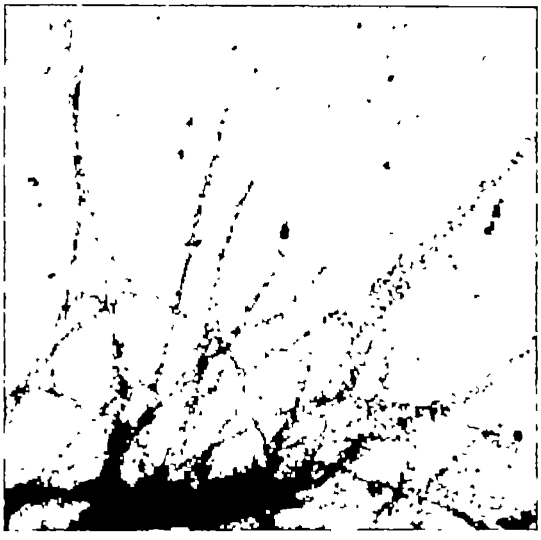
## Reticulin and Collagen

A RECENT letter by Little and Kramer[1] reporting some studies on reticulin prompts the submission of a preliminary account of some similar investigations now in progress. Attempts to determine the relation between collagen and reticular fibres using the electron microscope to examine teased-out or otherwise broken-down tissues are open to the criticism that the fibres observed are not histologically identifiable. Kramer and Little appear to have overcome this objection and to have reached the conclusion that the fibrils of reticulin have the same structure as collagen fibrils—a conclusion which the following experiments confirm.

The reticulin of adult rat and human spleens has been investigated using two different procedures. In the case of rat spleen, the method was to cut 10-μ frozen sections which were mounted on collodion films on fine stainless steel mesh, and then to digest these sections with pancreatin until only the fibrous elements of the connective tissue remained. After thoroughly washing and drying, suitable pieces of mesh were cut out, the specimens shadowed with palladium and examined in the electron microscope. Apart from the collapse of the material on to the film on drying, the fibrous network is very little disturbed, and reticulin could be identified as branching and anastomosing networks of fine fibres, quite distinct from the relatively massive bundles of collagen. In all cases the reticular fibres showed the same characteristic cross-banding as is shown, for example, by rat tail tendon, a true collagen.



Collagen fibres from human spleen capsule after silver impregnation. × 20,000

The human spleen material was treated differently. A fresh spleen was cut into slices of about 5 mm. thickness, well washed and then digested in pancreatin until only a fibrous network remained. A well-washed slice of this material was fixed in formalin, washed, dehydrated and finally embedded in a camphor-naphthalene medium. This was sectioned at 10 μ, the sections being mounted on collodion films on glass. The embedding material was removed by sublimation *in vacuo*—a process which minimizes disturbance of the fibres. Optical micrographs of these preparations were compared with those of ordinary histological preparations of spleen, silver-impregnated and stained with Van Gieson's fluid. From this comparison the reticular fibres in the collodion-mounted specimens were clearly identified, and these fields were examined in the electron microscope after palladium shadowing. Again the reticular fibres show precisely the same banded structure as does true collagen obtained by teasing the splenic capsule.

It seems, therefore, beyond doubt that the fibres of reticulin are morphologically identical with those of collagen. This does not necessarily imply that the two kinds of fibre are identical in all respects. Indeed, their responses to the Bielchowsky–Foot silver impregnation technique are markedly different and remain to be explained. This phenomenon of argyrophilia is at present under investigation. The accompanying photograph is of human spleen capsule fibres teased out after Foot silver impregnation, and shows that the metal is deposited as particles of colloidal dimensions on the fibres, and is not a chemical combination with them. It would appear that silver staining is an interface phenomenon occurring at the fibre – ground substance boundary, and may depend more upon variations of the latter than on differences in the fibres.

These studies are continuing and will be published fully elsewhere.

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Nov. 17.

[1] Little, K., and Kramer, H., *Nature*, 170, 499 (1952).

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## Photo-Insolubilization of Dextran

THE insolubilization of many dichromate-sensitized protein dispersions, notably albumins, gelatins, etc. after exposure to light, is well known and is the basis of most photo-engraving procedures[1]. Polysaccharides, such as starch and gum acacia, and polysaccharide derivatives such as methyl cellulose and, more recently, surface-hydrolysed cellulose esters[2], similarly become insoluble when exposed to light in the form of thin, dry films.

It has been shown recently in these laboratories that dextran, a poly-glucose obtained by the fermentation of sucrose by a number of organisms, more particularly *Leuconostoc* species, also exhibits photo-insolubilization, a property which is very clearly demonstrable with the water-soluble dextran produced by the *L. mesenteroides* organism described by Stacey and Swift in 1948[3]. Degradation of the macromolecule[4] produces nitrogen-free fragments which can be separated into homologous polysaccharide fractions of differing molecular sizes. It has been shown that these degraded polysaccharides are also capable of being photo-insolubilized, and the interesting discovery has been made that there appears to be a relationship between molecular size (expressed in terms of viscosity) and light sensitivity.

In general, preparations with molecular weights in excess of one million show a greater speed of insolubilization as compared with preparations having molecular weights of less than 500,000. Preparations with mean molecular weights in the region of 300,000 show rates of insolubilization comparable with the proteins conventionally used in photo-mechanical processes. Variation of dichromate concentration does not appear to affect the rate of insolubilization, that is, the general sensitivity of these dextrans, to any marked degree.

After heating for two minutes at an optimum temperature of 250° C., the insoluble image has been found to be resistant to etching acids.

A more detailed account of this development will be published elsewhere.

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Sept. 3.

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## Effects of some Chelate Compounds upon the Formation *In vitro* of Melanin

It is said that cupric ions accelerate the autoxidation of 3,4-dihydroxyphenylalanine (dopa)[1] and, on the other hand, that they combine with pterins, riboflavin, amino-acids and other organic substances to form chelate complexes[2]. We have therefore carried out some experiments to investigate the behaviour of metal-bound pterins and riboflavin in relation to the rate of oxidation of dihydroxyphenylalanine.

Fig. 1 gives the results of manometric measurements indicating that the oxidation of dihydroxyphenylalanine is much more highly accelerated by the presence of both folic acid and cupric sulphate than by the presence of the latter alone, while folic acid itself appears to have no effect. The rate of blackening of the solution appears to be higher than that due to oxygen uptake, in the presence of both substances. Xanthopterin behaves similarly, and is more active than folic acid in the presence of cupric ions, whereas leucopterin does not accelerate the oxidation even if accompanied by cupric ions.

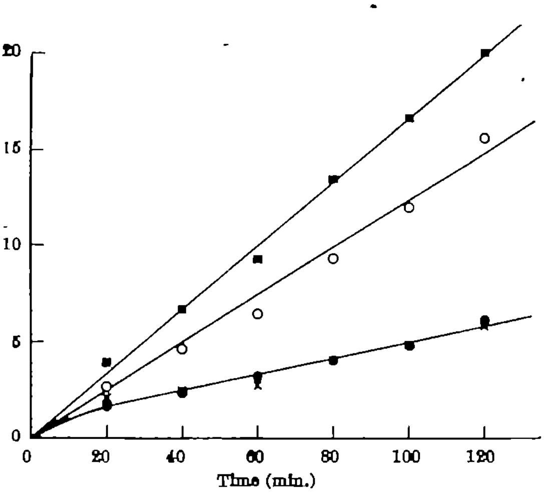

Fig. 1. Acceleration of oxygen uptake by dihydroxyphenylalanine due to the chelate compound of folic acid and cupric ions (pH 7·8, 37·5° C.).
—●—, 0·5 c.c. of $M/15$ phosphate buffer solution and 1·8 c.c. of distilled water in the main chamber.
—×—, 1 c.c. of distilled water in the first preparation replaced by 1 c.c. of 80 mgm. per cent folic acid suspension.
—○—, 0·5 c.c. of distilled water in the first preparation replaced by 0·5 c.c. of $10^{-3}$ $M$ cupric sulphate solution.
—■—, 1·5 c.c. of distilled water in the first preparation replaced by 0·5 c.c. of $10^{-3}$ $M$ cupric sulphate solution and 1 c.c. of 80 mgm. per cent folic acid suspension.
Each of the side arms of the manometric flasks contained 0·5 c.c. of 60 mgm. per cent solution of dihydroxyphenylalanine, which was transferred into the main chamber at 0 hr. Each of the wells contained 0·3 c.c. of 10 per cent solution of potassium hydroxide

These results suggest that pterins, when they form chelate compounds with certain metals, behave like enzymes in accelerating the autoxidation of dihydroxyphenylalanine, their activities being different according to structures of their rings. In this connexion, the investigations of E. L. Smith[3] were of much interest to us, for they interpret enzymic activities by rather simple principles which fundamentally are based upon the chelation of organic substances with metallic ions.

Riboflavin, the photodynamic accelerator of the autoxidation of dihydroxyphenylalanine[4], is also known to form larger complexes by capturing

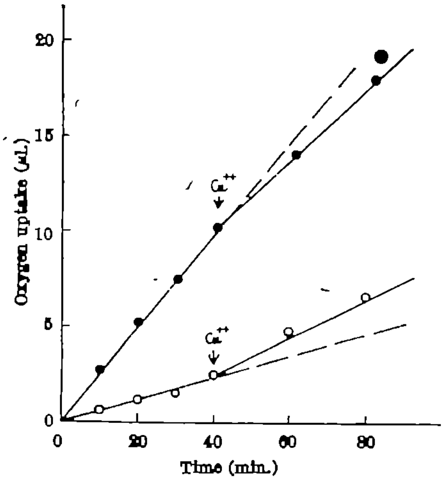

Fig. 2. Effect of riboflavin on oxygen uptake by dihydroxyphenylalanine, before and after the addition of cupric ions, under irradiation with a 200-W. tungsten lamp (pH 7·8, 37·5° C.).
—○—, 1 c.c. of 60 mgm. per cent solution of dihydroxyphenylalanine, 0·5 c.c. of $M/15$ phosphate buffer solution and 0·8 c.c. of distilled water in the main chamber.
—●—, 0·5 c.c. of distilled water in the first preparation replaced by 0·5 c.c. of $10^{-4}$ $M$ solution of riboflavin.
Each of the side arms of the manometric flasks contained 0·5 c.c. of $10^{-3}$ $M$ solution of cupric sulphate, which was transferred into the main chamber 40 min. after the beginning of measurement. Each of the wells contained 0·3 c.c. of 10 per cent potassium hydroxide

metallic ions[3]. We therefore examined this substance before and after it was mixed with cupric sulphate. Our results show a sharp contrast to those given by pterins. As Fig. 2 shows, the accelerating effect of riboflavin was much hindered by the addition of cupric ion which, if added independently, could accelerate the oxidation to a certain extent. A mixture of riboflavin and copper also showed less degree of acceleration than that of riboflavin alone. We believe that this may be due to the decrease of photodynamic activity of riboflavin, which was found previously to be proportional to the intensity of fluorescence[4], for we found that contact with the metal resulted in a considerable weakening of the fluorescence from riboflavin.

Another example of the effect of chelation may be mentioned. Zinc ion is the only metallic ion reported to accelerate the conversion of dopa-chrome (red substance) to leuco-substance—the second step in the formation of melanin[5]. This can be confirmed in Thunberg tubes. We prepared dopa-chrome by adding sodium hydroxide to dihydroxyphenylalanine. After neutralizing with hydrochloric acid, we put it into a Thunberg tube, de-aerated and mixed it with zinc sulphate at $p$H 6·8. The red colour disappeared gradually. Now, if xanthopterin was added to this system, the time of decolorization was prolonged somewhat. This again may be attributed to the capture of the metallic ion by xanthopterin, for the latter alone could have little effect upon this step.

Further details of our investigations will be published elsewhere.

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## Stepwise Degradation of Polypeptides from the Carboxyl End

Many methods have already been described for the selective degradation of peptides from the carboxyl end[1]. However, the several chemical steps involved in those procedures do not allow their utilization on a micro-scale. Linstead, Shephard and Weedon[2] have recently published a study on the decarboxylation of α-N-acylamino-acids in alcoholic media by anodic oxidation into alkoxyalkylamides (acylaminoethers), with a 74–91 per cent yield.

We applied the same anodic oxidation on a micro-scale to N-acyl derivatives of polypeptides (1 cm.$^3$ of 0·1 per cent solution in methanol; platinum electrodes of 1 cm.$^2$ total surface area, 3 mm. apart; 200–250 volts, D.C.; 50–150 m.amp.; 10–30 min.; 0° C.). The initial amino-acid of the acylated peptide (I) is decarboxylated into (II):

$$\begin{tikzcd} \underset{\text{(I)}}{X\text{—NH.CH}R'\text{.CO—NH.CH}R\text{.CO}_2\text{H}} \arrow[r] & \underset{\text{(II)}}{X\text{—NH.CH}R'\text{.CO—NH.CH}R\text{.OCH}_3} + \text{CO}_2 \arrow[d, "\text{HCl}"] \\ \underset{\text{(IV)}}{X\text{—NH.CH}R'\text{.OCH}_3} + \text{CO}_2 & \underset{\text{(III)}}{X\text{—NH.CH}R'\text{.CO}_2\text{H}} + \text{NH}_3 + R\text{.CHO} + \text{CH}_3\text{OH} \arrow[l] \end{tikzcd}$$

The initial amino-acid no longer appears on a paper chromatogram of the hydrolysis products of (II). If (II) is heated for a short time with dilute aqueous hydrochloric acid, the methoxyalkylamide is hydrolysed into (III). After evaporation to dryness *in vacuo* and re-dissolution in dry methanol, (III) is decarboxylated by a new anodic oxidation into (IV). The spot of the second amino-acid is no longer detectable on a chromatogram of the hydrolysis products of (IV).

By this simple method, which involves only manipulations easily carried out on a micro-scale, polypeptides were degraded stepwise from the carboxyl end, and the sequence of amino-acids was determined by their successive disappearance on chromatograms after hydrolysis.

We found that Sanger's dinitrophenyl derivatives of peptides may also be submitted to carboxyl anodic oxidation. Thus, time and material are saved by combining Sanger's method for the determination of the amino terminal amino-acid with our new method for the determination of the carboxyl terminal amino-acid.

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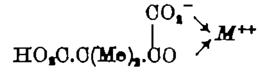
## Metal Ion Catalysis of the Decarboxylation of Oxalo-Acetic Acid

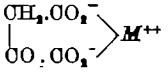
In order to explain the catalysis of oxalo-acetic acid decarboxylation by metal ions, intermediate complex formation between the metal ion and the acid anion has been postulated. In an attempt to determine the nature of this complex, Steinberger and Westheimer[1] studied the kinetics of the decarboxylation of the dimethyl substituted acid. In this way they showed that the catalysis did not proceed through an enolic form of the acid. From a further consideration of the general characteristics of decarboxylation reactions, they suggested that the metal complex involved in the catalysis had the formula, $MA$, which was formed from $MHA^+$, by the loss of a proton.

$MHA^+$



$$\text{HO}_2\text{C.C(Me)}_2\text{.CO—CO}_2^- \rightarrow M^{++}$$

$MB$



$$\text{CH}_2\text{.CO}_2^- \text{—CO.CO}_2^- > M^{++}$$

Pedersen[2] examined the catalytic decarboxylation of the parent acid in greater detail. He obtained, from kinetic data, a stability constant of $10^4$ for the formation of a cupric complex of the acid, and suggested that this complex was of the same kind as

*MA*. Now *MA* is a complex of an α-keto acid, and another complex, *MB*, could also have been formed. The latter is a complex of a dicarboxylic acid. The measurement of the stability constants for the formation of both types of complex together with the observation of Pedersen might then be used for describing in more detail the suggested mechanism of the catalysis. The data for the dicarboxylato-complexes are available from the literature, and we have measured the stability of the complexes of pyruvic acid in order to make this comparison (see table).

LOGARITHM OF THE STABILITY CONSTANTS OF CERTAIN METAL COMPLEXES

| Ligand | $pk_1$ | $pk_2$ | log $K_{Cu}$ | log $K_{Zn}$ | Ref. |
|---|---|---|---|---|---|
| Malonic acid | 2·86 | 5·70 | 4 80 | 3·68 | 7 |
| Succinic acid | 4·19 | 5·48 | 3·33 | 2·70 | 7 |
| Oxalo-acetic acid | 2·30 | 3·88 | 4·00 | — | 2 |
| Tartaric acid | 2·88 | 3 94 | — | 2·68 | 8* |
| Acetic acid | 4·75 | — | | 1·57 | 7 |
| Glycollic acid | 3·71 | — | — | 1·92 | 8* |
| Pyruvic acid | 2·35 | — | 2·50 | 2·10 | |

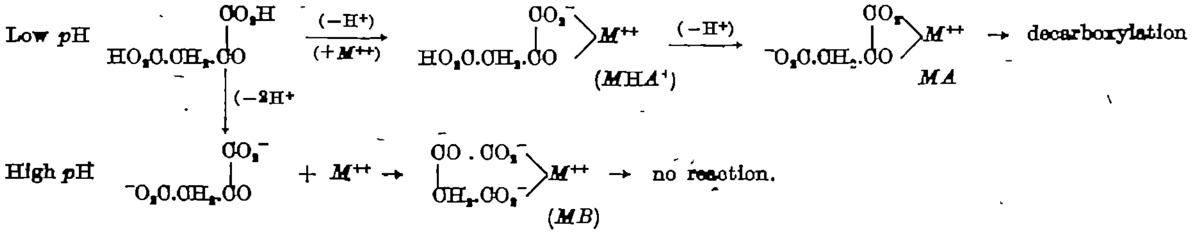
* Measured at ionic strength 0·2.

The data show that the stability constants of both the zinc and the cupric complexes of dicarboxylate anions have considerably larger values than those of the pyruvates. The value Pedersen[2] obtained is much nearer the former, and this might suggest that his complex constant referred to the formation of a complex of formula *MB*. However, the formation of the two complexes $MHA^+$ and *MB* is controlled by the *p*H such that the relative amounts of each are given by :

$$\frac{[MHA]}{[MB]} = \frac{K_1.[H]}{K_2.k_2}, \qquad (1)$$

where $K_1$ and $K_2$ are the stability constants for the formation of the complexes $MHA^+$ and *MB* respectively, and $k_2$ is the second acid dissociation constant of oxalo-acetic acid. From the data in the table and equation (1), the two different complexes might be expected in equal amounts at about *p*H 2·0–3·0. Below this *p*H the complex $MHA^+$ would predominate. It is to be expected that *MA* will only form in the *p*H range in which *MHA* is formed rather than *MB*. Now *MA* will have a different stability constant, $K_3$, from $MHA^+$ or *MB*, such that $K_3 = \frac{K_1.k_3}{k_2}$, where $k_3$ is the acid dissociation constant of $MHA^+$. As $k_3 < k_2$, Pedersen's constant, $K_3$, would be expected to be greater than $K_1$—as is found—and the determination of stability constants does not discriminate between *MA* and *MB*.

At higher *p*H values the formation of *MA* or *MB* need not proceed through $MHA^+$, and either one of the two complexes will be formed, depending only upon their relative stability. It is to be anticipated that *MB* will be the more stable, and the formation of this complex would account for the absence of catalysis at higher *p*H values[5]. The complete reaction scheme would then be :



The rate of some other catalysed hydrolyses have somewhat similar features to the above decarboxylation[4]; but it is of particular interest that the catalysis of many enzymatic reactions is similar to that described[5], and in particular that this catalysis also goes through a maximum with *p*H. The recent work of Albert[6] has illustrated further the importance of the formation of two different complexes from the same ligand and metal ion.

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## Newton's Work on Geometrical Optical Aberrations

IN Newton's "Opticks" (editions of 1704, 1717 and 1721 and the subsequent editions and translations, so far as we have been able to ascertain) an erroneous condition is given for the proportion α of the radii of a symmetrical thin triplet (the inner lens being of water) in order to correct the system for spherical aberration for distant objects. Calling the curvature of the first and second surface $R_1$ and $R_2$ respectively, the formula gives $\alpha^3 = (R_1/R_2)^3 = (KK-KI)/(RK-RI)$, where $R/I = n_g$, the refractive index of the two outer (glass) lenses, and $R/K = n_w$, the refractive index of the inner (water) lens. The fraction can be simplified to $K/R$, and gives a large amount of under-correction.

No indication is left of the deduction of the condition. The correct and complete form is : $a\alpha^3 + b\alpha^2 + c\alpha + d = 0$, where $a$, $b$, $c$ and $d$ are functions of a high degree in $n_g$ and $n_w$. This form cannot by any reasoning be simplified to a cube root condition for α.

By means, however, of an unwarranted application of the formula for the spherical aberration of a single spherical surface for a parallel incident pencil, as given by Newton in "Lectiones Opticæ", I, Prop. 31, a curious result is obtained. When we transfer the angular aberration of the first surface to the image space by multiplication by $(n_g/n_w) . (n_w/n_g) . (n_g/1)$, doing the same for the aberration of the second surface with the factor $(n_w/n_g) . (n_g/1)$, for the third surface with the factor $n_g/1$, and adding the contributions of the four surfaces, we get the condition for the correction of spherical aberration :

$$\alpha^3 = (n_g - n_w)\,(n_g^4 + n_w^4)/(n_g - 1)\,(n_g^4 + 1)n_w^2.$$

Within the range of refractive indices for glass in Newton's time, it appears that the factor $(n_v^4 + n_w^4)/(n_v^4 + 1)n_w^2$ is practically constant and equal to $1/n_w$. Thus the condition for $\alpha$ can be written: $\alpha^2 = (n_v - n_w)/n_w(n_v - 1) = (\underline{KK} - \underline{KI})/(RK - KI)$. With the value of $\alpha$ following from it, the spherical aberration, indeed, is considerably reduced—to about 0·6 that of a single lens of best form (to reduce spherical aberration).

If this, indeed, was originally meant by Newton, only one letter in the formula had been erroneously printed; that the error is present in each edition can be explained by the fact that Newton had no interest in this condition on account of the chromatic aberration, which, according to him, was always present and larger, and which led him to the construction of a reflecting telescope.

Each of the letters of the original formula has been changed into one of the other possible letters; but the change as given above is the only one which leads to a better correction.

It was further ascertained that the correction outside of the axis for distant objects by means of a symmetrical thin ('cemented') triplet is always much worse than for a single lens of approximately convex-plane form, at least unless enormous amounts of spherical aberration are being introduced. This means that the Scholium to Prop. 98 of the first book of the "Principia" is either incorrect or refers to a non-symmetrical triplet.

It would be worth while, we think, to look into what is left of Newton's papers and letters to see if there is any indication that he had worked in this direction.

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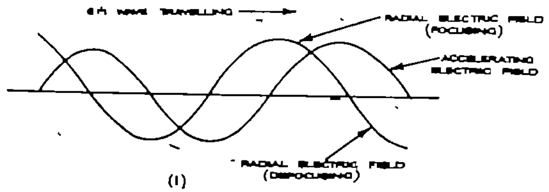
## A Heavy-Particle Accelerator

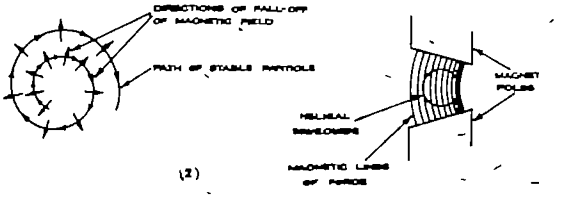
A method of overcoming the defocusing effect of the electromagnetic wave in the Walkinshaw heavy-particle accelerator[1] has been suggested by Chick and Petrie[2]; an alternative solution to the problem is here proposed.

If the stable position for the particle bunch on the travelling wave could be made to lag in phase from the normal position by an angle between 90° and 180°, it would then be in a region of focusing instead of defocusing radial forces[3,4] (Fig. 1). For stability in this region, however, it is necessary that a particle which loses energy shall gain in phase on the electromagnetic wave, and vice versa. It is suggested that this can be achieved by introducing a constant magnetic field gradient across the helical guide, the axis of which should then be made to take the form of a spiral in the plane perpendicular to the magnetic field, the dimensions depending upon the magnetic field-strength and the rate of acceleration (Fig. 2).

A particle with an excess or deficit of energy will then leave the equilibrium orbit and pass into a region of lesser or greater magnetic field-strength. In the non-relativistic region, therefore, the angular velocity of a particle with an excess of energy can be made less than that corresponding to the stable orbit and vice versa (Fig. 3).


Wave travelling
Radial electric field (focusing)
Accelerating electric field
Radial electric field (defocusing)

(1)



(2)

The above mechanism will be modified by the presence of the radial electric focusing forces, which are the differential of the accelerating field. Phase stability will therefore be dependent upon both the magnetic field and the accelerating field.

It may be shown that phase stability exists if:

$$n > \frac{\pi r_s^2}{2\lambda_g E} F_s \cos\theta_1,$$

where $n = \frac{r_s}{H_s}\frac{dH}{dr}$; $r_s$ is radius of stable orbit; $\lambda_g$ is wave-length of accelerating field in the guide $\left(= \frac{v}{c}\lambda_a\right)$; $\lambda_a$ is wave-length of accelerating field in air; $v$ is velocity of particle; $c$ is velocity of light; $E$ is kinetic energy of the particle; $F_s$ is maximum value of electric accelerating field multiplied by charge on the particle; $\theta$ is phase angle defined as $\theta = 0$ for zero accelerating field. It may also be shown that radial-focusing exists if:

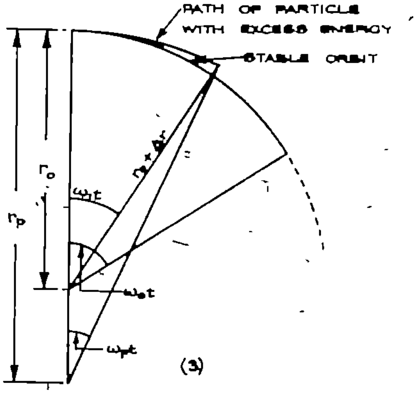
$$n - 1 < \frac{\pi r_s^2}{2\lambda_g E} F_s \cos\theta_2.$$

The phase angle over which particles will be captured will be $\theta_{1\max} - \theta_{1\min}$, where

$$\theta_{1\max} < \cos^{-1}\frac{2\lambda_g E}{\pi r_0^2 F_0}(n - 1);$$

$$\theta_{1\min} > \cos^{-1}\frac{2\lambda_g E}{\pi r_0^2 F_0}\, n.$$

From this it can be seen that $n$ may be made greater than 1 by reducing $\theta_{1\max}$.



(3)

$r_p\omega_p$ = velocity of particle.

Phase stability if, for $v_p/v_s > 1$, $d\omega_1/dt$ is negative, and $v_p/v_s < 1$, $d\omega_1/dt$ is positive

Since $\frac{\lambda_0 E}{r_0^2} \propto H_0^2$, we have $H_0^2 \propto \frac{1}{n-1}$,

and $H_0$ will therefore be smaller for larger values of $n$; from which it follows that the separation between successive revolutions will be greater for larger $n$. Advantage might have to be taken of this in a practical design to avoid the injector on the second revolution.

Using available figures[1,2] as typical operating conditions, we find for protons: injection energy, 2 MeV.; radio-frequency, 300 Mc./s.; $F_0$, 25 keV./cm.; $n$, 1; $r_0$, 20 cm.; $H_0$, 10 k.gauss; $\theta_{\text{max.}} - \theta_{1\text{min.}}$, 90°; energy gain in first revolution, 3 MeV. approximately; distance between first and second orbits, 12 cm. approximately. For $n = 1$, $\theta_{\text{max.}} = \pi/2$, so that the phase stability condition becomes dominant. Hence, for a constant value of $\theta_{1\text{min.}}$ and $n = 1$, $H_0$ will vary along the stable orbit as $E^{-1/4}$. Thus orbit separation may be increased as acceleration proceeds. Following the reasoning adopted by Thomas[5], the focusing and defocusing effects of so reducing the magnetic field along the stable orbit should cancel.

I wish to acknowledge the help I have received from discussions with members of the Radiotherapeutic Research Unit, in particular P. H. Flanders, during the preparation of this communication.

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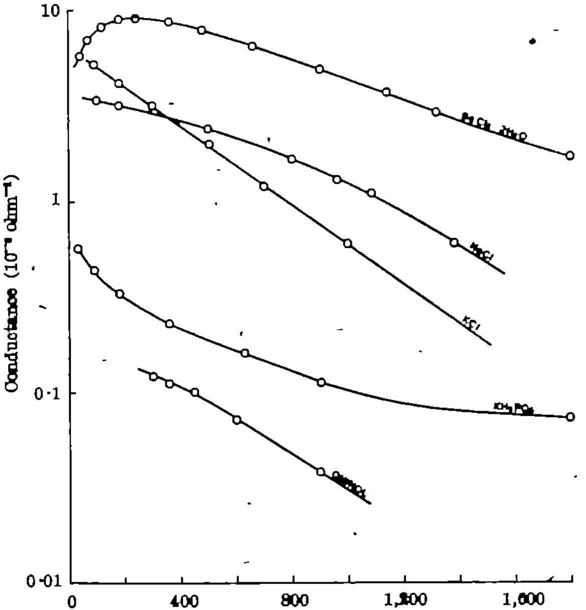
## Electrical Conductivity of Certain Crystalline Materials after Grinding

IT was recently reported[1] that quinol shows a large increase in low-frequency dielectric loss on grinding. The effect is temporary and decreases with time. It has now been found that this phenomenon is more general and occurs with many inorganic salts and some crystalline organic compounds.

In these materials the dielectric properties of the lightly pressed crystals before grinding are such that the loss factor increases with decreasing frequency and ultimately rises in proportion to $1/f$ (where $f$ is frequency); it is assumed that the loss factor in the latter region is entirely due to D.C. conduction. On grinding, the magnitude of the low-frequency dielectric loss factor increases at all frequencies, often by as much as a factor of 1,000.

The experiments were performed with electrodes in the form of bevelled brass pistons surrounded by a polystyrene cylinder, which enabled the grinding and measurement to be carried out in rapid sequence in a controlled atmosphere. The A.C. conductance at a particular frequency was measured as a function of time.

The results for four inorganic salts and for quinol, dried for several weeks over calcium chloride and then ground in air over calcium chloride, are given in the accompanying graph. Smaller effects were observed with urea, copper sulphate and resorcinol; and other compounds, such as sugar, paraffin wax and 4:4′-dihydroxy-diphenyl, gave no measurable effect.



Effect of grinding on the conductance of various crystalline materials at 16 kc./s.

Values of conductance before grinding ($10^{-8}$ ohm$^{-1}$): $BaCl_2.2H_2O$, 0·16; $KH_2PO_4$, 0·023; NaCl, 0·017; KCl, 0·005; quinol, 0·004

Several grinding experiments were performed with these electrodes in a vessel which could be evacuated or filled with any desired atmosphere. It was observed that the rate at which the A.C. conductance decreased, following the initial increase on grinding, was more rapid the lower the relative humidity of the surrounding atmosphere. Also, the equilibrium value of the A.C. conductance was less the lower the relative humidity. At pressures below about 5 mm. of mercury, no increase in A.C. conductance was observed on grinding. Moreover, if the increase had already been produced by grinding in a normal atmosphere, it was eliminated by evacuation.

The effect was not present in sodium or potassium chloride, or in quinol which had been thoroughly dried by heating and then ground in an atmosphere over phosphorus pentoxide. Even when such thoroughly dried materials were ground in the laboratory atmosphere, the increases in conductivity were small. On prolonged exposure to the laboratory atmosphere, the return to the state giving a large grinding effect was comparatively slow, particularly with sodium chloride.

The results of this work suggest that the low-frequency dielectric properties of these materials before grinding arise from the presence of highly conducting regions at the crystal surfaces due to adsorbed layers of water. Also, there is some water (or solution) held in the crystals, possibly in small cracks, which, on being released by grinding, distributes itself over the freshly created surfaces. The water present on these surfaces in excess of that in equilibrium with the surrounding atmosphere then evaporates, resulting in a decrease in the D.C. and A.C. conductances.

In connexion with these results, extensive experiments on the adsorption of gases on sodium chloride have been carried out by Durau[2], who found that prolonged heating was necessary to remove the last traces of water.

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## Infra-Red Spectra of Coals and Coal Products

I WAS interested to read the comments of Gordon and his collaborators on the infra-red spectra of coal[1]. The spectral range of our earlier work[2] was limited to 1,000–10,000 cm.$^{-1}$, because our first thin sections were mounted on fluorite plates with a transmission limit of 1,000 cm.$^{-1}$. Later work, as yet unpublished[3], using the 'Nujol' dispersion technique[4], extended the spectra of coals to 650 cm.$^{-1}$, the limit of the rock-salt prism spectrometers used.

Spectra of eighteen samples of bright coals (that is, mainly vitrain) of varying rank from Warwickshire, Northumberland, Yorkshire and South Wales were recorded. Humic acids, and pyridine and aniline extracts from several of the coals, were also examined. Most of the strong absorption bands were assigned to specific chemical groups present in the coal structure. The results and major conclusions are briefly summarized here.

The general level of absorption intensity was constant for the lower-rank coals. The general absorption intensity was higher for a coking coal and very much higher for a low-volatile steam coal. Gordon's spectrum of an anthracite[1] is almost devoid of structure except at the low-frequency end. Graphite examined in 'Nujol' at the same path-length as used for the coals was completely opaque from 5,000 cm.$^{-1}$ to 650 cm.$^{-1}$. A 'Nujol' dispersion c. 2 μ thick showed a continuous structureless absorption of 70–80 per cent over this spectral range. This marked increase in general absorption for the high-rank coals can be correlated with the development of optical anisotropy[5], and with orientation and growth of crystalline regions found in X-ray diffraction studies[6]. It seems to mark the beginning of a transition from an aromatic structure (see below) towards a graphite-type structure.

The general similarity in the spectra of coals of all ranks examined (except anthracite[1]) suggests that the molecular skeleton remains practically unchanged. As one might expect from the decrease in oxygen content with increase in rank, bands which can be assigned to oxygen-containing groups (OH, C=O, C—O—, etc.) decrease in intensity with increase of rank. The main absorption assigned to the C—O— stretching-frequency occurs in the region of 1,250 cm.$^{-1}$, suggesting that the OH groups are mainly phenolic rather than aliphatic hydroxyl.

The molecular structure seems very complex, but the C—H and —C=C— stretching frequencies, and the CH out-of-plane deformation frequencies near 880, 820 and 750 cm.$^{-1}$, when correlated with the spectra of a large variety of aromatic compounds[7], indicate the presence of both single ring and condensed aromatic structures. Aliphatic CH$_2$- and CH$_3$-groups can be detected. Two carbonyl frequencies have been found; the stronger, near 1,690 cm.$^{-1}$, probably arises from aldehyde or keto-groups, while the second, near 1,730 cm.$^{-1}$, suggests the presence of a smaller proportion of ester groups.

For a low-rank coal, the spectrum of the material extracted by pyridine was practically identical with that of the parent coal.

A study of the hydroxyl frequencies in the spectra recorded suggests that hydrogen bonding between hydroxyl groups is one of the factors determining the physical structure of coals. Orchin and Storch[8] have postulated a hydrogen-bonded structure for coal, following their work on solvent extraction. Dryden[9] has briefly discussed the significance of the spectroscopic results and the part played by hydrogen bonding in the solvation of coals.

The humic acid spectra were clearly different from those of the parent coals, and had features in common with graphitic acid and mellitic acid (hexacarboxybenzene).

As Gordon *et al.* have noted[1], pitch extracts exhibit spectra bearing a remarkable resemblance to the coal spectra. Hadži[10] has studied the spectra of a variety of coal and tar extracts and has identified chemical groupings also found in the coal spectra.

The results summarized above, which were obtained several years ago, will be published in detail elsewhere.

I am indebted to Prof. G. B. B. M. Sutherland for his guidance during the course of this work, and to the late Dr. D. H. Bangham for his interest and encouragement. Thanks are also due to Prof. R. G. W. Norrish for facilities kindly provided in the Laboratory of Physical Chemistry, Cambridge. The research was sponsored by the British Coal Utilization Research Association and permission to publish this work is gratefully acknowledged.

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Nov. 11.

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## A Trigonometric Series used in Physical Problems

IN connexion with a boundary-value problem in room acoustics, we were led to consider the following trigonometric series. It has been noted further that certain other trigonometric series encountered by K. S. Krishnan[1,2] and L. S. Goddard[3] in different physical situations can be obtained as special cases of the above series.

The series concerned is:

$$\sum_{n=1}^{\infty} \frac{\sin(n+\theta)x}{n+\theta} \cdot \frac{\sin(n+\varphi)x}{n+\varphi} = A(\theta,\varphi;\ x), \text{ say,}$$

$$0 < x < \pi,$$

and $A(\theta,\varphi\,;\,x)$ can be expressed as

$$\frac{1}{2}\,\frac{\cos(\theta-\varphi)x}{\theta-\varphi}\,[\psi(1+\theta)-\psi(1+\varphi)]+$$
$$\frac{1}{2}\,\frac{\cos(\theta-\varphi)x}{\theta-\varphi}\,[c(\theta,2x)-c(\varphi,2x)]+$$
$$\frac{1}{2}\,\frac{\sin(\theta-\varphi)x}{\theta-\varphi}\,[s(\theta,2x)+s(\varphi,2x)],$$

where

$$\psi(x)=\frac{\Gamma'(x)}{\Gamma(x)},\quad c(\theta,x)=\sum_{n=1}^{\infty}\frac{\cos(n+\theta)x}{n+\theta},$$
$$s(\theta,x)=\sum_{n=1}^{\infty}\frac{\sin(n+\theta)x}{n+\theta}.$$

The transformations for $c(\theta,x)$ and $s(\theta,x)$ were obtained by G. H. Hardy[4].

Putting $\theta=\varphi$ and taking the sum of $A(\theta,\theta\,;\,x)$ and $A(-\theta,-\theta\,;\,x)$, one obtains the result (Krishnan, *loc. cit.*):

$$\sum_{n=-\infty}^{\infty}\frac{\sin^2(nx+\alpha)}{(nx+\alpha)^2}=\frac{\pi}{x}.$$

Putting $\theta=-\varphi=\alpha m$ ($\alpha>1$, $m=1,2,3\ldots$) and $x=\pi/\alpha$, one obtains (Goddard, *loc. cit.*):

$$\sum_{n=1}^{\infty}\frac{\sin^2(n\pi/\alpha)}{n^2-\alpha^2m^2}=0.$$

The corresponding series involving the cosines, namely,

$$\sum_{n=1}^{\infty}\frac{\cos(n+\theta)x}{n+\theta}\cdot\frac{\cos(n+\varphi)x}{n+\varphi}=B(\theta,\varphi\,;\,x),\text{ say,}$$

can also be treated in the same manner.

The last series can be used to obtain the result

$$\sum_{n=-\infty}^{\infty}\frac{\cos^2(nx+\alpha)}{(nx+\alpha)^2}=\left(\frac{\pi}{x}\right)^2\left[\operatorname{cosec}^2\left(\frac{\pi x}{\alpha}\right)-\frac{x}{\pi}\right].$$

The details of the calculations and certain other results will be published elsewhere.

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## Multiple Meson Production

It has recently been reported by Daniel *et al.*[1] that in high-energy collisions between nucleons, besides π-mesons, some heavier mesons of about 1,300 $m_e$ mass are also created. The purpose of the present note is to estimate the theoretical probability of emission of a heavy meson in a collision process, using the statistical theory developed by Fermi[2]. The collision is studied in the centre-of-mass system of the particles and it is assumed that the total energy $W$ ($W$ is the energy in the centre-of-mass system) is suddenly released in a small volume,

$$\Omega=\frac{4\pi}{3}(\hbar/\mu c)^3\,2Mc^2/W,$$

surrounding the nucleons ($M$ = mass of the nucleon, $\mu$ = mass of π-meson). One then calculates statistically the probability that a certain number of mesons are created.

On a suitable modification of Fermi's results, we find that the probability, $P(s,n)$, of two nucleons, $s$ heavy mesons (of mass $K$) and $n$ π-mesons being present in the final state of collision, is given by:

$$P(s,n)=\frac{8\cdot5}{(2+s)^{s/2}}\,\frac{(29\cdot3/\omega)^{s/2}}{\{(6n+3s+1)/2\}!}\,.$$
$$\left\{\frac{6\cdot31}{\omega^{1/3}}\left(\omega-2-\frac{2}{3}s\right)\right\}^{3n+\frac{3}{2}s+\frac{1}{2}}\exp\left\{-\frac{6\cdot31}{\omega^{1/3}}(\omega-2)\right\}$$

where $\omega=W/Mc^2$ and we have taken $K/M=2/3$; $\mu/M=0\cdot15$. In deriving the above result the nucleons and the heavy mesons have been treated in the non-relativistic approximation, whereas π-mesons have been treated in the extreme-relativistic approximation. Further, the conservation of angular momentum has not been considered.

The table gives the results obtained from the above formula.

| $\omega$ | Energy of primary particle in laboratory system | Average number of π-mesons produced when no heavy meson is created | One heavy meson is created | | Ratio of the number of heavy mesons to π-mesons created in a collision |
|---|---|---|---|---|---|
| | | | Probability of the event* | Average number of π-mesons produced | |
| 3 | 3·5 $Mc^2$ | 1·2 | 7 | | ~ 1/17 |
| 4 | 7·0 | 2·5 | 9 | 1 | ~ 1/29 |
| 5 | 11·5 | 3·5 | 11 | 2·2 | ~ 1/34 |
| 6 | 16·9 | 4·4 | 12 | 2·3 | ~ 1/39 |

* The probability of the event when no heavy meson is produced is taken to be 100.

It will be noticed that, for collisions involving primary energies up to about 20 $Mc^2$, the possibility of a heavy meson being created is small. (The relative probability of two or more heavy mesons being created is very small and does not alter the conclusions drawn. For very high energies the above formula breaks down.) The slightly higher ratio of the number of heavy mesons to that of π-mesons, near the threshold energy for the creation of a heavy meson, will also be observed. This is due to the fact that, according to this theory, the probability of creation of a heavy meson varies more slowly with increasing energy than does the average number of π-mesons created.

In the extremely high energy region, where the heavy mesons and the nucleons have also to be treated in the extreme relativistic approximation, it follows from thermodynamic considerations[2] that the number of heavy mesons produced will be comparable to the average number of π-mesons, the ratio being governed mainly by the ratio of their respective statistical weight factors.

I am grateful to Mr. J. Hamilton for his interest in the work. I am also indebted to the Government of India for the award of a scholarship.

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## Mean Square Radius of randomly coiled Molecular Chains

An expression for the mean square radius of a randomly coiled long-chain polymer, that is, for the mean square distance of its constituent groups from their centre of mass, was first derived by Debye[1]. Debye's formula applies only to very long chains; the following simple derivation is valid for any unbranched chain, provided the correlation between two atoms depends only on the number of links separating them (this implies neglect of the excluded volume effect).

According to a theorem by Lagrange[2], in a system of $n$ particles the mean square distance $R_n^2$ of the particles from their mass centre is given (in the case of equal masses) by:

$$R_n^2 = \sum_i r_{Gi}^2/n = \sum_{i,j} r_{ij}^2/n^2. \qquad (1)$$

Here the $r_{Gi}$ denote the distances of the individual particles from the mean centre and the $r_{ij}$ their mutual distances; the double sum has to be taken over all pairs of particles (once only). If the particles are arranged in the form of a chain and the average is taken over all possible configurations of the chain, equation (1) leads to:

$$n^2 < R_n^2 > = \Sigma < r_{ij}^2 > = (n-1) < r_{12}^2 > + (n-2) < r_{13}^2 > + \ldots + < r_{1n}^2 >, \qquad (2)$$

where the signs $< \; >$ denote statistical averages.

For links of constant length $l_0$ and mutually independent directions:

$$< r_{1j}^2 > = (j-1)\, l_0^2, \qquad (3)$$

which yields with the use of (2):

$$< R_n^2 > = \frac{1}{6}\, l_0^2\,(n - 1/n) = \frac{1}{6} < r_{1n}^2 > (1 + 1/n). \qquad (4)$$

For a constant valency angle $\pi - \omega$ and free rotation about bonds, it is known that[3]:

$$< r_{1j}^2 > = l_0^2 \left[ (j-1)\, \frac{1+\alpha}{1-\alpha} - 2\, \frac{\alpha - \alpha^j}{(1-\alpha)^2} \right], \qquad (5)$$

where $\alpha = \cos \omega$. Substitution of this into (2) yields

$$< R_n^2 > = \frac{l_0^2}{n^2} \left[ \frac{1}{6}\, \frac{1+\alpha}{1-\alpha}\,(n^3 - n) - \frac{(n-1)\alpha}{(1-\alpha)^2} \left( n - \frac{2\alpha}{1-\alpha} \right) - \frac{2\,(\alpha^3 - \alpha^{n+1})}{(1-\alpha)^4} \right]. \qquad (6)$$

More complicated correlations can be treated in an analogous way. In all cases in which there is no preferential tendency for the chain to develop in any specific direction in space, Debye's result[1] is obtained for large $n$, that is:

$$< R_n^2 > = < r_{1n}^2 > \left[ \frac{1}{6} + O\,(n^{-1}) \right]. \qquad (7)$$

The subject of this note formed part of the fundamental research programme of the British Rayon Research Association.

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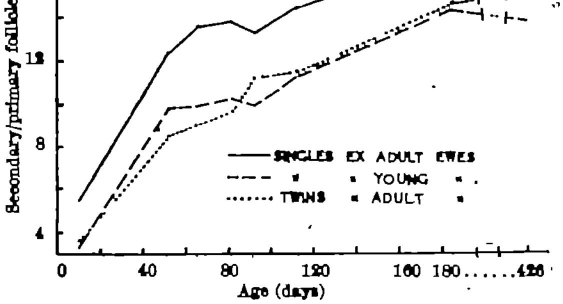
## Follicle Development in the Australian Merino

So far as we are aware, there is no published information of a quantitative nature on the post-natal development of the follicle population in the skin of the merino sheep, although Carter and Hardy[1] have presented quantitative data for the pre-natal period. In his classical description of the development of the follicle group, Carter[2] was concerned with descriptive morphology and ontogenic considerations rather than with quantitative aspects. His clear definition of the two follicle types (primary and secondary), their relative place in the developmental sequence, and their fundamental arrangement in group form lays the foundation on which quantitative considerations may be built. The most satisfactory measure of the progress of development of the follicle population is the ratio of secondary follicles to primary follicles ($S/P$). The validity of this unit rests on the observation (Carter[2]) that the primary population within any region is determined by approximately the eighty-sixth day of pre-natal life, and that only secondary follicles develop thereafter. While it has not been proved that no primary follicles develop after this time, the histological evidence is heavily in this direction.

Unpublished observations at this College on causes of variability in the skin and fleece of merino sheep have shown that, at fifteen months of age, the $S/P$ ratio of twins is frequently lower than that of singles, and those for the progeny of young ewes are also lower than those of mature ewes. It was decided, therefore, to study the development in these classes from early post-natal life. Skin sections were taken from the mid-side at 10, 52, 66, 82, 92, 113, 185 and 426 days of age, a single section of 1 cm. diameter being taken from each animal at each sampling period.

These sections were examined histologically by a method which was essentially the same as that described by Carter[2]. The accompanying graph shows the relationship between the $S/P$ ratio and age in three groups of lambs taken at random from a flock of South Australian (Bungaree) merino.

The consistently lower ratio in those groups subject to some nutritional penalty (twins and progeny of young ewes) is quite evident. Theoretically, it is not possible for the $S/P$ ratio to decline unless there is a loss of secondary follicles. Whether this is the cause of the three points showing a lower ratio than at the previous observation cannot be stated with certainty. Such a decline in ratio could also appear as a result of sampling variations, although this seems unlikely in view of the numbers involved. Of particular interest is the relatively large difference in the



$S/P$ ratio at ten days of age, when the first sections were taken. This difference appears to be too large to have developed since birth, and strongly suggests that the late pre-natal development of secondary follicles may be affected by the fœtal environment. In a further series of observations, a significant correlation ($r = 0 \cdot 56$) between birth-weight and $S/P$ ratio at birth has been noted, and seems to establish beyond doubt that the ratio at birth is influenced by the general pre-natal environment. Subsequent observations have also shown that the rate of development of secondary follicles during early post-natal life is closely associated with growth-rate in general and particularly with rate of expansion of skin.

These observations form part of a larger series being conducted at this College, and financed largely by the Commonwealth Scientific and Industrial Research Organization from the Wool Research Trust Account; grateful acknowledgment is made for this assistance. The detailed observations will be published elsewhere in due course.

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## Inhibition of Populations of *Hæmonchus contortus* in Sheep fed on White Clover (*Trifolium repens*) High in Lotaustralin

Melville *et al.*[1] have shown that strains of New Zealand white clover (*Trifolium repens*) may contain up to 0·033 per cent hydrogen cyanide. It occurred to me that such a concentration might be lethal to internal parasites of sheep.

Preliminary *in vitro* experiments demonstrated that solutions of potassium cyanide, approximating to the concentration of hydrogen cyanide which could be expected in the rumen of sheep fed on white clover, killed some trichostrongylid infective larvæ. Further, some infective larvæ in water exposed over macerated clover also were killed.

A third step was to administer known populations of *Hæmonchus contortus* infective larvæ to lambs reared free from parasitism and fed on pure stands of the following plants: (1) New Zealand certified pedigree white clover, a strain selected and bred by the Grasslands Division of the Department of Scientific and Industrial Research, high in the cyanogenetic glucoside, lotaustralin; analysis at the initiation of the experiment revealed 0·023 per cent hydrogen cyanide. (2) Red clover (*T. pratense*) containing a doubtful trace of hydrogen cyanide (white clover of low cyanide content was not available at the time of the experiment). (3) Cocksfoot (*Dactylis glomerata*), a grass chosen because it was available and did not contain hydrogen cyanide.

Fourteen seven-month old Romney lambs were simultaneously placed in each of the three parasite-free experimental paddocks. The lambs were permitted four days to become accustomed to the diet, and then each was given 2,000 *H. contortus* infective larvæ. After fourteen more days in the paddocks, the lambs were killed and the *H. contortus* populations counted. Only fifth-instar parasites were found. The average *H. contortus* populations for the groups were: on white clover, 509·6 worms; on red clover, 613·9 worms; on cocksfoot, 698·6 worms. Thus the average populations of the white and the red clover groups were, respectively, 72·9 and 87·8 per cent of the cocksfoot group. The average differences required for significance between the groups at the 5 per cent and 1 per cent levels are, respectively, 121·9 and 163·1. Thus it is seen that there is a highly significant difference in worm populations between the white and the cocksfoot groups; but between these two groups and the red clover group, population differences do not reach the 5 per cent level of significance. There is doubt that cyanide content is the only factor involved. The work is being continued.

I am indebted to the following officers of the N.Z. Department of Scientific and Industrial Research: Messrs. L. Corkill, L. W. Gorman and P. Sears of the Grasslands Division, for provision of the experimental areas and plants; to Mr. J. G. Fraser of the same Division, for chemical analyses; and to Mr. A. C. Glenday of the Applied Mathematics Laboratory, for statistical treatment of data. The work is being financed with the aid of a grant from the Department of Scientific and Industrial Research.

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## Action of Insulin on the Frog (*Rana temporaria*)

Earlier investigations of the action of insulin on cold-blooded vertebrates have shown that, although large doses usually lead to the appearance of typical convulsions, there is often a long latent period (1–2 days at room temperature) during which there are no visible symptoms[1–3]. In experiments performed in March and May 1952 the action of insulin on the blood-sugar level of the frog was followed, at intervals, from the time of injection to the development of convulsions. The frogs were kept at room temperature (17°–20° C.) and were injected with four units of insulin (Wellcome 40) in the dorsal lymph sac. The sugar content of the blood was determined by a modification of the method described by King[4] for obtaining "true sugar" values, which are 15–20 mgm./100 ml. lower than those previously recorded for the frog[5].

There was no change in the mean blood-sugar level in the first $1\frac{1}{2}$ hr. after insulin ($23 \pm 1 \cdot 81$ mgm./100 ml.), but after 5 hr. it had fallen to a very low value ($3 \pm 0 \cdot 69$ mgm./100 ml.), which was maintained to the end of the experiments when the frogs had shown typical insulin convulsions[1,2]. In one series of experiments (May 1952) parallel estimations of the glycogen content of the liver and gastrocnemius muscles were made (calculated as percentage wet weight of tissue). The mean muscle-glycogen content fell slightly between 5 hr. and 24 hr. after insulin (from $0 \cdot 53 \pm 0 \cdot 06$ to $0 \cdot 32 \pm 0 \cdot 06$ per cent, $P < 0 \cdot 05$), possibly followed by a further decrease associated with the occurrence of convulsions ($0 \cdot 23 \pm 0 \cdot 05$ per cent). The changes in liver-glycogen content in the first 24 hr. were not significant, but after convulsions had occurred there was a marked fall (from $1 \cdot 71 \pm 0 \cdot 13$ to $0 \cdot 36 \pm 0 \cdot 22$ per cent, $P < 0 \cdot 001$).

In the light of the above experimental results the following hypothesis is put forward to account for the delayed appearance of insulin convulsions in the frog. The first action of insulin is a marked depression of glycogenolysis in the liver[4,7], perhaps accompanied by increased uptake of glucose by the tissues, leading to the development of an extremely hypoglycæmic condition. The frog then utilizes its peripheral carbohydrate stores for its energy needs, as suggested by the decrease in muscle glycogen. In general, the carbohydrate reserves of the central nervous system are considerably lower than those of the muscles, and it may be assumed that they would be the first to be exhausted. When this occurs the typical insulin convulsion appears. These convulsions have been observed to be accompanied by marked temporary contraction of the melanophores[5], suggesting the release of adrenaline which presumably also causes mobilization of some of the liver glycogen. This glucose production by the liver is responsible for the rapid recovery of the frog, which then appears quite normal for a few hours. Eventually another convulsion occurs, and the cycle is apparently repeated until the liver reserves are exhausted, when death occurs. Such a hypothesis also accounts for the fact that the time required for the appearance of convulsions depends on the environmental temperature rather than on the dose of insulin[1,2]. It has, in fact, been pointed out that the graph of the rate of action of insulin at various temperatures corresponded very closely to the curve for oxygen consumption[1].

Experiments on fish have shown that there is a correlation between the rate of action of insulin and the activity of the fish[3], and also that in a given species the former varies with temperature[6]. This suggests that the mode of action of insulin in certain fishes may be similar to that proposed for the frog.

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## Heat Inactivation of Strawberry Viruses

THE first and most effective measure for the control of virus diseases of strawberries is the provision of healthy planting material. Selection on the basis of virus tests has resulted in a virus-free clone of the Royal Sovereign variety and revived its commercial cultivation; but except for the recently bred variety Auchincruive Climax, no plants of other widely grown varieties have been found without at least a mild crinkle virus.

Experiments on heat therapy of strawberry plants infected with crinkle viruses were started in 1950, using a thermostatically controlled water-bath and a laboratory oven. It was found that although plants would survive only seven hours in water at 35° C., they would survive up to seven days in the oven at 33° C. Graft tests to the sensitive indicator, *Fragaria vesca*, in 1951 and again in 1952, showed that the mild crinkle virus had been inactivated in one plant (var. Perle de Prague) by oven treatment, and that one plant of Huxley's Giant had a reduced virus content.

In 1952, a propagation frame was adapted by the addition of thermostatically controlled heaters and double glazing, which gave temperature regulation within 2° C. In a series of experiments, young plants, growing in 3-in. pots and with all but the youngest leaf removed, were subjected to 37 ± 2° C. for periods ranging from five to twelve days. After a recovery period of about two weeks, the surviving plants were infested with non-infective aphids, *Pentatrichopus fragaefolii* Cock., which were transferred after 24 hr. to test plants (*Fragaria vesca*). Virus was always transmitted from unheated control plants in comparable tests. The heated plants which gave no virus transmission were re-tested with aphids, and those again yielding no virus were grafted to *F. vesca* plants. Apparently complete virus inactivation has occurred in plants of the varieties Early Cambridge, Huxley's Giant and Perle de Prague, and their clonal propagation is proceeding rapidly. The application of heat therapy to other varieties will follow.

Work on technique and on the determination of precise heat inactivation periods for different viruses is still in progress; the results obtained so far which may be useful to other investigators are summarized as follows.

The lowest temperature-time at which inactivation occurred was 33° C. for six days. Although some plants were killed, eight days at 37° C. gave the most reliable results; eleven days was the longest time any plant survived at this temperature.

Three viruses have been inactivated, which are, in the probable order of their sensitivity to heat: (*a*) an undescribed virus which causes severe leaf necrosis on Royal Sovereign and bud proliferation on *F. vesca*; (*b*) the mild crinkle virus (virus 1)[1]; and (*c*) the crinkle virus (virus 3)[2]. The yellow-edge virus (virus 2)[3] was not included in these experiments.

Plants previously thought, on the basis of vector and graft tests, to be infected with single viruses have been shown to contain at least two, one of which is inactivated more rapidly than the other.

Some plants which had given no virus transmission by aphids a few weeks after treatment gave transmissions when tested three months later, presumably owing to 'resurgence' of virus from deep-seated tissues.

Plants in the frame with daylight survived 37° C. for three days longer than did those in the dark oven. Warm water killed strawberry plants more quickly than did air at the same temperature, and plants survived longer incubation when the soil was moistened daily to prevent wilting than when saturated. Well-rooted plants withstood heat treatment better than recently potted plants.

The difference between varieties shown in the proportion of plants surviving heat treatment is thought to be due mainly to different susceptibility to fungal infection (for example, by *Botrytis cinerea*) under these conditions of high humidity and temperature. More plants survived in a sterile medium, 'Vermiculite', than in steam-sterilized soil.

A. F. POSNETTE

East Malling Research Station,
Kent.
Nov. 27.

[1] Prentice, I. W., and Harris, R. V., *Ann. App. Biol.*, 33, 50 (1946).

[2] Prentice, I. W., *Ann. App. Biol.*, 36, 18 (1949).

[3] Prentice, I. W., *Ann. App. Biol.*, 35, 279 (1948).

## Cytoplasmic Particles in Bean Root Cells

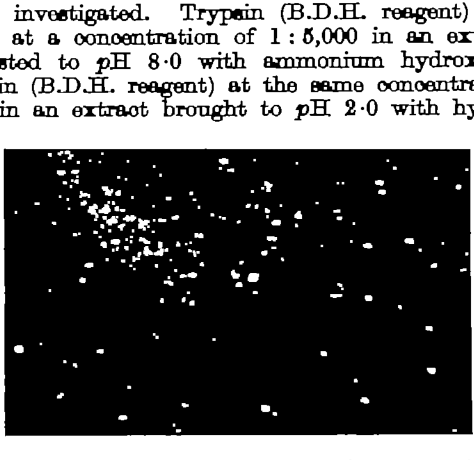
In the course of an investigation of the composition of certain aqueous extracts of tissues from the bean root, the material was examined in an electron microscope. Small spherical granules, slightly smaller in size than the microsomes described by Claude[1], Brachet and Jeener[2], and Stern[3], were detected. The size of the particles varied with the maturity of the tissue from which they were taken.

Bean seeds were germinated and sections cut from roots of standard length using the techniques previously described[4]. Aqueous extracts were prepared from sections cut from the regions 0–2·0; 7·0–9·0; and 13·0–15·0 mm. from the apex of the root. Each zone was cut into five 0·4-mm. fragments. The groups of sections were placed in petrol ether, stored overnight at + 4° C., and then washed, and ground with a glass pestle and mortar. 2·0 ml. of glass-distilled water was added and the resulting suspension centrifuged at approximately 5,500 $g$ for 45 min. Finally, the clear supernatant was diluted 5,000 times with glass-distilled water.

Silver-plated grids with 'Formvar' films were used as carriers in the electron microscope. A drop of fluid was transferred to the grid, and, after drying under reduced pressure in a vacuum desiccator over phosphorus pentoxide, the preparations were gold shadowed and examined in a Phillips electron microscope. Photographs were taken by Mr. G. W. Ripley at a magnification of × 20,000. The particle-size was measured after projecting the electron micrographs on to a screen.

The accompanying photograph shows a typical electron micrograph of particles from the apical zone of the root. Measurements showed average diameters for the particles from the three zones of 0–2·0, 7·0–9·0 and 13·0–15·0 mm., of 37 mμ, 24 mμ and 20 mμ, respectively. Clearly, the particles are largest in the meristematic cells and tend to decrease in size as the cell matures. It was found that a similar change occurred when fragments are excised and cultured on water at 25° C. for 48 hr. During culture the average diameter in tissue from the apical zone decreased from 36 to 28 mμ, and in the 13·0–15·0-mm. zone from 20 to 13 mμ.

Since particles similar to those described above have been found by earlier workers[1–3] to be composed of ribonucleoprotein, the effects of trypsin, pepsin and ribonuclease on the bean root particles were investigated. Trypsin (B.D.H. reagent) was used at a concentration of 1 : 5,000 in an extract adjusted to $p$H 8·0 with ammonium hydroxide; pepsin (B.D.H. reagent) at the same concentration but in an extract brought to $p$H 2·0 with hydrochloric acid; and ribonuclease (purified Armour Laboratories) at 1 : 10,000 in an untreated extract. Aliquots were incubated at 25° C. for 3, 8 and 21 hr. in each case with and without the enzyme. Extracts from the zone 0–2·0 mm. from the tip were used for these experiments.



Electron micrograph of cytoplasmic particles in aqueous extract of region 0–2·0 mm. from apex of bean root. Magnification on print, × 30,000

With the exception of the extract treated with trypsin, particles were present in all preparations even after 21 hr. incubation. With trypsin there was little change during the first 3 hr., but a marked change after 8 hr. At the end of 8 hr. incubation the particles had almost entirely disappeared. A similar effect was observed in the extract treated for 21 hr. with trypsin. These observations suggest that the particles are composed of protein. The result with ribonuclease does not eliminate the possibility that they may also carry ribonucleic acid. If the skeletal framework is protein, removal of ribonucleic acid may not affect the overall size.

It is probable that the particles are structural components of the cytoplasm. Their significance in the metabolism of the cell is not yet known. It may be noted, however, that the change in size accompanies corresponding changes in the rate of increase of protein and in the activities of certain enzyme systems.

Further work on the chemical composition and metabolic activity of the particles is in progress, and a detailed account will be given elsewhere.

We thank Dr. R. D. Preston for facilities for using the electron microscope and Mr. G. W. Ripley for technical assistance.

E. Robinson
R. Brown

Botany Department,
University, Leeds 2.
Oct. 23.

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[1] Claude, A., *Science*, 97, 451 (1943).

[2] Brachet, J., and Jeener, R., *Enzymologia*, 11, 196 (1945).

[3] Stern, K., Cold Spring Harb. Symp. Quant. Biol., 7, 212 (1939).

[4] Robinson, E., and Brown, R., *J. Exp. Bot.* (in the press).

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## Effect of Thyroid Gland on the Cultivation of *Amœba proteus*

A PRELIMINARY study of the effects of thyroid gland tablets on *Amœba proteus*, placed singly or in bulk in hollowed-out glass squares, having been made without any definite results, the whole of the resulting material was used for inoculating culture 12, boiled wheat grains being the pabulum. For many months the $p$H of this culture fluctuated around $p$H 4, and *Euglena* flourished. Bean and pea cotyledons were substituted as pabulum. Small amœbæ, length 10–20 μ, were now present in culture 12. Miguel's fluid was added and the $p$H rose to $p$H 6·2. After a few months had elapsed, adult *A. proteus* appeared, and culture 12 was so flourishing that it was divided up into sub-cultures. These cultures are readily distinguished from our stock cultures even by a biologist quite ignorant of their history by: (1) the larger size of the adult amœbæ in them, (2) the persistence of the adult stage beyond the normal span (the time occupied by the amœbæ to grow from newly hatched to sporulation stage is twelve months); and, therefore, (3) the rarer occurrence of developmental stages in the culture; (4) difficulty in making successful sub-cultures from the original.

Dr. T. G. Rennie having kindly procured thyroid tablets of the same strength as those used above, the experiments are being continued to see if a race of 'giant' *A. proteus* can be secured.

MONICA TAYLOR

Notre Dame, Dowanhill,
Glasgow, W.2.
Aug. 5.

## University Botanical Teaching and Training

THE report of the discussion on botanical teaching held at the British Association meeting this year raises a number of interesting problems[1]. I cannot agree with Dr. Ashby when he suggests that the specific requirements of potential employers, and, in particular, government departments, should determine the scope and content of honours courses. I have heard similar arguments out here in New Zealand where government departments form the major avenue of employment for the abler students. It is surely our duty to see that students have a sound botanical, rather than a vocational botanical, training.

After acquaintance with several types of botanical training, and at the risk of appearing biased, I believe that something along the lines of the Cambridge system, as described by Prof. Briggs, meets several of the points raised and in particular has sufficient flexibility for the future specialists without losing the advantages to be gained from an overall education. The introduction of the half subjects, although regarded with suspicion by many at first, has, I think, been a happy proposal because it permits specialists to have a wider choice of ancillary subjects. I was surprised that no one raised the desirability of altering the present system in British universities where a subject tends to be studied as a unit over a whole year. The Cambridge half-subject system or the American semester system would merit much closer study in relation to the needs of present-day botanical teaching.

It might be of interest to refer to some organizational points at Auckland University College. Although there is no honours degree at the bachelor level, nevertheless the teaching is at the honours level. Certain prerequisites are laid down by the various heads of departments. Thus in botany a student who intends to study the subject for more than one year must do a year of chemistry before proceeding to study additional plant physiology. Any student taking the B.Sc. degree with botany as the major unit must, in addition, do one year in zoology. Those students who stay on to take an M.Sc. have not only a thesis to do but also there are additional lecture courses. These comprise formal courses in economic botany, history of botany and evolution, together with a number of topics selected from various fields of botany and changing from time to time. There are further prerequisites also; for example, a student specializing in genetics must have done a year of mathematics, a student in plant physiology is expected to have done a second or third year in chemistry, while an ecologist must attend a surveying course in the Geography Department. We also make use of specialists in other fields; for example, the professor of organic chemistry and the professor of geography both give some lectures in the course of economic botany.

Finally, the unit system at Auckland has great advantages, though it is not quite so flexible as the Cambridge system. Only one subject is studied over three years and at least one other subject over two years. This provides five units, and as eight are required for the degree the remainder can be taken as one-year courses in three other different subjects, or another subject can be taken to the second-year stage or one to a third-year stage. While this system provides very considerable flexibility, one must admit that it does raise time-table problems, though these can be solved.

V. J. CHAPMAN

Department of Botany,
Auckland University College,
New Zealand.
Dec. 10.

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[1] *Nature*, 170, 770 (1952).

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THE main difficulty in botanical teaching lies in the fact that three or even four years of study are not enough to train a biologist for all the requirements of modern life.

In this Department the first year is devoted to a general survey, necessitated by the completely insufficient knowledge the students bring with them from the schools. Thereafter students may proceed with zoology as second major; but chemistry as second major is becoming increasingly popular. As I consider any specialization in the first three years to be undesirable, I think it would be better if those majoring in botany and zoology could have the opportunity of following biochemical courses in case their interest lies in this field.

In the second year, courses in systematics of lower and higher plants and in physiology are given. In the third year, the main courses are those in taxonomy, anatomy, cytology and plant breeding; but there are also short courses in ecology, and in phytogeography in relation to climatology. Practical ecology is taught during a fortnight's course at Frankenwald, the University's Pasture Research Station.

Students proceeding to the honours course (fourth year) find no prescribed syllabus. Considerable choice of subjects is made according to their special interests. The system is one of individual tuition and serves three purposes: (*a*) extension and broadening of knowledge in some of the fields studied in the first three years, (*b*) self-activity, by learning how to tackle problems and apply different techniques with criticism, (*c*) discovery of abilities. A course of this type stimulates the interest of the student, not only in his own work, but also in that of others.

In conformity with the principle of general biological training in the first three years, which is based upon the undeniable interrelationship of all facets of modern botany, we created a special honours course in 'bio-ecology'. This course is based on botany and zoology as majors and has ancillary subjects like surveying, statistics and geology.

Subjects like ecology and other border-line fields are very suitable to demonstrate the complexity of apparently simple problems.

N. P. BADENHUIZEN

Department of Botany,
University of the Witwatersrand,
Johannesburg.
Dec. 16.

# FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

## Monday, February 16

Institution of Post Office Electrical Engineers (at the Institution of Electrical Engineers, Savoy Place, Victoria Embankment, London, W.C.2), at 5 p.m.—Mr. F. C. Meade: "An Approach to the Economics of P.O. Engineering Training".

Royal Geographical Society (at 1 Kensington Gore, London, S.W.7), at 5 p.m.—Dr. E. C. Willatts and Mrs. M. G. C. Newson: "Pattern of Population Trends in England and Wales".

Society of Chemical Industry, Crop Protection Panel of the Agriculture Group (at the Chemical Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Papers on "Physical Factors in relation to Biological Activity of Insecticides".

University of London (in the Physiology Theatre, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Dr. T. S. Work: "Biosynthesis of Proteins".* (Further Lecture on February 20.)

Society of Chemical Industry, London Section (at the Royal Institution, 21 Albemarle Street, London, W.1), at 6 p.m.—Mr. J. H. Cummins: "The Development of Chemistry in Australia" (Jubilee Memorial Lecture).

Sheffield Metallurgical Association (joint meeting with the Local Section of the Institute of Metals, and the Society of Engineers and Metallurgists, in the University Building, St. George's Square, Sheffield), at 7 p.m.—Mr. W. A. Baker: "The Constitution and Properties of some Titanium-Base Alloys".

## Tuesday, February 17

Society of Chemical Industry, Agriculture Group (in the Chemistry Lecture Theatre, Royal College of Science, South Kensington, London, S.W.7), at 2.30 p.m.—Dr. A. Eden: "Substitute Feeding Stuffs".

Royal Institution (at 21 Albemarle Street, London, W.1), at 5.15 p.m.—Prof. A. J. S. Pippard: "The Behaviour of Engineering Structures". (Further Lectures on February 24 and March 3.)

Physical Society, Low Temperature Group (joint meeting with the Institute of Refrigeration, at the Institution of Mechanical Engineers, Storey's Gate, St. James's Park, London, S.W.1), at 5.30 p.m.—Discussion on "Novel Refrigeration Cycles".*

University of London (in the Electrical Engineering Theatre, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Dr. M. V. Wilkes: "The Design of Electronic Digital Computers".* (Further Lectures on February 24, March 3 and 10.)

Royal Aeronautical Society (at 4 Hamilton Place, London, W.1), at 7 p.m.—Mr. A. H. Yates: "Recent Developments in Gliding".

Royal Society of Medicine, Pathology Section (at 1 Wimpole Street, London, W.1), at 7.45 p.m.—Symposium on "Hæmoglobin Metabolism".

## Wednesday, February 18

Society of Chemical Industry, Corrosion Group (joint meeting with the Newcastle Section of the S.C.I., and the Chemical Engineering Group, in the Stephenson Building, King's College, Newcastle-upon-Tyne), at 2.30 p.m.—Dr. W. H. J. Vernon: "Some Recent Progress in Corrosion Research"; at 6 p.m.—Mr. K. A. Spencer and Dr. H. B. Footner: "Protective Coatings for Buried Pipelines".

Physical Society, Colour Group (at the Institute of Ophthalmology, Judd Street, London, W.C.1), at 3.30 p.m.—Scientific Papers.

Eugenics Society (at Manson House, 26 Portland Place, London, W.1), at 5 p.m.—Prof. T. H. Marshall: "Social Selection in the Welfare State" (Galton Lecture).*

Royal Meteorological Society (at 49 Cromwell Road, London, S.W.7), at 5 p.m.—Scientific Papers.

Physical Society, Acoustics Group (at the Science Museum, Exhibition Road, London, S.W.7), at 5.15 p.m.—Mr. D. H. Follett: Demonstration of some Old Instruments—Musical and Otherwise—from the Acoustics Collection in the Science Museum.

Royal Microscopical Society (at Tavistock House South, Tavistock Square, London, W.C.1), at 5.30 p.m.—Dr. M. H. F. Wilkins: "The Performance of Spherical-Mirror Reflecting Objectives when used for Ultra-Violet Photomicrography".

University of London School of Pharmacy (in the Chemistry Lecture Theatre, London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 5.30 p.m.—Sir Henry Dale, O.M., F.R.S.: "The Future of Pharmacy and Pharmacology" (Charter Lecture).*

Institution of Electrical Engineers (at Central Hall, Westminster, London, S.W.1), at 6.30 p.m.—Mr. A. R. Cooper: "Light from the Dark Ages, or the Evolution of Electricity Supply" (Faraday Lecture). (Admission by ticket obtainable from the Institution.)

Royal Institute of Chemistry, London Section (joint meeting with the British Association of Chemists, at the Wellcome Research Institution, 183 Euston Road, London, N.W.1), at 6.30 p.m.—Prof. C. K. Ingold, F.R.S., and others: A Discussion on "Education in Chemistry".*

Institute of Petroleum, Stanlow Branch (joint meeting with the North-Western Section of the Institute of Fuel, at the Grosvenor Hotel, Chester), at 7.30 p.m.—Mr. S. J. Young: "Methane at Point of Ayr Colliery".*

## Thursday, February 19

Royal Society (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Scientific Papers.

University of London (in the Physiology Theatre, University College, Gower Street, London, W.C.1), at 4.45 p.m.—Prof. V. B. Wigglesworth, F.R.S.: "Chemical Aspects of Insect Physiology".* (Further Lectures on February 26, March 5 and 12.)

Institution of Mining and Metallurgy (at the Geological Society, Burlington House, Piccadilly, London, W.1), at 5 p.m.—Mr. J. S. Sheppard: "Precise Azimuths from Steep Sights"; Mr. R. Daniel: "Diamond Mining Practice in Kimberley, South Africa".

Linnean Society of London (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Captain Cyril Diver, and others: "Nature Conservancy".

London Mathematical Society (at the Royal Astronomical Society, Burlington House, Piccadilly, London, W.1), at 5 p.m.—Prof. G. de Rham: "On some Plane Curves which are defined by certain Functional Equations".

Royal Anthropological Institute (at 21 Bedford Square, London, W.C.1), at 5.30 p.m.—Mr. V. W. Turner: "Village Structure of the Mwinilunga Lunda".

Society of Chemical Industry, Road and Building Materials Group (at the Building Centre, Store Street, London, W.C.1), at 6 p.m.—Dr. B. H. Knight: "The Stability of Asphalt Mixtures as affected by Aggregate Size".

Royal Society of Tropical Medicine and Hygiene (at Manson House, 26 Portland Place, London, W.1), at 7.30 p.m.—Dr. M. A. C. Dowling: "The Malaria Eradication Experiment in Mauritius".

University of London (in the Swanley Hall, Wye College, Wye, Ashford), at 8.15 p.m.—Prof. W. Arthur Lewis: "The Economic Development of Under-developed Countries".*

## Friday, February 20

Institute of Navigation (at the Royal Geographical Society, 1 Kensington Gore, London, S.W.7), at 5 p.m.—Capt. R. C. Alabaster: "Navigation and the Operation of Jet Aircraft".

Institution of Mechanical Engineers (joint meeting with the Applied Mechanics Group, at Storey's Gate, St. James's Park, London, S.W.1), at 5.30 p.m.—Dr. K. H. R. Wright: "An Investigation of Fretting Corrosion".

University of London (at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 5.30 p.m.—Dr. D. P. Cuthbertson: "Problems of Quality and Quantity of Protein".*

Institution of Electrical Engineers, Education Discussion Circle (at Savoy Place, Victoria Embankment, London, W.C.2), at 6 p.m.—Discussion on "Circuit Conventions, with particular reference to Alternating-Current Circuit Vector Diagrams" (to be opened by Mr. J. G. Fleming).

British Institute of Radiology (in the Reid-Knox Hall, 32 Welbeck Street, London, W.1), at 6.30 p.m.—Mr. A. Nemet and Mr. W. B. Cox: "The Contrast Problem in High Kilovoltage Radiography".

Society of Chemical Industry, Fine Chemicals Group (in the Chemistry Lecture Theatre, King's College, Strand, London, W.C.2), at 7 p.m.—Scientific Papers.

Royal Institution (at 21 Albemarle Street, London, W.1), at 9 p.m.—Rt. Hon. Lord Brabazon of Tara: "The Birth of Flight".

## Saturday, February 21

Biochemical Society (at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 11 a.m.—Symposium on "Biological Transformations of Starch and Cellulose".

British Psychological Society (in the Psychology Department, University College, Gower Street, London, W.C.1), at 2.30 p.m.—Dr. Clarence H. Graham: "Psychology in Japan".

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# APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Inspector (with a good honours university degree in physics or biology, and teaching experience) of Schools (General) in the Ministry of Education for Northern Ireland—The Secretary, Civil Service Commission, Stormont, Belfast (February 19).

Lecturer in Agricultural Chemistry—The Secretary, Edinburgh and East of Scotland College of Agriculture, 13 George Square, Edinburgh (February 20).

Assistant Research Biologist—The Secretary and House Governor, Mount Vernon Hospital, Northwood, Middx (February 21).

Chief Chemist of the Coke Oven Installation at Nantgarw, near Cardiff—The Divisional Establishment Officer, National Coal Board, South-Western Division, Cambrian Buildings, Mount Stuart Square, Cardiff (February 21).

Assistant Lecturer or Demonstrator (with a good honours degree in chemistry or biochemistry) in Chemical Pathology—The Registrar, The University, Manchester 13 (February 28).

Assistant Lecturer or Lecturer in the Department of Electric Power Engineering—The Registrar, The University, Liverpool (February 28)

Deputy Chief Mechanization Engineer (Ref. TT/590), and Mechanization Engineers (2) (Ref. TT/591), in the Mechanization Branch of Production Department at London headquarters—The National Coal Board, Establishments (Personnel), Hobart House, Grosvenor Place, London, S.W.1, quoting the appropriate Ref. No. (February 28).

Lecturer (Grade III or II) in Experimental Physics—The Registrar, The University, Bristol (February 28).

Scientific or Senior Scientific Officer (Ref. G.35/53A) to assist in ante-mortem and post-mortem investigations on quality of meat, and a Senior Scientific Officer (Ref. G.36/53A) for investigation on general microbiology of foodstuffs, at the Low Temperature

Research Station, Cambridge—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting the appropriate Ref. No. (February 28).

Senior Lecturer in Pure Mathematics—The Registrar, The University, Sheffield (February 28).

Readership in Biochemistry at University College—The Academic Registrar, University of London, Senate House, London, W.C.1 (March 4).

Research Officer to the Division of Animal Health and Production, Sydney, to collaborate in the present programme of research in the mammalian skin and hair by means of tissue culture and grafting, together with histochemical, biochemical and biophysical methods—The Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting No. 4139 (March 7).

Scientific or Senior Scientific Officer (with a first- or second-class honours degree in chemistry, physics or chemical engineering) for research in physical, physico-chemical and biochemical problems on the preservation of fish, at the Food Investigation's new Humber Laboratory, Hull—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting F.32/53A (March 7).

Senior Research Worker to assist with the development of researches into family and community organization on Merseyside, and a Research Worker to assist with the development of researches in the industrial field on Merseyside—The Registrar, The University, Liverpool (March 7).

Chair of Physics at Queen Mary College—The Academic Registrar, University of London, Senate House, London, W.C.1 (March 9)

Deputy Director of Research—The Director of Research, British Leather Manufacturers Research Association, Milton Park, Egham, Surrey (March 9).

Lecturer in Engineering—The Registrar, University College, Cathays Park, Cardiff (March 14).

Lecturer in Psychological Medicine—The Secretary of University Court, The University, Glasgow (March 14).

Lecturer or Assistant Lecturer in Botany (with special interests in taxonomy and morphology) at University College, Ibadan, Nigeria—The Secretary, Inter-University Council for Higher Education in the Colonies, 1 Gordon Square, London, W.C.1 (March 14).

Scientists (with good honours degree or equivalent) in the Physics Department—The National Coal Board, Central Research Establishment, Stoke Orchard, Cheltenham, quoting TT/592 (March 14).

Senior Agricultural Economist (Farm Management Liaison Officer) and an Agricultural Economist, in the Provincial Agricultural Economics Service of the Department of Agricultural Economics—The Registrar, University College, Aberystwyth (March 14).

Nuffield Research Fellowships and Assistantships in the Department of Genetics for research on microbial genetics—The Secretary of University Court, The University, Glasgow (March 15).

Professor of Pharmacology—The Deputy Secretary, Royal College of Surgeons of England, Lincoln's Inn Fields, London, W.C.2 (March 16).

Regius Professor of Logic in the University of Aberdeen—The Private Secretary, St. Andrew's House, Edinburgh 1 (April 1).

Research Assistant to the Professor of Medical Chemistry in the John Curtin School of Medical Research—The Secretary, London Office of the Australian National University, 27 Russell Square, London, W.C.1 (April 30).

Assistant Lecturer in Physiology and Pharmacology—The Registrar, The University, Nottingham.

Electrical Engineers at a Ministry of Supply Research Establishment near Sevenoaks: (a) for development work on electrical components, (b) for trials of experimental equipment, (c) for development of electromechanical devices—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting D.20/53A.

Engineers in the Post and Telegraphs Department, Nigeria—The Director of Recruitment, Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting CDE.108/14/65.

Lecturer (Grade I) in Mechanical Engineering, and a Lecturer (Grade II) in Mechanical Engineering—The Registrar, The University, Nottingham.

Regional Trials Officer (with degree in botany or agriculture or equivalent qualification, and practical experience in crop production) for work possibly at Cambridge—The Secretary, National Institute of Agricultural Botany, Huntingdon Road, Cambridge.

Scientific Officers at Capenhurst: for molecular theory of gases and applied fluid dynamics (Ref. 411), and for aerodynamics of compressors and high-speed machinery development (Ref. 412)—The Ministry of Supply, Division of Atomic Energy (Production), Risley, Warrington, Lancs, quoting the appropriate Ref. No.

Senior Electrical Engineer in the Public Works Department, Sudan—The Sudan Agent in London, Sudan House, Cleveland Row, London, S.W.1, endorsed 'Senior Electrical/Engineer 1818'.

Senior Lecturer in Chemistry (with qualifications and experience in organic chemistry) at Bradford Technical College—The Director of Education, Town Hall, Bradford.

# REPORTS and other PUBLICATIONS

(*not included in the monthly Books Supplement*)

## Great Britain and Ireland

British Engine Boiler and Electrical Insurance Co., Ltd. Technical Report, New Series, Vol. 1. Pp. 212. (Manchester: British Engine Boiler and Electrical Insurance Co., Ltd., 1952.) 12s. 6d. [112

City and Guilds of London Institute. Report of the Council for the Year 1951. Pp. 64. (London: City and Guilds of London Institute, 1952.) [112

Proceedings of the BTH Second Summer School in Electrical Engineering. Pp. 212. (Rugby: British Thomson-Houston Co., Ltd., 1952.) [112

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# THE PRINCIPLE OF QUINQUENNIAL GRANTS

IN recent years there have been comments from both interested and disinterested sources on the success with which the University Grants Committee has carried out its task of allocating Government funds to British universities. It is a task which has required much knowledge and care, though it may be open to question whether this is realized by those advocating the application of a similar device in other fields of activity depending on Government support. However that may be, it is worth while examining some of the suggestions which have been made for new bodies on the lines of the University Grants Committee.

The fields suggested are varied, but they have one feature in common : they all require as a condition of efficient working that there should be a longer period than the calendar year for the review of their projects or activities. The last annual report of the Advisory Council for Scientific and Industrial Research, for example, was concerned at the adverse effect on the work of the Department of Scientific and Industrial Research of sudden or unexpected limitations in the Department's budget, and the absence of reasonably firm budgetary expectations for several years ahead. The Council's plea that the Department should at least be given the flexibility which the right to carry over unspent money from year to year would confer, found strong support in a subsequent debate in the House of Lords last June.

A like difficulty has been encountered by the British Institute of Management, which has also pointed out the impossibility of arranging for the efficient conduct of research on a year-to-year basis with no budgetary certainty. The British Council, in quite another field, has encountered the same difficulty, and the Government's handling of the question of overseas information services on a year-to-year basis has already called forth some well-deserved criticism. Nor will it have escaped notice that the Tweedsmuir Committee, in presenting its proposals for the reorganization of the Imperial Institute, recommended that the system of grant should be placed on a quinquennial basis. The success of the scheme which it advocates would, it is urged, "be prejudiced from the beginning if those in charge of it only know from year to year what money they can count on from official sources, and are limited to budgeting expenditure on a rigid annual basis". More specifically than the other bodies already mentioned, the Tweedsmuir Committee mentioned the University Grants Committee, and its comment is worth quoting : "It is the common experience of organizations responsible for educational and cultural relations that their programmes are liable to be seriously affected, and at times actually frustrated, if they are tied to annual budgets, so far as Government subventions are concerned. We need do no more here than quote the example of the University Grants Committee, which owes its admittedly successful operations over a number of years to the fact that it has been able to plan its grants to Universities on the basis of quinquennial programmes. We strongly urge that the new Institute be treated on a similar basis, both in regard to recurrent and non-recurrent expenditure".

What is here contended is that the administration of Government funds should be effected by methods appropriate to the purpose of that expenditure, and not by methods determined primarily by financial convenience. The argument is not invalidated because public ignorance of the Imperial Institute, to which the Tweedsmuir report testifies, would militate very considerably against the success of the device in that instance. As part of a general scheme for securing the wise and efficient expenditure of public money on educational and cultural purposes, the new Institute might well be included. If some such device cannot be found, the Tweedsmuir Committee gives clear warning that it would be wiser to abandon pretence and accept the humiliation of closing the Institute and putting the premises to other use.

Some very clear thinking will obviously be required before any such scheme of quinquennial budgeting and accounting could be formulated. The device, or rather its extension, is likely to be opposed by the Treasury on traditional grounds. Such opposition should be overcome by demonstrating the wastefulness and inefficiency of the annual system; and accordingly every care should be taken that no claims are advanced which cannot be fully substantiated as being in the public interest on that ground alone.

Nor is reception by the Government likely to be favourable, if only for the reason that some further slice of public expenditure is removed from immediate control and that an incoming Government will be bound, possibly for several years, by the allocations of its predecessor. That case, however, is equally answerable. It should be emphasized that the object is, not the elimination of control, but the exercise of control where it will be most effective and ensure that expenditure already incurred is not wasted by short-sighted action. Nor, where scientific or technical research is concerned, should there be any hesitation in pointing out to-day the fallacy of imagining that under present conditions any efficient economy in national expenditure can be achieved without touching the categories in which it is now mainly incurred.

That brings us back once more to the question of public understanding and appreciation of what is involved, and public discussion must proceed while the exact means for providing the appropriate control are elaborated. Research is obviously one broad category to be covered, and the trend of questions in recent months in the House of Commons regarding expenditure on the Department of Scientific and Industrial Research, with the Government's abandonment of even the planning of a Science Centre, have increased the misgivings which were brought to a head by the Advisory Council's report. Much fundamental research is already safeguarded through the grants made under the University Grants Committee; but these amount to a small fraction only of the national expenditure on scientific and industrial research. Whether under the Lord President of the Council the functions of the Advisory Council on Scientific Policy could be developed to provide the appropriate safeguards for Parliamentary grants for scientific and industrial research in general might at least be worth examining.

The position of the social sciences and of bodies like the British Institute of Management requires further consideration. It is conceivable that a 'Social Grants Committee' might meet the situation; but there are obvious difficulties and objections. On the research side it might overlap the functions of the University Grants Committee, unless university institutions were clearly excluded. Even with such exclusion, the Committee could scarcely frame its grants without full knowledge of the social research at university institutions, and there is at present no social science research council which could assist. Furthermore, while it might be simple for such a body to cover the new Imperial Institute, the activities of the British Council are another question, particularly in view of the relation of its overseas activities to those of other, including Government, bodies now being considered by the Overseas Information Services Committee.

Here it may be observed that while the Clapham Committee on the Provision for Social and Economic Research, reporting in July 1946, rejected as premature the proposal for a Social and Economic Council on the lines of the Medical Research Council or the Advisory Council for Scientific and Industrial Research, it recommended consideration of the establishment, under the University Grants Committee, of a sub-committee to advise on matters relating to the social sciences. The Committee was clearly alive to the importance of continuity in such research, and the need for financial arrangements other than on an annual basis has been endorsed by subsequent experience as well as by the practice of the Nuffield Foundation and the United Kingdom Carnegie Trust in making their grants. Something wider is, however, required; though it requires consideration whether it is possible for all such grants for social and cultural purposes to be administered through one body, or whether some other arrangement, for example, under the Lord President of the Council or a sub-committee of the Advisory Council on Scientific Policy, would be wiser.

From the point of view of recruiting and retaining staff for overseas information work, long-term planning is essential. In any event, the need for co-ordinating the activities in this field of the British Council, the external services of the British Broadcasting Corporation and the work of the Central Office of Information, leads to a similar conclusion. It may be recalled, moreover, that the Select Committee on Estimates itself, in its ninth report for the session 1951–52, recommended, as a result of its inquiry into overseas broadcasting, a system of quinquennial grants for the overseas services of the B.B.C., in order to enable the Corporation to plan ahead for reasonable periods in providing what is essentially a long-term project.

As has been observed earlier (see *Nature*, 170, 634; 1952), the administration of such grants and the continuing scrutiny of the appropriateness of particular services to changing conditions may well involve the establishment of an independent body on the lines of the University Grants Committee. On practical grounds there will be objections to multiplying such bodies, and some hard thinking will be necessary to determine the minimum which will serve the objective, without either overlapping or failing to provide support and continuity where they are required in the national interest. Provided, however, these objectives are clearly defined, the task is not insuperable, and the attempt to discharge it could promote that clearer mutual understanding between the scientific man and administrator, using these terms in their widest sense, which is an essential condition for the functioning of devices of this type.

The recent memoranda published by the U.S. Commission on Financing Higher Education (see *Nature* of February 14, p. 273) are a most welcome contribution to the clear thinking that is essential to secure the smooth functioning of the University Grants Committee system in future, still more its extension into other fields. First there must be a large measure of public understanding of what is required, of the importance of the method of control or accounting being adjusted, not primarily to administrative or budgetary convenience, but to the purpose to be served—scientific, technical, cultural or educational. Without that understanding, adoption of such a system is unlikely for long to provide bodies such as the British Council, the British Institute of Management, the Imperial Institute or even the British Broadcasting Corporation, which are ill-equipped with defences such as the universities still enjoy against infringements of their autonomy, with the necessary safeguards for continuity of their research and like activities. That task of education should be the first to be tackled. It extends somewhat beyond the field over which the Parliamentary and Scientific Committee is normally active; nevertheless, the Committee could play an important part so far as science is concerned, whether we are concerned with the physical sciences or the social sciences. The Committee already enjoys a large measure of goodwill which should make it considerably easier to promote a clearer understanding between the administrator—Minister or Civil servant, member of Parliament—and the scientist or technologist. What is important is that no exasperation over the mistakes or follies of the past should be allowed to impede the co-operation in this task of public education of all who understand what is involved, whatever their primary interest may be. The extension of any such device must be advocated solely on the grounds of national interest—whether economic, social, technical or scientific—and of its appropriateness to the purpose to be served; its adoption for any particular purpose or field must be supported by a resolute and sustained effort to secure the sympathy and understanding of all affected, no matter how unfortunately the situation may have been prejudiced in the past.

# ADOLF VON BAEYER: CHEMIST AND MAN

## Adolf von Baeyer, 1835–1917

Von Karl Schmorl. (Grosse Naturforscher, Band 10.) Pp. ix+214. (Stuttgart: Wissenschaftliche Verlagsgesellschaft m.b.H., 1952.) 12.50 D. marks.

ADOLF VON BAEYER was born in 1835 and died in 1917. His astonishingly long period as an active worker in chemistry extended from the early days of the classical theory of organic molecular structure until the coming of sub-atomic chemistry: his first research paper was published in 1857 and his last in 1915, at the age of eighty. Soon after Bunsen had succeeded Gmelin at Heidelberg in 1852, the young Adolf Baeyer went to his laboratory from Berlin as a *Doktorand*. Being attracted to organic chemistry, Baeyer soon attached himself to Kekulé, then a little-known ***Privatdozent*** at Heidelberg. Baeyer's work with Kekulé, on arsenic methyl chloride, brought him the Berlin doctorate in 1858, a historic year that witnessed the publication of Kekulé's fundamental theory of organic molecular structure.

From the Gewerbe-Institut at Berlin, Baeyer migrated to the Strassburg chair in 1872, and three years later he succeeded Liebig at Munich. It was at Munich, with the aid of a galaxy of collaborators whose names were later to become household words in chemistry, that Baeyer carried out the long and varied series of researches which entitled him to be regarded as the founder of modern structural organic chemistry. One of his most famous pupils, W. H. Perkin, jun., to whom Baeyer became "the object of a lifelong intellectual devotion", selected his researches on indigo and its derivatives as "among the most brilliant in the whole range of organic analysis and synthesis", and characterized his "schwere, scheussliche und gefährliche" researches on the reduction of the phthalic acids as "so masterly in all their details that they must always remain as a monument to Baeyer's experimental skill and theoretical ability".

The book under review, which is the first comprehensive biography of Baeyer to be published, gives a concise and documented review of his contributions to organic chemistry; but it is chiefly remarkable for a good deal of new material, including some interesting illustrations, relating to Baeyer's ancestry, family circumstances and personality. In 1932, Prof. Hans Rupe, of Basle, published some charmingly written reminiscences of life in Baeyer's laboratory in the early 'nineties of the past century (*Nature*, 131, 294; 1933). This and other sources have been drawn upon by the present biographer in building up an edifying picture of the personality of this great chemist. In these references the celebrated 'Bleikammer', or 'lead chamber', naturally looms largely; such was the name given to the room in which Baeyer submitted students of pharmacy and medicine to oral examinations, which included, at one time, exhaustive questions on the lead-chamber process for making sulphuric acid.

Baeyer had certain unorthodox characteristics as an examiner, such as turning his back upon the candidate, giving him abruptly a time limit for each question, and tapping impatiently with his pencil while the unhappy victim was considering what to say. "What do you see having a red colour when you go into a pharmacist's shop? You have two minutes in which to answer." On such occasions Baeyer was apt to formulate questions designed (in his opinion) to make the candidate think, rather than to reproduce book knowledge. One can imagine the *Examensangst* (expressive word !) of an aspiring pharmacist when asked suddenly : "What happens when a red cyclist collides in the street with a Munich tramcar ? You have three minutes in which to answer". When the second-hand of the examiner's watch reached the prescribed mark without the astonished candidate having referred to the effect of bringing together the primary red and blue colours, Baeyer would admonish him : "Sie müssen denken lernen !" Naturally, there was another side to all this, and at intervals unofficial collections of Baeyer's questions were issued in the form of a 'swot book', or, to give it a more dignified name, an *Examensfragenheftchen* ; and Baeyer found it increasingly difficult to hit upon new questions.

Altogether, this is an informative and entertaining book, deserving of a wide welcome from chemists and others.

JOHN READ

## PSYCHIC REMINISCENCES

### Telepathy and Spiritualism

Personal Experiments, Experiences and Views. By Dr. J. Hettinger. Pp. 150. (London : Rider and Co., 1952.) 16*s*. net.

### Psychic Oddities

Fantastic and Bizarre Events in the Life of a Psychical Researcher. By Hereward Carrington. Pp. 183. (London : Rider and Co., 1952.) 16*s*. net.

IN these two books by, respectively, Dr. J. Hettinger and Mr. H. Carrington, the authors summarize some of their experiments and conclusions in psychical research.

The first is an account of Dr. Hettinger's personal attempts to arrive at the truth regarding telepathy and spiritualism. In the course of his discussion he provides abstracts of some of his previously published works, including his two books, "The Ultra-Perceptive Faculty" and "Exploring the Ultra-Perceptive Faculty", which deal with his investigation of the alleged faculty of certain persons whereby paranormal knowledge is gained about a person or thing through the use of some object acting as a key or pointer. From the simpler type of experiment, Dr. Hettinger proceeded to an interesting and ingenious "pictorial method" in which he attempted to show that the transmission of the content of illustrated matter could be conveyed to a percipient. with results so far in advance of what might be expected by chance or other normal factor that a paranormal explanation had to be invoked.

Before dealing with his own experiments, Dr. Hettinger briefly discusses those of some of his contemporaries, including Dr. S. G. Soal, Mrs. M. Goldney, Mr. Whately Carington and Dr. J. B. Rhine. With regard to many of these experiments, he is of the opinion that they do not, as is often claimed, test the existence of any psychic faculty through statistical evaluation or ascertain the functioning of such a faculty as regards past, present and future.

Although Dr. Hettinger is convinced of the validity of his own findings and their value as pointing the way to various further possibilities, he does not appear to have dealt seriously with the published criticisms of his experiments in relation to the chance factor, bias in the assessment of the results, and inadequacy of the control material. Although, at first sight, it would appear that many of his results are clearly due to the operation of some unknown factor, this feeling is much weakened by a careful scrutiny of the conditions and by the omission in the printed accounts of details clearly necessary to any fair appraisal of the facts. Although the book has both an index and a bibliography, only two items in the latter are dated, and only two give the place of publication, omissions which, in a work of this kind, are difficult to excuse.

In his "Psychic Oddities", Mr. Hereward Carrington, the veteran American psychical researcher, has put together a number of his personal reminiscences coupled with a selected number of odd experiences recorded by others. Unlike Dr. Hettinger, he has made but a few lengthy series of experiments himself, and in this volume he is content to give the reader a lively sketch of mediums, research workers and magicians he has known, interspersed with many amusing anecdotes. Unfortunately, Mr. Carrington has failed to provide adequate documentation for the stories he tells, and thus the reader is debarred from following up the material, tracing it to its source and then judging whether there is any case to answer.

E. J. DINGWALL

## DUNS, SPINNERS AND SEDGES

### An Angler's Entomology

By J. R. Harris. (New Naturalist Series.) Pp. xv+268+48 plates. (London and Glasgow : Wm. Collins, Sons and Co., Ltd., 1952.) 25*s*. net.

TO the entomologist the fly-fisher's nomenclature is baffling. His almost mystic faith in some particular artificial fly, on a particular stretch of water, on a particular evening is impressive, especially when he is successful ; and yet, somehow, it savours far more of chance than of sound intention.

Mr. J. R. Harris takes us right into the heart of these arcana, not as an iconoclast debunking the whole mystery but as an angler and entomologist who, more successfully than his predecessors, has tried to make sense of it. His is the right approach for the fisherman, because it starts from what he knows and has experienced—from his 'known' to his 'unknown'. This book is not a treatise on aquatic entomology : it is what it purports to be, an angler's entomology dealing with the questions the intelligent angler asks and the information he seeks. Without obtruding systematic entomology, it brings the work of Kimmins and Hynes—to mention only two systematists—to the assistance of the fisherman in unravelling the almost bewildering assortment of names given by his forbears to the flies he uses and the insects he sees.

It deals first with the Ephemeroptera or mayflies (duns and spinners), describing without too much detail their life-histories and habits, their enemies and their place in classification. Then follows a similar but shorter account of the Trichoptera or caddis-flies (sedges), the Perlidæ or stone-flies and a few Diptera like *Bibio* and the Chironomids. All this is straightforward, sound entomology. Next in the final third of the book come chapters on "Period Flies and Fish", on the taste and sight of fish, on those flies which are more attractive to fish and on fly dressing. There are four appendixes giving a list of angler's insects, keys to duns and spinners, descriptions of Ephemeroptera and hints on fly dressing.

The book is handsomely illustrated: one illustration in particular, of a stretch of water on the River Teith, gave me a sharp fit of nostalgia. Distribution maps and a good bibliography complete the angler's fare.

The special interest of this book lies in its combination of fisherman's lore and entomological science, in which neither is allowed for too long to dominate the other. Some of the author's comments are shrewd and worth noting, such as that while dichotomous keys afford the best scientific means of identifying an insect, really the best way is to be so familiar with the insect as to know it by sight, a method employed long after the diagnostic characters of the key have been forgotten. How true we know that to be. Then it is interesting to note that it may be more easy to identify an insect not from a dead specimen but from its effigy. Here again, long experience and intuition, only to be passed on in practice, can remind the man of science that his vocabulary is still too limited or his observation subconsciously too acute to allow him to record and describe all.

To me the best thing about this book is that the author never suggests that angling may become a science. To him, as to all true anglers, it is an art, and it would indeed be a bad day for us if all the rods on the river were equally lucky because everyone knew which ephemerid to put on. There are two questions one would like to ask the author: Why are the *Caenis* species called the "Angler's curse" and what has happened to "Jock Scott"?

J. W. Munro

# REFERENCE BOOK OF INTERFEROMETERS

## Modern Interferometers

By C. Candler. Pp. 502. (London: Hilger and Watts, Ltd., 1951.) 57*s.* 6*d.* net.

For many years Ewart Williams's "Applications of Interferometry" has been a standard British reference for physicists: the fact that a hundred-page monograph should occupy such a position for so long is evidence of the need for a more comprehensive work on interferometry. C. Candler's book goes far to satisfy this need. Whereas Williams treats the subject from a theoretical point of view and describes interferometers as examples of a particular class, Candler generally discusses a whole range of instruments in a more-or-less arbitrary order. For this reason the book is somewhat discontinuous, but is very suitable for the practical scientist who wishes to learn something about an instrument he has to use. Two-thirds of the book are devoted to interferometers, and the remainder to diffraction gratings.

The first chapter outlines the proposed arrangement of the material adopted. Instruments are to be grouped according to their functions: the measurement of difference in optical path, of length, of wave-length and of refractive index, and the analysis of hyperfine structure. This system is barely recognizable in the ensuing chapters, however. Chapter 2 deals with suitable light sources and factors affecting the widths of spectral lines, while Chapter 3 discusses the fundamental standards of length, although descriptions of the determination of the length of the metre in terms of light wave-lengths are deferred to Chapters 5 and 19.

Chapter 4 deals with interference effects in thick plates and thin films, and includes accounts of non-reflecting films, interference filters and surface finish; in connexion with the last, it is misleading to suggest that the technique adopted by Timms is very similar to that employed by Tolansky, as in only one of these is multiple-beam interference utilized. The next three chapters describe the principle and application of the Michelson interferometer and its derivative due to Twyman and Green. Bates's wave-shearing interferometer receives only two pages, with the Mach–Zehnder interferometer mentioned only (a diagram of one version of this instrument is also included at the end of the book). An account of the latter applied to the examination of fluid flow, as in wind tunnels, would have been a useful addition.

Interferometers used in the measurement of length and angle gauges are described in Chapter 8. The inclusion of an optical measuring machine and an optical comparator, neither employing interference, appears irrelevant. In Fig. 8.3 (p. 195) the author states that the prism has been drawn oversize "to avoid violating the laws of optics": a more serious violation is the inclusion of an eyepiece in the diagram, as with this arrangement the observer merely views an image of the pinhole. The eye is, of course, placed in the plane of the pinhole; a telescope of low power can both transfer this to a more convenient position and slightly magnify the gauges under examination.

Chapter 9 describes the Fabry–Pérot étalon and its use in the determination of the metre, while the next chapter deals with the stellar interferometer. Reflexion and transmission échelons are considered in some detail in two further chapters. An an illustration of the rather discontinuous treatment, Chapter 13 returns to the Fabry–Pérot étalon, dealing with its application to the measurement of wave-length and to the analysis of hyperfine structure. A chapter is allocated to the Lummer–Gehrke plate: the statement that this interferometer employs a process combining diffraction with refraction should surely read—reflexion with refraction. Four chapters on diffraction gratings follow, covering plane and concave gratings, their ruling, properties and methods of mounting. A short account of grating replicas is included; but no mention is made of developments during the past few years. Three short, concluding chapters describe the Fabry–Pérot étalon as a refractometer, and the Rayleigh and Jamin refractometers.

Numerous references are listed at the end of each chapter, with additional ones given in an appendix. The book already covers an enormous field, but, from the point of view of completeness, micro-interferometers might well have been included; the only reference is two paragraphs on the interference microscope. Space could have been found by the omission of irrelevant material, such as the examples quoted. Diagrams and script are clear, and the style is very readable. Because of the distribution of material, however, it is more suited as a book for reference than for general reading.

K. J. Habell

# BASES OF MICRO-CLIMATOLOGY*

By SIR DAVID BRUNT, F.R.S.

THE most fundamental factor which has to be taken into account in micro-climatology is the incoming solar radiation by day, and the long-wave radiation and absorption by the atmosphere and the surface of the ground. Over bare soil the absorption and emission of radiation by the earth are both brought about by a very thin layer of soil. When the soil has a covering of vegetation, the effective locus of both absorption and radiation may be situated at any level between the solid surface of the ground and the top of the vegetation, and this locus may be a layer the depth of which will depend on the character of the vegetation.

The main factors which control the change of temperature of the surface and of the air in contact with it, as a result of the transfer of heat by radiation and absorption, are the nature of the soil, soil drainage, vegetation, contour of the ground, aspect of the ground and nearness to large sheets of water.

## Climatology of Bare Soil

The climatology of bare soil is relatively simple. When the surface of the ground is heated by the absorption of incoming solar radiation by day, or cooled by the loss of heat by long-wave radiation by night, the gain or loss of heat at the surface is in part compensated by conduction to or from lower layers. It can be shown that in given meteorological conditions, or in other words, for a given rate of gain or loss of heat from the surface, the rate of change of surface temperature is proportional to $1/\sqrt{ks}$, where $k$ is the coefficient of thermal conductivity of the soil, and $s$ is its heat capacity[1]. Since soil is an aggregation of solid particles with the spaces between them filled with air or water, both the conductivity and the heat capacity will depend upon the extent to which these spaces are filled with air or with water. Since both the conductivity and heat capacity of air are very small, it follows that for a soil containing much air $1/\sqrt{ks}$ will be great, and surface temperature will vary rapidly when there is a net gain or loss of heat at the surface. Thus a sandy soil will have a large diurnal variation of surface temperature, and this is well exemplified by a comparison of meteorological observations at South Farnborough, on a sandy soil, with simultaneous observations at Croydon, on a chalky soil. The observations were taken during March 28–29, 1933, during a short spell of clear weather. (The Rickmansworth observations will be referred to later.)

Table 1

| | Max. March 28 | Min. March 29 | Range |
|---|---|---|---|
| Croydon | 65° F. | 35° F. | 30° F. |
| South Farnborough | 69 | 30 | 39 |
| Rickmansworth | 66·9 | 21·4 | 45·5 |

Thus the lighter the soil the warmer will be the clear afternoons and the colder the clear nights.

When the air within the soil is partially replaced by water, which has a higher conductivity and heat capacity, the variability of temperature is diminished. The fact that the fall of temperature from sunset to sunrise is much greater in summer than in winter, in spite of the fact that the time-interval from sunset to sunrise is much longer in winter than in summer, is due to the higher water content of the soil in winter. Water-logged soil has a lower diurnal variation of temperature than dry soil, or well-drained soil; but on undrained soil the evaporation of water from its surface maintains the surface temperature at a lower level by day and by night than on the same soil when well drained.

Soils may be arranged in the following order of decreasing diurnal variation of surface temperature: sandy soil, light loam, chalky soil, heavy loam and clay.

On clear nights the surface temperature of snow falls well below that of bare soil, since snow is about nine-tenths air. But, underneath a layer of snow only a few inches deep, the ground temperature has been observed to remain steadily at 0° C., while the upper surface of the snow varied from − 15° to − 4·6° C.

## Effect of Vegetation

The air above grass is colder by night and warmer by day than air above a bare surface. This is the joint effect of the trapping of air between the grasses, and of the poor conductivity of the soil-layers in which the roots are embedded. The first cause is more effective among tall than among short grasses, while the second may have very great effect where the grass root systems form a mat of horizontally running stems below the surface of the soil, such as one finds on the Romney Marshes. Evaporation from the surface of the grass leaves must also contribute to the lower night temperature.

A. Ångström[2] found that, in a field of grass 1 m. high, the incoming solar radiation was 1·08 cal. $cm.^{-2}$ above the grass, decreasing to 1·04, 0·28 and 0·19 cal. $cm.^{-2}$ at 0·5, 0·1 and 0 m., respectively, above the ground surface. The highest afternoon temperature and the lowest night temperature might thus be expected to be about 10–20 cm. above the ground, where the grasses are dense enough to absorb most of the radiation downwards. The same layer should be the effective outward radiating surface at night, and so the level of lowest temperature.

Similar results were derived by R. Geiger[3] in a field of winter rye. When the rye was short, radiation passed readily down to the ground; but after its height had grown beyond 0·5 m., the lower leaves showed rapid growth and formed the effective absorbing and radiating layer. The highest temperature by day and the lowest temperature by night were to be found at the highest level at which the lower leaves formed an effective obstacle to the downward passage of solar radiation by day and the upward passage of long-wave radiation by night. As the crop ripens the lower leaves wither, and the height at which the day and night extremes of temperature occur decreases but does not fall to zero. Cornfields surrounded by meadows are found on sunny afternoons to be sources of strong convection currents, in which a sail-plane can soar readily.

Within a bed of antirrhinums, at an early stage of growth the horizontal leaves offer a complete barrier to the passage of radiation in either direction. With well-developed plants the highest temperature during the afternoon is at about the level of the uppermost leaves, while the temperature falls off with distance from this level both upwards and downwards. Again, on a clear night the upper leaves form the effective outward radiating surface of the plants. The air cooled by the cold leaves can sink down to the ground, while partially mixing with the air below. The result is to yield the lowest air temperature at the ground, with an inversion of temperature up to levels above the uppermost leaves of the plants.

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* Based on a lecture delivered at Wye College, Kent, on December 4.

In a forest with a thick canopy of leaves, the uppermost layer of the canopy is the effective absorbing and radiating layer. On a sunny day the ground below the trees, and the air immediately above it, remain cooler than the ground and the air above it in the open. On a clear night the air cooled by contact with the upper leaves of the canopy sinks to the ground, with the result that the air immediately above the ground is slightly colder than the air at the level of the canopy. In clear weather the air temperature at the ground is at all times lower than that of the air at the top of the canopy, and is lower by day and higher by night than the air temperature over open ground.

In a wood which has not a complete canopy of leaves, or among such plants as raspberry canes, some sunshine penetrates to the ground, and some is absorbed by the trunks of the trees. Day temperatures will then be intermediate between those in a forest with dense canopy and those in the open.

Some typical temperatures, observed by C. E. Cornford at East Peckham, Kent, on the morning of May 30, 1937, are given in the table below[4], these being minimum temperatures measured at 3 ft. above the ground.

Table 2

| | | | |
|---|---|---|---|
| Bare soil | 49·5° F. | Meadow close cropped | 45·7° F. |
| In wood | 49·0 | Meadow longer grass | 43·0 |
| Among raspberry canes | 48·2 | Grass and clover | 43·5 |

An unusual type of vegetation, judged by our experience of British trees, is the mallee scrub of Australia. The individual mallee tree has a number of trunks growing up from the same root, and its leaves hang downward vertically. The leaves thus help to check the horizontal movement of air, but allow radiation from the ground to pass outward freely, so that the temperature falls well below that over open ground. Any area covered with mallee scrub acts as a source of cold air.

## Effects of Contour

On a clear night the surface of the ground is cooled by radiation, and cools the air immediately above it. The cooling of the air is greatest over grass, especially over long grass. On sloping ground the cold air flows down the slope much as water would, yielding what are known as 'katabatic winds'. The cold air flowing downhill fills any hollow in the ground, and accumulates at the foot of the slope unless there is some ready exit which it can follow. The effect of accumulation in a valley-bottom of cold air from the slopes above is illustrated by the data in the last row of Table 1. The data refer to a station in a little sheltered valley which runs into the valley of the River Chess about halfway between Rickmansworth and Chorley Wood. At this station the diurnal range of temperature was 50 per cent higher than at Croydon. It is clear that neither a sheltered valley nor the lower reaches of an extensive grass-covered slope can offer an ideal location for either a home or an orchard. In some cases it is possible to deflect the current of cold air sideways by means of a diagonally running wall or thick hedge, or hessian screen, and so minimize the discomfort or damage such cold air can produce.

It was noted earlier in this article that over a snow surface the air can cool at night to temperatures far below those which would be found over bare or grassy ground similarly situated. Sloping snow-covered ground can therefore produce very strong katabatic winds, which can attain very high speeds down valleys which are fed with cold air from the sloping sides over extensive areas. Very strong katabatic winds are formed in this manner in valleys on the Antarctic continent.

## Effect of Aspect

B. A. Keen[5] states that on a slope facing south the soil temperature at 1½ in. below the surface may be as much as 15 deg. F. higher, with a correspondingly lower moisture content, than on a slope facing south. Aspect can thus have an important bearing on the local climate.

## Effects of Nearness to Large Sheets of Water

The diurnal variation of the surface temperature of deep water is small enough to be negligible by comparison with that of the ground, and places near large sheets of deep water will have a climate comparable with that of the seaside.

[1] Brunt, D., *Quart. J. Met. Soc.*, 58, 39 (1932).

[2] Ångstrom, A., *Geog. Ann.*, 4 (1925).

[3] Geiger, R., "The Climate near the Ground" (Harvard Univ. Press, 1950).

[4] Cornford, C. E., *Quart. J. Roy. Met. Soc.*, 66, 553 (1938).

[5] Keen, B. A., "The Physical Properties of the Soil", 290 (London: Longmans Green and Co., Ltd., 1931).

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# BIOSYNTHESIS AND ENERGY TRANSPORT BY ENZYMIC REDUCTION OF 'ONIUM' SALTS

By Dr. D. W. WOOLLEY

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THERE has been such marked success in the understanding of the mechanism of simple enzymic syntheses, and of how energy is transferred in the course of carbohydrate metabolism, through use of the concept of an energy-rich phosphate bond such as that contained in adenosinetriphosphate, that among biochemists it is generally conceded that both the synthesis of a variety of chemical constituents of living matter, as well as the controlled transfer of energy in processes of life, probably occur through the functioning of 'active' or energy-rich phosphate esters and anhydrides. The purpose of this article is not to dispute this concept, because a vast amount of existing evidence makes it seem quite probable that carbohydrate fuel is burned, and the energy is captured for other vital functions by the intervention of such phosphorus compounds. Rather, it is my purpose to point out that living matter contains enzymes which bring about special types of syntheses, and that these reactions are not driven directly by the energy contained in phosphate compounds. In fact, phosphorus is not concerned in some of the biochemical syntheses. The energy which appears to drive these reactions seems to reside in quaternary ammonium ions or in sulphonium ions, and is liberated when these 'onium' compounds are reduced during the course of the reaction. In the case of the quaternary substances the reduction is from nitrogen of a valence of 5 to tertiary bases in which nitrogen has a valence of 3, while in the sulphonium compounds sulphur changes in valence from 4 to 2. The term 'valence' is used here because it simplifies the presentation. It denotes merely the number of bonds. However, the electronic transfers can be appreciated much more if one states that nitrogen in the quaternary ammonium compound acquires a pair of unshared electrons when it passes into the tertiary base. In the quaternary compound, this pair was shared with a carbon atom as a covalent bond. In other words, nitrogen in the tertiary base has acquired sole possession of the two electrons which, in the quaternary salt, it shared with carbon. Similarly, with the sulphonium compounds, the changes in shared electrons are not emphasized by the use of the term 'valence'.

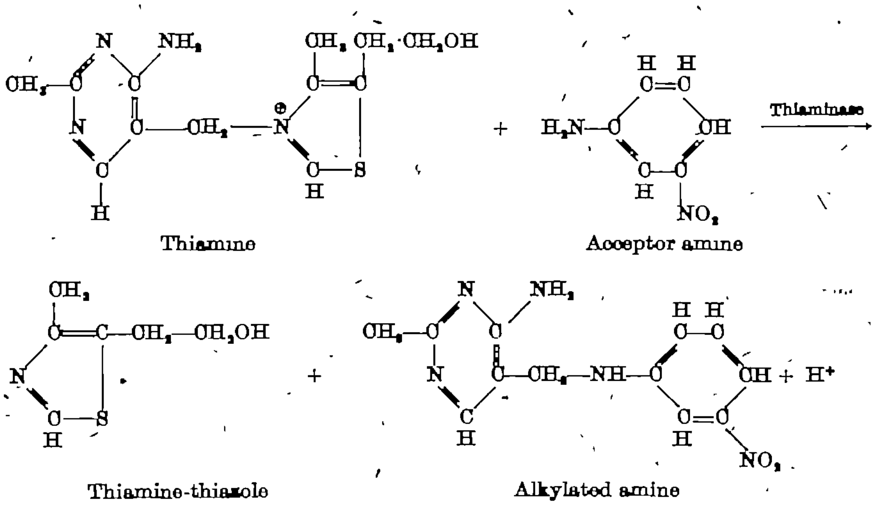
It seems probable, as will be discussed below, that some peculiarly useful properties arise from reactions in which 'onium' compounds are reduced, and that living organisms may employ them partly for this reason. In any event, these enzymic syntheses through the reduction of 'onium' compounds constitute a new mechanism for the formation of special substances and for the transfer of energy in living organisms.

The views of the author on this subject have arisen from a study of the enzyme of carp which destroys thiamine (aneurine, vitamin $B_1$). Because of this, let us consider the action of this enzyme, and substantiate the argument with other examples which have arisen in recent years.

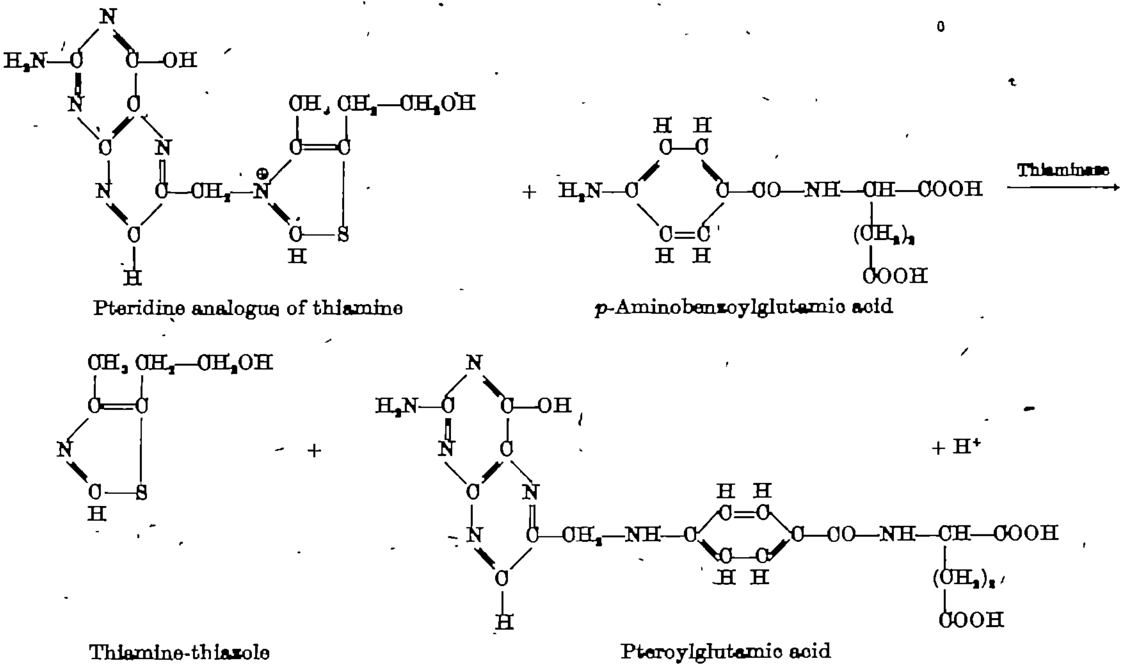
The existence of carp thiaminase, that is, an enzyme in carp which actively destroyed thiamine, was detected in 1941[1,2] after it had been noted that the feeding of ground raw fish to foxes called forth an epidemic disease which could be prevented or cured by injection of this vitamin[3]. The enzyme could be extracted from the fish by means of hypertonic salt solutions, and could thus be obtained free from cells. Subsequent investigations by many workers have revealed a similar enzyme to be present in such diverse living things as clams, several species of fresh-water fish, certain micro-organisms, and bracken ferns[4]. Somogyi[5] has also detected the ability of mammalian organs to destroy thiamine, although, in my experience, this ability of mammalian tissues, if it exists, is slight in comparison with that of carp and clams. Nevertheless, such thiamine-destroying enzymes seem to be widely distributed in diverse organisms.

The fact that carp extracts actually destroyed thiamine and did not merely sequester it was shown by the isolation of the products formed[6]. This demonstration, along with the heat lability and dependence on pH and temperature of the vitamin-destroying activity of the tissue[6], indicated that an enzyme was involved. This enzyme was called 'carp thiaminase'. It has been purified by ammonium-sulphate fractionation[7]. The products which it formed were the thiazole moiety of thiamine (that is, 4-methyl-5-hydroxyethylthiazole), and a conjugate which contained the pyrimidine portion of the vitamin. A secondary reaction proceeding in carp tissues was recognized. This led to the formation of the free pyrimidine moiety of thiamine, 2-methyl-4-amino-5-hydroxymethylpyrimidine, from the conjugate formed in the main reaction. Clearly, then, the enzyme attacked thiamine and liberated the thiamine-thiazole, and at the same time attached the pyrimidine half of the vitamin to something else. It is in this latter process—the attaching to something else—that the synthesizing action of the reaction becomes clear.

The nature of this 'something else' was made plain by the work of Sealock and Davis[8]. Earlier investigators[6] had found that the action of carp thiaminase was greatly reduced when solutions of it were dialysed. The dialysable component, which was stable to heat, was considered to be a coenzyme. However, there was a strange property of the reaction which had caused much wonder in the early investigations. This was that a given quantity of enzyme would destroy a definite amount of thiamine very rapidly; but when more substrate was present, no more was destroyed, even during prolonged incubation[6,7]. Sealock and Davis recognized that the enzyme had two substrates, both of which must be present for the reaction to proceed. One substrate was thiamine and the other was the dialysable component. However, the second substrate was not specific, because any one of a variety of amines could serve. Thus, in the work of Sealock and Davis, either *meta*-nitroaniline, or *meta*-aminobenzoic acid was effective. In clams, this second substrate appears, from the work of Barnhurst and Hennessy[9], to be probably the amino-acid taurine (positive identification has not yet been accomplished, but the evidence in Barnhurst and Hennessy's and subsequent papers strongly suggests that the situation is as stated). So long as both substrates, that is, thiamine and a suitable second component, were fed into the reaction system, the enzyme continued to function, and did not stop in the puzzling fashion just mentioned[7,8]. The very



Equation 1. Carp thiaminase reaction with *m*-nitroaniline as acceptor



Equation 1. Synthesis of pteroylglutamic acid by the action of carp thiaminase

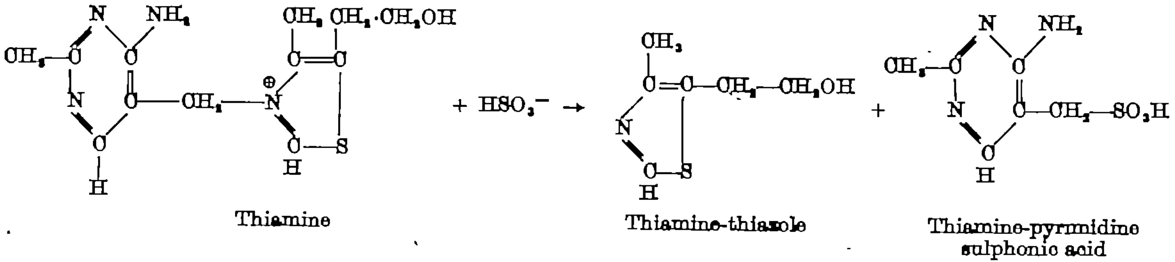
great activity of carp tissues in destroying thiamine can only be appreciated when the second substrate, which we may call the acceptor amine, is added. In fact, measurements of the quantity of thiaminase in tissues which were made prior to this discovery are of very questionable value. The true enzymic content can only be found when both substrates are present in excess.

The reaction catalysed by thiaminase can now be formulated in the manner shown in equation (1). The biochemical synthesis which this enzyme brings about thus becomes plain. It is the alkylation of the acceptor amine with the pyrimidine portion of the thiamine molecule. In the case of clam tissue studied by Barnhurst and Hennessy[9], the synthesis involves the alkylation of taurine (the acceptor amine) with this same alkyl group. The product is apparently what has been called 'icthiamine'[4]. Because several primary aromatic, and several aliphatic, amines can each be used readily by the enzyme as its second substrate, a variety of new substances can thus be formed. Some of these products have a complexity of structure which it is gratifying to find an enzyme can produce.

The synthesizing abilities of the enzyme became clear when it was possible to induce it to form a compound of widely-recognized biochemical importance, namely, pteroylglutamic acid[10]. The products formed from thiamine and acceptor amine are, as we have seen, thiamine-thiazole and alkylated acceptor amine. Pteroylglutamic acid may be viewed as an acceptor amine (p-aminobenzoylglutamic acid) which has been similarly alkylated. The only difference is that the alkyl group has been a pteridylmethyl rather than a pyrimidylmethyl. If, then, the proper pteridine analogue of thiamine were prepared in which the pteridine portion of pteroylglutamic acid replaced the thiamine pyrimidine, and if this quaternary salt were mixed with p-aminobenzoylglutamic acid and carp thiaminase, one could reasonably expect some pteroylglutamic acid to be formed (see equation 2). Actual experiment showed that some was, indeed, synthesized[10]. The reaction did not proceed as readily as was the case when thiamine, rather than its pteridine analogue, was one of the substrates. However, this may not be too surprising when the structural differences of the two analogous substrates are remembered. Although this synthesis of pteroylglutamic acid can thus be demonstrated *in vitro*, there is no reason for believing that the actual formation in living organisms follows this course. Rather, this seems to be an experimental model to illustrate the synthetical capabilities of this enzyme.

What is the source of the energy which brings about these syntheses? The reactions proceed with great speed in the absence of any dialysable phosphorus compounds. The true nature of the process can best be appreciated if one recalls a well-known, non-enzymic cleavage of thiamine. The vitamin reacts readily with bisulphite ions according to the scheme shown in equation (3). What is new about this reaction is to recognize that it is an oxidation-reduction. The sulphur in bisulphite is tetravalent, whereas that in the pyrimidine-sulphonic acid is hexavalent. Similarly, the quaternary nitrogen of thiamine is pentavalent, and the tertiary nitrogen of thiamine-thiazole is trivalent. In the reactions catalysed by carp thiaminase, a similar reduction of the quaternary nitrogen takes place. In both cases thiamine is the oxidizing agent, the quaternary nitrogen of which is reduced during the reactions. The author feels that this reduction of the thiamine nitrogen is the source of the energy.

Recently, a series of four papers has appeared in which the true nature of the thiaminase reaction is concluded to be that of base exchange[11]. Pyridine was found to react with thiamine in the presence of the enzyme to give a small yield of a substance in which the thiamine-thiazole was replaced by an unsubstituted pyridine ring with the thiamine-pyrimidylmethyl group attached to the pyridine nitrogen (see equation 4). This exchange of pyridine

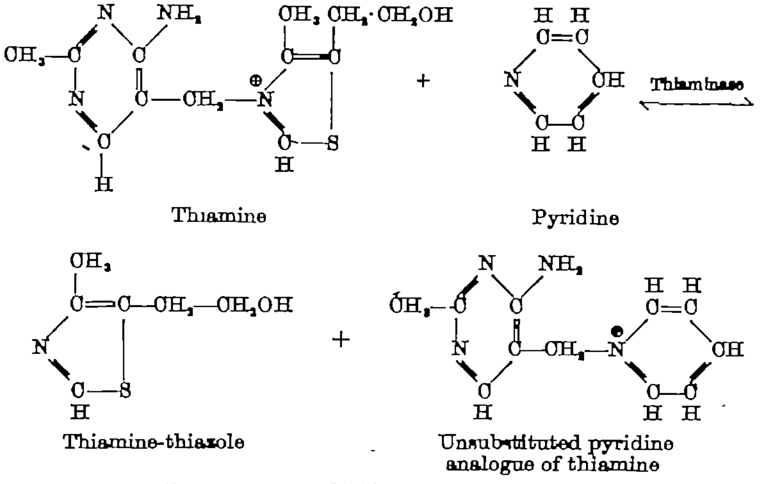


Equation 3. The well-known non-enzymic sulphite-cleavage of thiamine

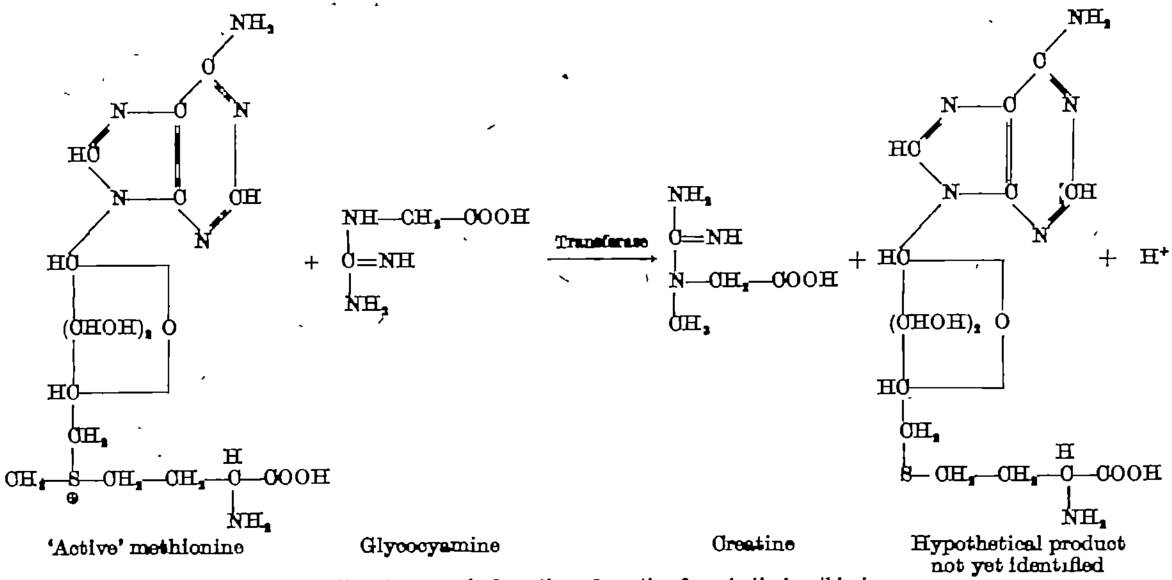
for thiamine-thiazole was found to be reversible in the presence of the thiaminase. The alkylation of primary amines in the manner in which we have been discussing was considered as just one more example of the base-exchange catalysed by thiaminase. To me, the emphasis on the base-exchange character of the reaction obscured the aspect of energy transport and ionic change (to be discussed presently), which are more important in the understanding of the real processes involved. The exchange of thiamine-thiazole for pyridine might easily be the result of a slightly lower energy-level of the unsubstituted pyridine analogue of thiamine when compared with the vitamin itself. The fact that this exchange was readily reversible by manipulation of the relative concentrations of the reactants and products might be in favour of such a view. On the other hand, I am not aware of any experiment in which thiaminase has been shown to reverse the alkylation of primary amines. Thus, when relative concentrations of the substances in equation (1) are manipulated, no one has yet been able to observe any synthesis of thiamine. The only way in which thiamine has yet been formed in such a situation is to utilize the energy of a glycolytic system. Thus, Barnhurst and Hennessy[9] have shown that although icthiamine (presumably taurine alkylated with the thiamine-pyrimidylmethyl group) plus thiamine-thiazole does not yield any thiamine in the presence of thiaminase, thiamine is formed when icthiamine and thiamine-thiazole are incubated with glycolysing yeast. In other words, the only way to reverse (or apparently to reverse) this reaction is to pour into the system a large amount of energy derived from the oxidation of glucose. In terms of the mechanical analogy to be discussed below, the quaternary storage battery must be recharged (that is, the nitrogen must be restored to the quaternary, pentavalent state) by the expenditure of the energy of glycolysis. Mere manipulation of concentrations of participants is not enough. In the case in which pyridine reversibly replaces thiamine-thiazole (as in equation 4), one still has a quaternary salt as the product, even though this pyridinium compound may perhaps be slightly less charged with energy than is thiamine itself. The difference in energy-level of the nitrogen in icthiamine or in the nitroaniline compound of equation (1), from that in the pyridinium salt, may well be of a different order of magnitude.

No exact calculations have yet been made of the change in free energy during the thiaminase reaction pictured in equation (1). This is partly because the position of equilibrium is very far to the right. The best approximations, from indirect measurements, have suggested a change in free energy of 7,000–8,000 Calories per mole. This value may require considerable revision in the light of future results.

Thiamine is by no means the only quaternary ammonium compound of recognized biochemical importance. One thinks also of cozymase (diphosphopyridine nucleotide), of triphosphopyridine nucleotide, of acetylcholine, of choline, and of carnitine, to mention only a few. Is there any evidence that enzymes exist which catalyse the reduction of such substances to tertiary bases in a manner similar to that pictured for the action of thiaminase on thiamine? Thus far only one (in addition to thiaminase) is known; but with the recognition of the basic phenomenon, a concerted search can be made which may uncover others. Up to the present time, progress has depended on chance discoveries. The other example is that of 'diphosphopyridine nucleotidase', or the enzyme which destroys diphosphopyridine nucleotide by cleavage at the quaternary link between ribose and nicotinamide. This enzyme was discovered by Mann and Quastel in mammalian brain and liver[11] and a similar enzyme has been found in other animal tissues. One such has been purified from the cultures of the fungus *Neurospora crassa*[12]. These enzymes attack the quaternary nitrogen in diphosphopyridine nucleotide, liberating nicotinamide, in which nitrogen has now a valence of 3. The other product is ribose-5 phosphate united in pyrophosphate linkage to muscle adenylic acid. This reaction differs markedly in at least one respect from that catalysed by thiaminase. With the diphosphopyridine nucleotidase, no acceptor amine is required; rather, water alone can be said to accept



Equation 4. Exchange of tertiary bases catalysed by thiaminase



Equation 5. Enzymic formation of creatine from 'active' methionine

the aldehydic end of the ribose phosphate portion of the molecule. With thiamine in the thiaminase process, there is no reaction without an acceptor more complex than water (that is, a suitable amine). It may well be that if a suitable acceptor for the diphosphopyridine nucleotidase could be found, the reaction would be greatly accelerated and the activity of the enzyme remarkably enhanced, just as was the case with thiaminase. If this were so, a rather complex molecule could be expected to form as the product, in which would be contained the ribosephosphate-adenylic portion of diphosphopyridine nucleotide.

The need to search for enzymes which act in this fashion on acetylcholine and other biologically important quaternary salts as one of their substrates seems self-evident.

Very recent disclosures have indicated that quaternary ammonium salts are not the only kind of 'onium' compounds which undergo the type of transformation just discussed. The work of Cantoni[14] on the nature of the so-called 'active' methionine has shown that sulphonium compounds exist in Nature and participate in certain important biochemical syntheses. The processes are so similar to those examined with the quaternary ammonium compounds that they warrant our attention. When either creatine or N-methylnicotinamide is synthesized in mammalian tissues, the methyl group which appears in these products arises from the terminal methyl group of methionine. However, methionine itself will not react. Rather, it must be activated by the intervention of adenosinetriphosphate and a special enzyme. When this special enzyme acts on adenosinetriphosphate plus methionine, 'active' methionine is formed. Cantoni was able to isolate this 'active' methionine, and showed, much to his surprise, that it did not contain phosphorus. (The old and established belief would have pictured the phosphorylation of methionine in order to activate it.) Rather, he showed that the 'active' methionine was a sulphonium salt in which adenosine had been added to the sulphur atom of methionine, thereby raising its valence to 4 as illustrated in equation (5).

This 'onium' salt is one of the substrates of the specific enzymes which transfer the methyl group. The second substrate is glycocyamine for the enzyme which synthesizes creatine; it is nicotinamide for the one which forms N-methylnicotinamide. (Because the product, N-methylnicotinamide, is itself a quaternary ammonium salt, it seems probable that the sulphonium compound is at a higher energy-level than the quaternary ammonium salts. The sulphonium compound, during reduction, can thus form a quaternary ammonium compound.) To me, the energy which drives these reactions has a source similar to that involved in the thiaminase reaction. It is the reduction of the sulphonium salt, in which sulphur has a valence of 4, to the divalent condition. In the course of this reaction, creatine or N-methylnicotinamide is synthesized. With such a mechanism in mind, the natural-occurrence in cabbage of a related sulphonium salt, namely, methioninemethylsulphonium chloride[15], has added interest.

We may well ask why Nature has troubled herself about this new mode of synthesis and energy transport. Why could she not have made do with the high-energy phosphate compounds alone? A mechanical analogy may help to clarify thinking about this question. Let us liken an organism to a motor-car. This rather elaborate mechanical contraption derives its energy from the controlled combustion of petrol, just as the living organism does by the combustion of carbohydrate. The modern motor-car has this major energy-yielding process rather well controlled. The coupling of the combustion to forms of useful work and to proper production of heat in desirable places has been neatly arranged. Nevertheless, for rather special purposes, for example, for lighting, it has been found much better to convert the energy into electrical forces, and to accumulate these in a storage battery for use when, and exactly when, required. Of course, one could still burn petrol in the headlights; but it is much better to have an electrical system. For ignition, this rather specialized form of energy is vital to the proper functioning of the main energy-yielding process. So also with living organisms, it may be found highly desirable, and possibly vitally important, to have other means of storing and utilizing energy. These oxidation-reduction reactions seem to be one of these specialized processes. The 'onium' compounds are the storage batteries in which this takes place. Just as in the motor-car, the recharging of these batteries is probably done by a reaction coupled to the main energy-yielding processes.

With this rather crude analogy in mind, let us examine two striking properties of the enzymic reduction of 'onium' salts which organisms may find useful. One is the ionic changes which result, and the other is the extraordinary speed of the reactions. When the quaternary ammonium compounds are converted into tertiary bases, or when sulphonium salts are similarly involved, one starts with a highly ionized but neutral salt, and ends with a weak tertiary base, which at physiological *p*H's is practically non-ionized. This fact arises from the strongly basic properties of quaternary ammonium bases, which are of the same order of basicity as is sodium hydroxide. Simultaneously with the obliteration of this ion, a hydrogen ion appears. The formation of acid, that is, a hydrogen ion, has, in fact, been used to measure both thiaminase[16] and diphosphopyridine nucleotidase[17]. Lorente[18] has recently remarked about similar ionic changes.

In the reduction of either thiamine or diphosphopyridine nucleotide, a relatively large organic ion disappears, and is replaced by a small hydrogen ion. Thus, not only is *p*H-control influenced, but also a more readily diffusible ion (the hydrogen ion) is suddenly formed.

The remarkable speed of the reduction of 'onium' salts warrants comment. Thus, the thiaminase of carp viscera will destroy all the added thiamine (provided the naturally occurring acceptor amines are in excess) in about five minutes[6,7]. The diphosphopyridine nucleotidase of brain is said to destroy an amount of cozymase equal to the dry weight of the brain in an hour[17]. While these great activities could be said to result from an extraordinarily large concentration of the respective enzymes in the tissues, the fractionations which have been carried out show that this is probably not the case. Hence we must conclude that the enzymes act with great speed.

In physiology, at least two processes are known to be associated both with remarkable speed and with the shift of ions. These are the propagation of nerve impulses and the contraction of muscles. Thus, the action potential is associated with, and may even be said to result from, the migration of potassium and sodium ions. The contraction of muscles depends on the migration of calcium and magnesium ions to the contractile substances[19]. One pictures these essential ionic changes as being caused by diffusion. However, recent work[20] has shown that diffusion based on osmotic differentials is much too slow to account for the observed speed of neural and muscular action. It is possible that the disappearance of the organic ion and the generation, on the spot, of the more readily diffusible hydrogen ion, might contribute to the real mechanism. The extraordinarily high speed of the reductions of 'onium' salts would be compatible with such an involvement. Furthermore, the prominent occurrence of 'onium' salts such as acetylcholine, thiamine, and diphosphopyridine nucleotide in nerves, and of carnitine in muscles is suggestive. Creatine, the role of which in muscular contraction has long been ascribed to creatine phosphate, might assume a second role, because, as we have seen, it is synthesized in muscle by an enzyme which acts on the 'active' methionine, a sulphonium salt, with concomitant ionic changes.

There is no real proof that these enzymic processes have anything to do with nerve transmission or muscular contraction. Even if the reduction of 'onium' salts should be found to be of importance in these processes, the actual compounds may be different from those discussed here. Nevertheless, enough circumstantial evidence is at hand to warrant further study.

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# OBITUARIES

## Prof. T. C. Hodson

Thomas Callan Hodson, who died at his home in Tisbury, Wiltshire, on January 26, aged eighty-one, was born at Hornsey, Middlesex, in December 1871. He was the son of Arthur Hodson, R.N., and Mary Catherine Hodson *née* Callan. The eldest of six children, he went to school at Christ's Hospital, where he became a Grecian, and left in 1890 to go to Queen's College, Oxford, with an Eglesfield scholarship. He took no degree at Oxford, but he competed successfully in 1893 for the Indian Civil Service and in 1894 went via Bengal to Assam. He served in the Khasia and Jaintia Hills, and was for some time personal assistant to the Chief Commissioner of Assam, Sir Henry Cotton. He served later on in the Manipur State, where he was president of the Durbar, but retired from the Service in 1901. He was registrar of East London (now Queen Mary) College during 1903–14; from 1914 until 1920 he served with the British Forces in France, and by 1919 had risen to the rank of colonel, and his services were mentioned in dispatches. During 1921–23 he was principal of Hornsey Rise Training College, and after that he lectured on anthropology in Oxford, London, Cambridge and Michigan, ultimately succeeding Dr. A. C. Haddon as reader in ethnology in Cambridge in 1926.

In 1932 the William Wyse chair of social anthropology was created in Cambridge, and Hodson was the first professor to hold it. He was elected to a professorial fellowship at St. Catharine's College, where he became a resident fellow and shared with no little satisfaction to himself and to his colleagues in the corporate life of the College. He had been secretary of the Royal Anthropological Institute during 1912–14, and he was later an associate editor of the "Encyclopædia Britannica" (14th edition). He held the Silver Medal of the Royal Society of Arts.

As an anthropologist, Hodson was particularly interested in the linguistic side of his subject, and his first publication was a grammar of the Thado Kuki language (1906). His knowledge of Manipur and the Manipuris enabled him in 1908 to contribute a monograph on "The Meitheis" to the Assam Government's tribal series, which he followed with "The Naga Tribes of Manipur" in 1911. His lectures at the London School of Oriental Studies, delivered in 1922, were published by the Forlong Fund as "The Primitive Culture of India".

Hodson was endowed with intense industry and an unquenchable activity and persistence. As holder of the chair in Cambridge, he set himself unequivocally to popularize the Tripos of Archæology and Anthropology, and succeeded so well that when he retired in 1937 the numbers had gone up from about a dozen to quite four times that number. But it is on account of his own personality that he will be best remembered: decidedly irascible, very intolerant of control or of opposition, he never forgot a kindness shown to him, and all those who followed his varied and rather stormy vicissitudes combined in admiration of his tenacity and fortitude in what were often very difficult circumstances.

In his family life Hodson was extremely happy. His wife and children were as devoted to him as he was to them, and the successes of his children more than made up for the disappointments of the earlier part of his career.

J. H. HUTTON

## Dr. H. G. Reeves

HARRY GORDON REEVES, senior lecturer in biochemistry in the Medical College of St. Bartholomew's Hospital, London, died on November 22 at the age of fifty-eight, following a recurrence of the severe bronchitis which had caused him considerable discomfort and ill-health in recent winters.

Dr. Reeves's professional career can be divided into two distinct parts. He took his B.Sc. degree with honours in chemistry in 1920 at Birmingham, where he also took the degrees of M.Sc. (1921) and Ph.D. (1924). In the latter year he became a demonstrator in the Physiology Department at King's College, London, and in 1928 he took his D.Sc. degree and became a demonstrator in the Physiology Department at St. Bartholomew's Hospital, a post which entailed heavy and varied teaching duties. Thus Reeves had few further opportunities for doing research; but on the other hand, he acquired a knowledge of all branches of physiology which was to stand him in good stead during his career as a teacher of biochemistry. He made useful contributions to our knowledge of the metabolism of dihydroxyacetone in muscle and other tissues, but it is by his teaching that Gordon Reeves will be remembered.

It was during the second phase of his service at 'Barts', starting in 1936 with his transference to the newly created Department of Biochemistry and Chemistry, that Reeves grew to full stature as a university teacher. Promotion came fairly rapidly. After a short period as demonstrator, he became lecturer and then senior lecturer in biochemistry—a well-deserved recognition of the good work he did during the war-time housing of the Preclinical School at Cambridge and the subsequent period of rehabilitation and expansion in Charterhouse Square.

As a teacher of the fundamentals of biochemistry in relation to medicine, Reeves was first-rate. There is surely a place in academic life for senior teachers of his type, and fortunate is the head of any large department who can call at any time on the services of such a versatile, capable and loyal colleague. Many hundreds of students who have passed through the Preclinical School at 'Barts' have good reason to be grateful to him. His colleagues are the poorer by the loss of a cheerful and ever-willing beloved friend.

A. WORMALL

# NEWS and VIEWS

## Scientific Research and the Ministry of Supply: Sir Harry Garner, K.B.E., C.B.

AFTER thirty-six years of government service, Sir Harry Garner retires on February 21 from his post as chief scientist of the Ministry of Supply, and will be succeeded by Dr. O. H. Wansbrough-Jones. Sir Harry had intended to become an astronomer; but in 1917 the demolishing of his office during an air-raid necessitated his transfer from the Royal Naval Air Service to the Royal Aircraft Factory (now Establishment), and it was there that, by virtue of his mathematical ability, he became known throughout the aeronautical world for his work on the 'Bristol' fighter aeroplane, in which he made the first measurements ever to be taken in flight on the aerodynamic rotary derivatives of an aircraft. He was the first to develop the fundamental techniques for testing sea-planes and flying-boats and of the hydrodynamics of hull design, and he has always been, and still is, a firm believer in the future of the flying-boat. In 1952 he gave the Wilbur Wright Lecture to the Royal Aeronautical Society, his subject being "Prophecy and Achievement in Aeronautics". Sir Harry has been in turn the chief technical officer of the Marine Experimental Establishment, the Aeroplane and Armament Experimental Establishment and the Airborne Forces Experimental Establishment. In 1942 he was made deputy director of scientific research in the Ministry of Aircraft Production, later becoming principal director of scientific research (air) in the Ministry of Supply, and in 1949 he succeeded Sir Ben Lockspeiser as chief scientist. In this last office he has successfully tackled the difficult problem of building up the scientific staff of the Ministry of Supply, despite the severe shortage of scientific workers, and, though pressed to deploy more effort on applied problems, he has insisted that a proper proportion of the staff should continue to tackle fundamental research problems. He has played a leading part in the extension of the scheme for making promotions to the higher grades in the Ministry solely on the scientific merit of a person's work, and he also introduced a scheme whereby university staff are employed in Ministry of Supply research establishments during the summer vacation; this has led to a much wider appreciation of the excellent facilities and conditions of employment in the Scientific Civil Service. Sir Harry retires with the good wishes of a very wide circle of friends that he may now have more time to pursue his wide interests and his hobbies, which include oriental ceramics (on which he is writing a book), music, antique furniture and gardening.

### Dr. O. H. Wansbrough-Jones, C.B., O.B.E.

Dr. Wansbrough-Jones, who has been appointed chief scientist in the Ministry of Supply in succession to Sir Harry Garner, has been since 1951 principal director of scientific research (defence) in the Ministry of Supply. He was educated at Gresham's School, Holt, and Trinity Hall, Cambridge, of which College he was a Fellow and Senior Tutor at the outbreak of the Second World War. He had earlier been a research student of the Goldsmiths and Salters Companies and a Ramsay Memorial Fellow, and he had studied in Berlin under Prof. F. Haber. Dr. Wansbrough-Jones was a demonstrator in the Department of Colloid Science when he left Cambridge for service in the Army. After serving in many advisory and technical posts, mainly in connexion with chemical warfare, he retired from the Army with the rank of brigadier in 1946, his last appointment being that of director of special weapons and vehicles at the War Office. He was then appointed scientific adviser to the Army Council, a post which his military experience and scientific knowledge enabled him to hold with distinction and marked success. In 1951 he was moved from the War Office to the Ministry of Supply at a time of heavy increase in the activities of the Ministry, and he has held up to the present an important executive post there. This recent experience coupled with his previous work as a scientific adviser have specially fitted him for the post of chief scientist in the Ministry, where his energy, drive and power of application will find full scope.

### Dr. W. Cawood, C.B.E.

Dr. W. Cawood takes over on February 23 from Dr. O. H. Wansbrough-Jones (chief scientist designate) the post of principal director of scientific research (defence) in the Ministry of Supply. After graduating in 1929 at the University of Leeds, Dr. Cawood read for his Ph.D. under Prof. R. Whytlaw-Gray, obtaining this degree in 1931 and at the same time winning the Cohen Prize. He then worked in the Chemical Department of the University until 1938, publishing a large number of papers with H. S. Patterson and R. Whytlaw-Gray on the coagulation and other physical properties of aerosols. He also worked with H. S. Patterson on the stoichiometrical determination of the atomic weights of carbon, xenon, nitrogen and fluorine. This work was the first to predict the existence of the carbon-13 isotope. During this period he was appointed a Ramsay Memorial Fellow (1931–33), and also Moseley Scholar of the Royal Society (1933–38). Dr. Cawood joined the Air Ministry in 1938, and during the Second World War worked on air armament, chemical warfare, bomb-sights and fire control. In 1947 he became deputy director of the Royal Aircraft Establishment, and since then he has made a substantial contribution to the Ministry of Supply programmes on guided weapons, conventional air armament and rocket propulsion, for which work he was awarded the C.B.E. this year. Dr. Cawood's many friends will wish him every success in his new appointment.

### Volta River Aluminium Scheme

The White Paper on the Volta River Aluminium Scheme (Cmd. 8702) reported the agreement of the Gold Coast Government, the United Kingdom Government and the aluminium producers to set up a Preparatory Commission to follow up the work already done. The Gold Coast Government, with the concurrence of the United Kingdom Government, has now appointed Commander R. G. A. Jackson as special commissioner in charge of the Preparatory Commission. The cost of the Commission will in the first instance be met by the Gold Coast Government, but half the cost will be reimbursed by the United Kingdom Government. It is expected that the work of the Commission will take eighteen months to two years. Commander Jackson was responsible for establishing the Ministry of National Development in Australia in 1950. He was attached to the Pakistan Government early in 1952 for consultation on its development plans, and in the latter part of 1952, at the request of the Indian Minister of Finance, advised the Indian Government and Planning Commission on the implementation of the Indian Five-Year Plan and, in particular, the three major hydro-electric and irrigation schemes.

### *British Chemical Abstracts*

In a written answer in reply to a question from Sir Wavell Wakefield in the House of Commons on February 4, the Parliamentary Secretary to the Ministry of Works, as representing the Lord President of the Council, stated that he understood that the Chemical Council would shortly issue an appeal for funds to enable *British Chemical Abstracts* to continue publication during 1953. He added that the Department of Scientific and Industrial Research has already provided £5,000 to enable the Bureau to continue to operate while the appeal is being made and, provided a satisfactory response is forthcoming from industry, the Government is ready to make a further substantial contribution this year.

### Careers in Agricultural Research in Great Britain

A useful pamphlet entitled "Careers in Agricultural Research—Training Grants, Studentships and Fellowships awarded by the Agricultural Research Council, 1953" (pp. 14) has recently been issued by the Agricultural Research Council. There are openings for research workers in many of the twenty-six agricultural research institutes financed by the State. In addition, certain appointments in universities and other research institutions are financed by the Council; many of these are temporary in character, but are particularly attractive to the young worker who wishes to gain experience under the personal guidance of a distinguished man of science. The pamphlet also gives useful information about the scientific staffs of the Council and of the State-aided agricultural research institutes, and about the advisory services. This year the Council is offering for the first time two veterinary clinical fellowships to provide opportunities for suitably qualified veterinary clinicians and pathologists of Ph.D. standing to continue research for two or three years. The fellowships will be renewable annually up to a maximum of three years and will carry a stipend of £850 a year. In addition, the Council is continuing to offer a limited number of junior agricultural research fellowships, carrying a stipend of £600 a year, to research workers of outstanding ability; and a larger number of postgraduate training grants and research studentships in agricultural and veterinary science. Applications for awards should reach the Council by March 20. Further information and a copy of the pamphlet can be obtained on application to the Secretary, Agricultural Research Council, Cunard Building, 15 Regent Street, London, S.W.1.

### German Meteorological Service of the U.S. Zone

The former German meteorological service, the Reichswetterdienst, ceased to exist at the end of the Second World War, and separate meteorological services were set up in each of the Occupation Zones in Germany under the auspices of the respective Occupying Powers. A number of publications of the German Meteorological Service of the United States Zone have now been received. They consist of three series, the *Berichte* which report major researches, a minor series entitled *Mitteilungen*, and finally the 'year-books' containing the record of the observations made at meteorological stations in the Zone. The earlier numbers of the *Berichte* are mostly reports of war-time researches. Of these perhaps the most interesting is No. 1, by G. Schulz, which describes the work of the Cloud Investigation Centre, directed during 1940–45 by W. Findeisen. The work included laboratory research, observations in flight, and a theoretical study on sublimation nuclei, ice accretion on aircraft, temperature, humidity and electrical measurements from aircraft, determination of height of cloud top by balloon-borne apparatus, and condensation trails. Findeisen's researches on the critical temperatures for the formation of ice crystals by the condensation of water vapour in the atmosphere are described in this publication. In No. 3, W. Schwerdtfeger applies the observations made in the war-time meteorological reconnaissance flights over the North Sea and Atlantic in a study of the detailed structure of fronts and the relations between temperature distribution in fronts and the cloud and precipitation. Later numbers include an exhaustive description, by H. Hauer, of the weather and climate of the Zugspitze (2,962 m. above mean sea-level) based on the observations made during the fifty years since the famous mountain observatory was opened in 1900, and works on agricultural meteorology by S. Uhlig, N. Weger and W. Baier. As an example of the last class, No. 28 describes the effects of radiation from walls on growth of plants and of the influence of soil coverings of various types, from fine sand to aluminium foil, on the temperature and humidity of the soil and the air immediately above and on plant-growth.

### Astronomy at Geneva

The issues during recent years of "Publications de l'Observatoire de Genève" (Série A, Astronomie, Chronométrie, Géophysique; Fasc. 37–43, 1946–52) contain a number of short articles on such matters as seismic disturbances and the behaviour of the pendulums at the Observatory, an approximate solution of the motion of the isochronous pendulum, and the first quartz clock at the Geneva Observatory, illustrated with eight figures. No. 39 contains an article regarding the tercentenary of Newton, in which is reproduced a passage from the address presented by the Helvetian Society of Natural Sciences to the Royal Society; No. 40, "A propos du Centenaire de la Découverte de Neptune", reproduces a number of letters written by Gautier to his parents and also some of the correspondence between Le Verrier and Gautier, which show the close collaboration between them; and in No. 42 Pierre Challande gives a short mathematical analysis of the functioning of a quartz resonator in the neighbourhood of the frequency of resonance, illustrated by ten diagrams, and Dr. R. Luthy deals with the radiotelegraphic reception of the hourly signals. Two other "Publications"—"Résultats des Observations de Chronomètres en 1951" and "Série M, Météorologie" (Fasc. 25)—appeared in 1952; the latter gives a résumé of the meteorological results obtained at Geneva in 1951, first for the whole year and then in tabular form for each month from December 1950 to December 1951.

### The Blue-cheeked Bee-eater

A new species of bird, the blue-cheeked bee-eater (*Merops superciliosus*), was added to the British list in 1951. Publication of the record was delayed by the editors of *British Birds* since it was felt that the occasion demanded a specially prepared coloured plate. This has now been prepared by Mr. Roger Tory Peterson, and in a recent issue of the journal it is accompanied by details of the first observation of the bird by Miss Hilda M. Quick on the Scilly Isles in June 1951 (*Brit. Birds*, 45, No. 7; July 1952). The bird is about the size of a cuckoo and has a beautiful iridescent green colour with rather darker primaries. There is a dark copper spot on the throat, a black line through the eye, and the forehead and crown are pale blue. The blue-cheeked bee-eater has occurred as a vagrant in France and Sicily, but Europe is outside its normal range, which includes East Africa, Madagascar, north-west Africa, Egypt, Syria, Iraq and Persia, and most of the Oriental region. It would appear that the bird which Miss Quick saw belonged to the Middle Eastern race, although this is not certain.

### Studies of a Red Alga

In a recent paper, Dr. K. M. Drew (*Phytomorph.*, 2, 38; 1952) has compared collections of the common but insufficiently investigated red alga *Bangia fuscopurpurea* from Wales and Naples, by growing them for several generations, under controlled conditions in the laboratory, in a culture solution consisting of filtered sea-water, soil extract and added mineral nutrients. Reproduction has been by asexual spores throughout. Under identical conditions, marked differences, which are described and illustrated, have been consistently observed between the cultures from the two localities. The indications are that further investigations are required to ascertain if *B. fuscopurpurea* is an aggregate species comprising physiological and morphological races. The point is also made that the methods of spore formation in the genus *Bangia* merit re-examination, particularly with reference to the desirability of using the relevant data as a basis of generic distinction in this group.

### Persistence of *Rhizoctonia solani* in Soil

The effects of different living host and other plants, of various mineral additions to soil (sodium nitrate and calcium hydroxide), and of *Trichoderma lignorum*, with and without added corn meal, on the persistence of a heavy artificial inoculation of *R. solani* in the soil, have been investigated under controlled conditions by G. B. Sanford (*Canad. J. Bot.*, 30, 5, 652; 1952). The amount of disease induced in the host plants was found to be the best means of assessing the extent and persistence of the pathogen in the soil. Also, as the experimental results indicate, this organism depends essentially on parasitic nutrition for its propagation and persistence in the soil. *R. solani* disappeared from the soil in some 120 days when various cereals were planted at intervals of 21 days, but was abundant in soils planted with potatoes, beans and peas. The fungus was not suppressed by heavy inoculations with *Trichoderma lignorum* unless the latter was added with corn meal.

### A Dominant Sex-linked Mutation in the House Mouse

Although evidence for sex-linked mutations in the mouse has been presented by several investigators, only one of these reports involved a morphological mutation. The results of matings of a new dominant mutation in the mouse, Bent-tail, described by E. D. Garber, suggest that this mutation may be sex-linked (*Science*, 116, No. 3004; 1952). The expression of Bent-tail, in the female, may range from a single almost imperceptible kink to a series of well-defined kinks. In some extreme cases, the tail is bent back on itself and may be pressed against the body. In females, the tail is usually normal in length; in males, however, the tail is usually half the normal length, and the kinks are generally restricted to the end of the tail. Except for the kinks and shortness, the tail is apparently normal. A single Bent-tail male was found in a litter of seven mice resulting from a mating between a normal female of the Namru strain and a bald male. This male, mated with a normal sib, produced Bent-tail females and normal males, suggesting that the mutation was dominant and apparently sex-linked. Two females could not be positively identified as Bent-tail because of the poorly defined single kink. These two females when outcrossed to normal Namru males yielded Bent-tail and normal mice. When the original normal female was out-crossed to a normal Namru male, only normal mice resulted. Finally, the original Bent-tail male was outcrossed to three normal Namru females. These matings also indicated that the mutation was sex-linked and dominant.

### A Stain for some Fatty Materials

In a paper in the *Museums Journal* (November 1952), Mr. R. H. Harris, curator in the Museum of Zoology and Comparative Anatomy, University College, London, describes a demonstration which he undertook to define the supporting tissue in the manus of an Indian elephant. A median, sagittal section was prepared so that the cushion of fat and elastic tissue upon which the animal rests its weight could be clearly shown. The dissection was carried out in the fresh state, and, as there was no sharp contrast between the fat, elastic tissue and muscle fibres, it was decided to use a fat stain. This was prepared by adding to a solution composed of equal parts of acetone and 70 per cent alcohol sufficient Sudan III powdered stain to cause saturation. The solution was filtered and kept in a tightly stoppered bottle. Full experimental details are given by Mr. Harris; but the main point is that ultimately only the fat was stained, leaving all other tissues sharply defined. The method renders an anatomical feature in elephants visible for study and research, and the finished dissection provides a valuable museum exhibit.

### Hydroelectric Schemes in North Wales

Under the title "Hydro-electricity in North Wales", the North Wales (Hydro-Electricity) Protection Committee has issued a further illustrated pamphlet (pp. 8+4 pl.; from the Committee, 93*a* Scotland Road, Liverpool 3; 1952; 6*d*.), dealing with the six new schemes now proposed for North Wales and involving the areas Nant Ffrancon, Snowden, Upper Conway, Vale of Festiniog, Mawddach, and Plynlimon or Rheidol. The schemes affect the whole of the mountain country from Bangor to Aberystwyth, with the exception of Cader Idris. The Bill to be promoted by the British Electricity Authority is to cover the Plynlimon scheme, the largest, and the Vale of Festiniog. The pamphlet recapitulates the arguments against the schemes and appeals for financial support for preparing petitions against the Bills; the legal expenses involved in fighting such so-called 'private' Bills are heavy, and several thousand pounds is still required for this purpose.

### International Meetings in Physics

A number of international meetings in various fields of physics will be held this year, and these will include the following: meeting of the International Optical Commission, at Madrid, April 20–21 (Prof. J. M. Otero, Serrano 121, Madrid); International Congress of Acoustics, in Holland (The Hague, Delft, Eindhoven and Hilversum), June 16–24 (C. W. Kosten, Mijnbouwplein 11, Delft); colloquium on cosmic rays, organized by the University of Toulouse, at Bagnères-de-Bigorre, July 5–11 (Prof. L. Leprince-Ringuet, 17 rue Descartes, Paris 5e); symposium on fundamental theoretical physics and executive meeting of the International Union of Pure and Applied Physics, in Japan (Tokyo and Kyoto), September 15–23, under the presidency of Dr. H. Yukawa (Prof. P. Fleury, Institut d'Optique, 3 Boulevard Pasteur, Paris 15e). Further information can be obtained from the persons named in brackets.

### Frank B. Jewett Fellowship Awards

The American Telephone and Telegraph Co. has awarded five Frank B. Jewett fellowships to the following: M. Fixman, a graduate of Washington University, St. Louis, for research at the Massachusetts Institute of Technology on theoretical and experimental aspects of the behaviour of high-polymer molecules in solution, including the statistical mechanics of transport processes particularly involving macromolecules; Dr. H. Helson, a graduate of Harvard University, for the continuation of his work in the Mathematics Department, Yale University, on a clarification of the relations between the Wiener and Kolmogoroff prediction theory and certain questions in analytical function theory which are fundamental to cybernetics and information theory; R. G. Newton, a graduate of the University of Berlin and of Harvard University, for research on the connexion between the quantum field theories and detailed behaviour of nuclei and their effect on surrounding electrons; Dr. R. S. Pierce, a graduate of the California Institute of Technology, for further research on the principles of automatons, clarifying the mathematical fundamentals of how machines can perform near-human operations; and Dr. D. B. Ray, a graduate of Harvard University, for the continuation of his study, up to now conducted at Cornell University, on the essentials of random processes and prediction of events involving atoms and electrons.

These fellowships, which are awarded by a committee from the Bell Telephone Laboratories, are designed to stimulate and assist research in the physical sciences by those who have recently received doctorates or are about to receive them. The stipend is 4,000 dollars to the recipient and 1,500 dollars to the institution at which the research is carried out.

### Colonial Service: Recent Appointments

The following appointments have recently been made in the Colonial Service: J. L. Congdon (agricultural officer, Aden), director of agriculture, Aden; R. A. Silverlock (agricultural survey officer, Gold Coast), agricultural officer, Gold Coast; G. M. Stockley (director of geological survey, Tanganyika), director of geological survey, British Guiana; J. H. Hinds (senior agricultural officer, Gold Coast), pasture research officer, Northern Rhodesia; E. A. Lewis (deputy director, East African Tsetse and Trypanosomiasis Research and Reclamation Organization), director of the Organization; M. B. Noel-Buxton (fisheries officer, Gold Coast), senior fisheries officer, Gold Coast; D. McCallum (education officer, Kenya), meteorologist, East Africa High Commission; L. Piening, plant pathologist, Department of Agriculture, Gold Coast; A. M. M. Rees, agricultural economist, Northern Rhodesia; J. P. Scott, agricultural officer, Sierra Leone; T. E. Tomlinson, scientific officer, Sierra Leone; A. W. Reece, geologist, Uganda; L. R. Boulger, pathologist, Nigeria; B. W. H. Stronach, provincial tsetse officer, Tanganyika; Miss R. V. Suter, microbiologist, Microbiological Research Institute, Trinidad; J. W. Wholey, assistant conservator of forests, Nigeria.

### Announcements

H.M. The Queen has been graciously pleased to grant Her Royal Patronage to the Institution of Gas Engineers.

The Hinchley Medal of the British Association of Chemists has been awarded to Dr. Herbert Levinstein, a trustee and past-president of the Association. The presentation will take place in the West Hall of the Royal Society of Medicine, 1 Wimpole Street, London, W.1, on February 27, at 6.30 p.m., and Dr. Levinstein will speak on "Our Changing Chemical Industries: an Appraisement". Prior to the presentation, there will be a brief opening ceremony at the new headquarters of the Association, at Hinchley House, 14 Harley Street, W.1.

Dr. W. C. J. Ross has been appointed to the readership in chemistry tenable at the Institute of Cancer Research (Royal Cancer Hospital), University of London.

An Easter vacation school in relaxation methods will be held in the Imperial College of Science and Technology, London, during April 9–23. The course will be on the lines of those of previous years and will cover the numerical solution of linear algebraic equations, framework problems, Laplace's and Poisson's equations, the biharmonic equation, eigen-value problems, the heat-conduction equation, three-dimensional relaxation, etc. Lectures will be given in the mornings, and during the afternoons the instruction will consist of solving examples under supervision. The fee for the course is £10. Further information can be obtained from D. N. de G. Allen, Imperial College, London, S.W.7.

A summer school in analytical chemistry, organized by the Royal Institute of Chemistry and the Society of Public Analysts and Other Analytical Chemists and open only to members of these two bodies, will be held in the Royal College of Science and the Royal School of Mines, South Kensington, London, S.W.7, during September 6–12. The course will be divided into three parts, dealing with organic, metallurgical and biochemical analysis, respectively, and there will be one evening meeting on the need for statistical methods in analytical chemistry. The fee for the course is £13 (£3 for the lectures only of any one part); hostel accommodation can be reserved. The course is limited to fifty persons. Further particulars can be obtained from G. Murfitt, at Metals and Methods, Ltd., Bacon Works, Langley, near Slough, Bucks.

The eighteenth Cold Spring Harbor symposium on quantitative biology will be held during June 5–11, the general subject of the meetings being "Viruses". Emphasis will be on discussion of the quantitative aspects of virus research, particularly research with bacterial viruses, and the following problems will be discussed: virus in the vegetative state and its maturation, pro-virus, transition from pro-virus to vegetative virus, transition from the infective to the vegetative state, structure of viruses, biochemical studies of virus infections, host-controlled variations of viruses, and viruses in tissue culture. Further information can be obtained from the Biological Laboratory, Cold Spring Harbor, New York.

As in former years, a course in tropical hygiene for laymen will be held by the Ross Institute of Tropical Hygiene (forming part of the London School of Hygiene and Tropical Medicine) during July 20–24. The course is for workers in the tropics holding, for example, administrative or executive posts, whose responsibilities entail the health and welfare of others. Morning sessions will be devoted to malaria and its control, and in the afternoons other tropical diseases and problems such as hookworm, bilharzia, nutrition, housing and sanitation, and protection against heat will be dealt with. There is no fee for the course. Further information can be obtained from the Organizing Secretary, Ross Institute of Tropical Hygiene, Keppel Street (Gower Street), London, W.C.1.

The Institution of British Agricultural Engineers is offering a scholarship for students who experience financial difficulty in completing their studies during the academic year 1953–54 for the final examination of the National Diploma in Agricultural Engineering. The scholarship, which was given last year by the publishers of *Farm Mechanization*, is tenable at one of the colleges approved by the examination board of the Institution, and preference will be given to candidates with engineering qualifications. Application forms (to be completed by May 15) and further particulars can be obtained from the Secretary of the Institution of British Agricultural Engineers, 24 Portland Place, London, W.1.

Cambridge University Press announces that a list of errata so far discovered in the first edition of "The New Flora of the British Isles" by Clapham, Tutin and Warburg is now available. As most users of "The Flora" will want to transfer the necessary corrections to their copies of the book, the errata slip is being inserted loose in all remaining stock. Booksellers who wish to put the errata slip in their own stock copies, or to supply it to customers who have already bought the book, may have copies free of charge from the Cambridge University Press, Bentley House, 200 Euston Road, London, N.W.1.

# SUPPLY OF LABORATORY ANIMALS

A MEETING of representatives of the supporting societies of the Laboratory Animals Bureau of the Medical Research Council Laboratories, Hampstead, was held at the Royal Society of Medicine on January 22, with Dr. R. Lovell in the chair. The purpose of the meeting was to discuss a paper on "The Supply of Laboratory Animals", by Dr. W. Lane-Petter, the director of the Bureau; the paper had been circulated in advance. The Laboratory Animals Bureau has been established for nearly six years, and already it has gathered much useful, and some alarming, information on the sources of the animals used by physiologists, pharmacologists, etc., in their research work or in their work on the standardization of drugs and sera.

Each year the Home Secretary lays before Parliament a "Return of Experiments performed under the Act 39 and 40 Vict., C. 77". Dr. Lane-Petter's paper quotes the figures in the returns for the years 1939–51. They rise steadily from 954,691 for 1939 to 1,919,424 for 1951, and these figures do not include animals which are not returnable under the Act—for example, the control animals where only those of the experimental group are subjected to procedures "calculated to cause pain", most pregnancy-diagnosis tests, and procedures for the production of sera or other substances obtained from animals for medical, veterinary or scientific purposes. An analysis of figures obtained from various sources (inevitably not very accurate) indicates that mice constitute about 79 per cent of the total number of animals used, involving about 43 per cent of the total cost of the animals. The corresponding figures for rats are 8 and 9 per cent, respectively, for guinea pigs 6 and 18 per cent respectively and, at the other end of the table, for monkeys 0·1 and 7 per cent respectively. A table gives the main uses for which the various species are required: applied medicine (diagnosis of disease, pregnancy tests, serum preparation, serum titration, bio-assay and toxicity tests); and research and teaching (physiology, biochemistry, pharmacology, bacteriology and parasitology, endocrinology, nutrition, experimental surgery and teaching). It indicates that research uses the more expensive animals and that applied medicine has adopted the cheaper animals. These are the costs of the animals before being submitted to any experimental procedure. The behaviour of the animals during their laboratory existence has sometimes shown that it is more economical in the end to buy more expensive but really healthy animals than cheaper, less healthy ones. Nearly always home breeding is more expensive than buying from dealers (it would be prohibitive for dogs), and the advantages accruing from such must be weighed against the cost. The commercial breeder probably has lower overhead charges than the scientific breeder, he is probably a better business man and is much more of a specialist in his job. On the other hand, where litter-mate animals are required or animals from parents with a special dietary history, the only absolutely reliable way of obtaining them is by home-breeding; and when mice are required for virus chemotherapy or other virological research, they must be produced under conditions too exacting for commercial breeders.

The procuring of animals which are not specially bred by either a commercial breeder or by the laboratory needing them has some difficulties—for example, monkeys are best imported during the warm months, amphibians are most prolific in the late summer, and guinea pigs are often scarce in the early months of the year. Workers may therefore have to plan to carry out their work when supplies are likely to be good. Heavy demands for the more prolific animals, and especially of young ones, can only be met if orders are placed well beforehand to allow extra matings to be made.

It has been suggested that a general breeding station should be established for the supply of animals to the whole of a university or even to groups of universities. This might or might not have some financial advantage; it would certainly have many disadvantages, for, according to a simple principle of public health, the larger the colony the greater the chance of infection coming in and the less the chance of getting rid of it. Another suggestion which can scarcely be taken seriously is that there should be some centralized depot which would receive animals from all sources and distribute them as needed. The objections to this are the obvious difficulties of controlling the supply and demand, the possibility of infection and the slow adjustment of most animals to change of environment.

On the whole, it appears that most needs can be met from commercial sources and that the acquiring of animals from such sources will be more economical than breeding in the laboratory. It is, however, obviously desirable that some recognized authority should be familiar with the various breeding stations, the strains of animals available and their general condition. It should be able to recommend an alternative source of animals to a worker whose usual source has suddenly become unable to supply his needs. Such a central authority does, in fact, already exist in the Laboratory Animals Bureau. Much has already been done; but much remains to be done to encourage different breeders to produce well-defined strains and perhaps to improve existing strains on the lines used in farm-stock practice for upgrading.

The desirability of using 'inbred' strains of such animals as mice is questioned. The Bureau has discovered that many breeders who claim to supply inbred mice do not, in fact, know the real meaning of the term 'inbred', and, until information based on unquestionable 'inbred' strains is obtained, no reliable conclusion as to their desirability can be drawn. It has also been found that it is practically impossible to keep a colony of animals strictly infection-free, but that a high standard of hygiene will keep a colony healthy enough for most purposes.

To enlarge the supply of cats and dogs, a strong plea is put forward that the humane societies should hand over the really unwanted and ownerless animals that they acquire, for these societies are in a much stronger position than dealers and laboratory workers for ensuring that the cats and dogs which they collect are, in fact, unwanted and ownerless.

The discussion of the paper was opened by Prof. R. E. Glover, representing the Royal College of

Veterinary Surgeons, who approved of the Bureau's scheme of accreditation of breeders but emphasized the dangers of enlarging colonies beyond the limits of the personal care by the owner—for example, the increased danger of infection, and the possibly less careful treatment by subordinate staff. The operation of demand versus supply may be leading to price competition and the consequent annihilation of the smaller breeder whose contribution is useful and often very good. Prof. Glover maintained that cost in research work is indeed watched carefully, but the use of expensive animals as well as the cheaper ones has to be investigated in order to discover the best animal for the purpose in view. Commercial firms benefit by the experience of research workers when they take up large-scale production and test their own products. To overcome the difficulty of having a surplus of young animals at a time of year when they are least wanted, he suggested that a large proportion of these young animals in the glut season should be put to breeding so that the total production in the less good breeding season should, in fact, be increased. He thought that decentralization is distinctly advantageous, but that institutes run by universities on not too large a scale by competent scientific workers would afford a chance of studying animal husbandry and animal diseases; the institutes could train really good technicians, and each institute might specialize in one or two particular species. The linking-up of such institutes would obviously be valuable. Prof. Glover pleaded for more investigations into epidemics in animal colonies, particularly those of commercial breeders. A well-qualified research worker associated with some institute where he would have contact with clinicians, bacteriologists, etc., would be able to do most valuable work on animal epidemics.

Dr. C. C. N. Vass, representing the Physiological Society, emphasized the fact that expenditure on animals must be faced. Often the difficulty in experiments on cats and dogs is to get them of a known age. If this could be done by paying a higher price, it must be paid, and, since such an animal might be under observation for two years, the high price would be justifiable and in fact almost negligible.

Dr. H. J. Parish, representing the Pathological Society, agreed to the need of using healthy animals at almost any cost, particularly for such long-time experiments as are involved in work on prophylactics, which work, it might be stressed, is often done for the benefit of animals and not only for human beings.

Dr. S. J. Folley, representing the Biochemical Society, asked if the possibility of using rats in place of cats and dogs has been considered as carefully as possible; but Dr. Vass replied that, for teaching purposes, the rat is often too small an animal.

In reply, Dr. Lane-Petter said that if breeders' colonies are to be larger, they should be housed in separate small buildings; that prices are becoming stabilized; that putting surplus stock in the summer to breeding purposes would be workable; and that, if institutes for animal breeding should be set up by universities, they cannot be expected to produce all the animals needed. He mentioned again the work of the Bureau in visiting commercial breeders and in giving advice on the healthy running of the colonies.

Great appreciation of Dr. Lane-Petter's paper was expressed, and it was unanimously decided that it should be published *in extenso* or even enlarged, if possible in one of the scientific review journals.

# STUDY OF THE BRITISH FLORA DURING 1952

THE discovery, in remote parts of Scotland in recent years, of easily recognized plants such as *Kœnigia islandica* L. and *Diapensia lapponica* L.[1] is sufficient indication that there are still large areas in the British Isles awaiting botanical investigation. During 1952 two more species of northern distribution well known in Scandinavia have been added to our flora.

The finding by Sir Christopher Cox of *Artemisia norvegica* Fr. in north-west Scotland in August has already been announced[2]. Known only from Norway and the northern Urals, it belongs to a circumpolar group of closely related species which are very unlike representatives of the genus previously known from Britain. The other outstanding addition to our list of native species in 1952 is that of a sedge which appears in current Scandinavian literature as *Carex pulchella* (Lönnr.)[3-5]. It is allied to *C. serotina* Mérat (*C. Oederi* auct.), and has been brought to the notice of workers in Britain by Miss E. W. Davies (University College, Leicester). During the summer she found it in several localities in Perthshire and north-west Scotland, and there are specimens in herbaria collected earlier. For reasons of nomenclature she proposes to publish the discovery under an appropriate name which is not the one by which it is known in Scandinavia.

At the annual exhibition meeting of the Botanical Society of the British Isles, arranged in the lecture room of the British Museum (Natural History) (by kind permission of the trustees) on November 29, *Artemisia norvegica* was represented by Norwegian material exhibited by the Department of Botany of the Museum, and *Carex pulchella* by Scottish material in an exhibit prepared by Miss Davies.

Another addition claimed during the year is *Cakile edentula* (Bigel.) Hook. from the coast of north Scotland, the Outer Hebrides and Shetland[6]. Love has shown that while the British *Cakile maritima* Scop. (which is diploid) ranges around the whole coast of Europe and the Mediterranean, the tetraploid North American *C. edentula* occurs in Iceland and the Azores[7]. D. E. Allen (University of Cambridge) exhibited at the meeting British material determined as representing the two species, with drawings illustrating the characters of the leaves and fruits. A sedge from Ben Lawers which appears to be allied to *Carex parallela* (Laest.) Sommerf.[8] shown by N. Y. Sandwith (Royal Botanic Gardens, Kew), and an unnamed *Euphrasia* from Caithness displayed by Dr. E. F. Warburg (Department of Botany, University of Oxford) may, on further investigation, also prove new. An interesting hybrid between *Rumex conglomeratus* Murray and the naturalized South American *Rumex cuneifolius*, Campd., collected by Dr. F. R. Elliston Wright at Braunton Burrows, North Devon, and shown by J. E. Lousley, is apparently new to science.

The exhibition also included examples of important re-discoveries or extensions of range. One of the most interesting of these was *Ononis reclinata* L. collected last June by Miss H. M. Bigwood on the limestone of the Gower Peninsula. The locality is likely to be the one at which it was found by D. Sharpe on September 18, 1828[9], where, in spite of searches by competent botanists, it has not been seen since that date. The only other stations on the mainland are the well-known one in Devon, and the

Mull of Galloway, where it has not been found for many years. During 1952, *Arenaria norvegica* Gunn. was found by E. C. Wallace on basalt scree in what is only the second station on the mainland—the locality is in the Watsonian vice-county Westerness, 97. He also showed *Draba rupestris* R. Br., *Saxifraga rivularis* L., *S. nivalis* L., *Carex atrata* L. and other rare plants new to west Ross-shire. Miss F. E. Crackles exhibited the scarce grass *Calamagrostis neglecta* (Ehrh.) Gaertn. from Leven Canal, south-east Yorkshire, together with specimens of a putative hybrid with *C. canescens* (Weber) Roth., which grew with it[10]. A surprising extension of range was that of the fern *Dryopteris cristata* (L.) A. Gray from Dungeness, shown with other recent discoveries in Kent by F. Rose (Bedford College, University of London). *Limosella subulata* Ives, previously known only from Glamorgan and the vicinity of Portmadoc, was shown as living material from near Towyn, Merioneth, by Miss C. M. Goodman.

Additions to the list of British plants and to our knowledge of their distribution are of considerable interest; but the intensive studies of species, or groups of species, now being carried out represent work of greater fundamental importance. This work is being furthered by the introduction of new techniques over a wide field. It is a healthy sign that workers are adapting methods used in industry and other branches of science. Two exhibits at the 1952 meeting demonstrated the use of punched cards for statistical investigations. One of these, by P. C. Sylvester-Bradley (Department of Geology, University of Sheffield), illustrated the methods to be used in "The British Rose Survey" which he is organizing in collaboration with Dr. R. Melville. It is intended to enlist the help of a considerable number of assistants to score the characters of bushes in random colonies of roses. The characters are to be recorded on a 'Wilmott grid', and analysed by means of the Powers-Samas system of punched card coding. By this means it is hoped to ascertain the degree of 'reticulation' present.

An ingenious card-index system for ecologists was demonstrated by F. Perring and R. G. West (School of Agriculture, Cambridge). This is an attempt to simplify the task of sorting large quantities of ecological data, and the authors have in mind the possibility of such cards being stored in a national repository. Some thirty-five ecological features of the habitat are recorded by clipping out holes around the edges, while there is space in the centre of the card for listing 715 species of plants. By manipulating the cards it is possible to select all those showing any given combination of ecological factors. Watsonian vice-county numbers are used as part of the reference.

The co-ordination of characters within two 'varieties' of *Lathyrus nissolia* L. was shown by Miss M. J. Herbert and J. M. F. Cannon in an interesting three-dimensional graph-model. Three co-ordinates were employed: mean leaf ratio, pod axial diameter, and pod variation index, and the position on the graph of specimens examined was indicated by beads suspended on threads. Those representing "var. A", with a coloured bead to show the characters of the Linnean type specimen, were separated by a wide gap from those of "var. B", which is var. *pubescens* Beck. A map of the distributions in Europe showed that they occupy separate geographical areas, while living cultures indicated differences in the rate of growth.

Dr. H. G. Baker (Department of Botany, University of Leeds) exhibited *Limonium humile* Mill and *L. vulgare* Mill; these show pollen and stigma dimorphism. The former is monomorphic and self-compatible, and the latter dimorphic and self-incompatible—maps showed the relationship between the British and allied monomorphic and dimorphic species. Mrs. Y. Heslop-Harrison demonstrated variation in *Nymphaea alba* L. Dissections made from material collected in widely scattered localities over the British Isles seemed to indicate that the separation of *N. occidentalis* (Ostenf.) Moss is unjustified. An exhibit by P. T. Yeo (University College, Leicester) of *Euphrasia vigursii* Davey suggested that, while this puzzling plant appears on morphological grounds to be a hybrid between *E. anglica* Pugsl. and *E. micrantha* Rchb., it grows in places where it could not have arisen by direct crossing. O. Buckle and Dr. C. T. Prime illustrated the distribution of *Arum neglectum* (Towns.) Ridley in Sussex with a map and fresh material. Prof. T. G. Tutin (University College, Leicester) exhibited *Poa annua* L., *P. infirma* H.B.K. and *P. supina* Schrad., with hybrids between *P. annua* and the other two species. Of the first species he also showed three genetically different ecotypes which he has in cultivation. A. H. G. Alston (Department of Botany, British Museum (Natural History)) exhibited the hybrid ferns *Asplenium* × *Breynii* Retz. and *A.* × *murbeckii* Doerfl. synthesized from their parents by Dr. Meyer, with specimens found wild for comparison.

During 1952 the first original British Flora[11] for a generation was published, and the influence of this was to be seen in several of the exhibits. Dr. E. F. Warburg (Department of Botany, Oxford), one of the authors, showed some of the little-known segregates described in the Flora. D. E. Greenwood (Botany School, Cambridge) illustrated the distribution of two of these, *Salix cinerea* L. and *S. atrocinerea* Brot., in the Cambridge district with useful observations on the correlation of characters. Miss S. Littleboy showed work on *Galeopsis tetrahit* L. and *G. bifida* Boenn.

*Poa palustris* L. has been known in Britain since 1879. M. E. D. Poore and Dr. S. M. Walters (Botany School, University of Cambridge) showed maps marked with the stations from which it is known, and considered the evidence for its status. The localities now include Woodwalton Fen, where it is abundant, but unrecorded until 1950, and Wicken Fen, where it has only recently been verified though doubtfully identified material was collected there in 1941. Dr. Walters also had exhibits illustrating the distribution of *Alchemilla minor* Huds. sec. Wilmott, and, with Miss M. E. Bradshaw, the detailed distribution of species of *Alchemilla* in Teesdale. Other exhibits from the Botany School were: *Cardamine hayneana* (Rikli) Junge by D. E. Allen, *Galium pumilum* Murr. by K. M. Goodway, and *Alisma plantago-aquatica* L. and *A. lanceolatum* With. by C. A. Priestley. Further exhibits of small groups included: hybrid carices by Miss E. W. Davies, the affinities of *Catabrosa aquatica* L. by M. Borrill, and *Ranunculus flammula* L. by Miss P. A. Padmore (all of University College, Leicester); autogamous *Epipactis* in Britain and Scandinavia by Dr. D. P. Young, and *Helianthemum canum* (L.) Baumg. by Miss M. E. Griffiths. K. J. F. Park showed some interesting northern species of *Euphrasia*, Dr. A. Melderis (Department of Botany, British Museum (Natural History)) demonstrated hybrids of the

British *Elytrigia*, and G. O. Allen exhibited British charophytes.

An exhibit of considerable general interest, by W. T. Stearn (Department of Botany, British Museum (Natural History)), illustrated "The creation of new species through hybridisation resulting from man's activity". This included the species which have arisen from *Tragopogon pratensis* L. and *T. porrifolius* L., and the well-known *Spartina townsendii* H. and J. Groves. From the European Herbarium of the Museum were shown type-specimens of *Limonium* and *Rubus*, and material of special interest in connexion with recent field meetings of the Botanical Society. The Library of the Museum provided unpublished illustrations of the British Flora by Miss B. O. Corfe, F. H. Round, E. F. Bedford, Miss Margaret Knox and Miss Ellen Hawkins. J. E. Raven, P. D. Sell and Dr. C. West exhibited a series of specimens of little-known British *Hieracia* set out side by side with paintings by Mr. Raven of the same specimens before they were dried. Mrs. H. N. Clokie (Department of Botany, University of Oxford) had an exhibit dealing with Jacob Bobart the elder (1599–1679) and Jacob Bobart the younger (*c.* 1640–1719).

Limitations of space prevent reference to other exhibits, and the selection has been made on the basis of those which indicate the development of our knowledge of the British flora. It is evident that much of the current research is being carried out by younger workers. Many of them wisely restrict their studies to a single species, or to a small group of species, and these are being investigated in greater detail and from more aspects than would have been possible only a few years ago. Scope for the investigation of the British flora is still great. The record of discoveries and progress of research during 1952 is highly satisfactory.

J. E. LOUSLEY

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[2] *Gardeners' Chronicle*, 132, 112 (1952).

[3] Lid, J., "Norsk Flora", second edition, 170 (1952).

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[6] Allen, D. E., *Watsonia*, 2, 282 (1952).

[7] Love, A. and D., "Studies on the Origin of the Icelandic Flora", 1, Dept. of Agriculture Reports, Series B, No. 2, 1 (1947).

[8] Sandwith, N. Y., *Watsonia*, 2, 279 (1952).

[9] Groves, H., and Groves, J., *J. Bot.*, 45, 230 (1907).

[10] Crackles, E., "The Naturalist for 1952", 183 (1952).

[11] Clapham, R., Tutin, T. G., and Warburg, E. F., "Flora of the British Isles" (1952).

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# NATIONAL PHYSICAL LABORATORY, TEDDINGTON

## ANNUAL REPORT FOR 1951

THE annual report for 1951 of the executive committee of the National Physical Laboratory, Teddington, was presented to the meeting of the general board held on May 23 last and has since been published*. It consists of a general survey of the activities of the Laboratory and its various supervisory committees, together with more detailed individual reports, prepared by the respective superintendents or officers-in-charge, of the work undertaken by the ten Divisions, the Electronics Section and the Test House of the Laboratory.

The most important change during the year under review was the transfer of the Engineering Division to the new laboratories of the Mechanical Engineering Research Organization at East Kilbride. Other changes include the closing down of the Statistics Section of the Mathematics Division in order to concentrate on the construction and operation of the Division's two new machines, the ACE (automatic computing engine pilot model) and a 20-integrator differential analyser. No progress was made with the provision of a new ship tank and cavitation tunnel, and the Froude ship research sub-committee has expressed its deep concern at this lack of progress in the provision of what it considers to be equipment essential for the future development of the shipbuilding industry in Great Britain. An interesting development was the appointment of a small sub-committee to consider the possibilities of the utilization of solar energy.

The report states that, at the extensive series of open days, held during May 23–29, 1951, some 3,400 scientific research workers from universities, government departments and industry were invited to visit the Laboratory. On the two days prior to the meeting of the general board, a symposium on recent developments and techniques in the maintenance of standards was held[1] and the proceedings of this symposium have recently been published[2]. Other meetings held during the year included discussions on the properties of iron, on flaw detection and, with thermometer manufacturers, on the types of thermometers which the Laboratory should undertake to test.

The Laboratory took part in several exhibitions of scientific instruments, including the Royal Society soirées, the Physical Society annual exhibition, and the French scientific instrument exhibition at Paris. During the year an illustrated book, "Jubilee Book of the N.P.L.", describing the past and present work of the Laboratory, was published[3]. Other publications were the first booklet, entitled "Gauging and Measuring Screw Threads", in the series "Notes on Applied Science", and No. 1 in the short series of pamphlets dealing with the units and standards of measurement employed at the Laboratory[4]. The Laboratory has continued to receive many scientific and technical visitors from abroad, and both the director, Dr. E. C. Bullard, and senior members of the staff have paid visits to countries overseas to attend conferences or to exchange information with workers in other organizations. In addition to the names of the members of the general board, executive committee and sub-committees, the report lists the names and positions of the senior staff and includes a bibliography of the numerous scientific papers published by the staff during 1951.

The individual reports of the various sections of the Laboratory make interesting reading. The Aerodynamics Division, mainly concerned with problems connected with the design and performance of high-speed aircraft, reports much work in progress on delta and swept-back types of wings. A new high-speed laboratory was under construction, and two high-speed wind tunnels, one 36 in. by 14 in. and the other 25 in. by 20 in., together with a low-turbulence pressurized wind tunnel (8 ft. by 6½ ft.) were being planned. In the Electricity Division two fresh determinations of the ohm, by reference to the primary standards of mutual inductance and frequency, have been made. These agreed with each other to within one part in $10^6$, although they differed from the last set of absolute determinations, made

* Department of Scientific and Industrial Research: National Physical Laboratory. Report for the Year 1951. Pp. 77. (London: H.M.S.O., 1952.) 2s. net.

in 1936, by 15 parts in $10^6$. The change is attributed to a possible variation during the past years in the inductance standard. The Light Division has been mainly occupied with the development of the new methods of producing and copying diffraction gratings suggested by Sir Thomas Merton. Flat gratings with a ruled area of 6 in. by 6 in. have been made, and a special lathe, which will enable larger gratings of particular value to astronomers to be produced, was being constructed.

In the Metallurgy Division, investigations on the influence of the interstitially dissolved elements, oxygen and carbon, on the properties of iron, the elastic and plastic deformation of metals, the creep of high-temperature metals and alloys, and the equilibrium diagrams of alloys of titanium and oxygen and of titanium, iron and oxygen, have proceeded successfully. The Ultrasonics Section of the Physics Division has been concerned with the measurement of the elastic constants of solids by dynamic methods and of the absorption of 'Perspex' and 'Catalin' over the range 1–3 Mc./s. The Radiology Section, in order to establish British absolute standards of various radioactive isotopes, has made intercomparisons of measurements and techniques of several organizations, including the Atomic Energy Research Establishment and the Royal Cancer Hospital. Agreement has been reached on some isotopes.

The bulk of the research carried out in the Radio Division has been on wave propagation, and much basic information has been obtained. The study of ionospheric conditions has continued. Semi-conductors have been given special attention, and noise in germanium diodes and triodes, together with an examination of factors affecting the performance of these valves as rectifiers, amplifiers and oscillators, have been the subjects of investigation. Finally, the report records that the volume of work submitted for test in the Test House has increased appreciably, in some instances by as much as 50 per cent, and the sum received annually from test fees has been almost doubled.

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[1] See *Nature*, 168, 594 (1951).

[2] "Rec. Devel. Tech. Main. Stand." (London: H.M.S.O., 1952.)

[3] See *Nature*, 168, 410 (1951).

[4] See *Nature*, 169, 267 (1952).

## HUMAN RELATIONS IN INDUSTRY

THE scientific study of human relations in industry has been described by Dr. W. H. Scott, of the University of Liverpool, in two issues of the *Journal of the Institute of Personnel Management* (34, No. 319; March 1952; and 34, No. 321; September 1952).

In the first article Scott examines the nature and aims of the work of the industrial sociologist. The industrial sociologist, he suggests, studies the factory as a social system, as a network of relationships between individuals and groups. The most superficial analysis reveals that these relationships are far more complex than the traditional management–worker antithesis suggests. There are the relationships which exist between persons at various levels in the 'line' organization, from the top executive to the charge-hand; between executive and 'staff' personnel; between rank-and-file employees and their immediate supervisors; between managerial personnel and employee representatives; between rank-and-file employees and employee representatives; and between the various persons at a similar level in the organization as, for example, the members of the 'top' management group, the departmental managers, the foremen, or the rank-and-file employees in a particular department.

Although the sociologist may single out one or more of these particular aspects of relationships for detailed study, all are interdependent to some extent. Thus the relationships between employees and their immediate superiors are influenced by the relationships which exist at higher levels in the 'line', and the relationships between higher managerial personnel and employee representatives are determined to a large extent by relationships within the higher management group itself. It is the recognition of this interdependence which is leading sociologists increasingly to insist that any particular problem of relationships within an organization must be studied, and resolved, in terms of the totality of which it forms only a part. Endeavours to change the behaviour of supervisors by the development of more suitable selection and training procedures, for example, will be of limited value unless such endeavours are made as part of a wider plan to change attitudes and behaviour throughout the 'line' organization as a whole. Moreover, the factory does not exist *in vacuo*, and behaviour within its walls is closely associated with the attitudes and relationships which exist in the wider community.

After considering the difficulties confronting those who wish to investigate social relationships in industry, in his second article Scott discusses some of the contributions of current systematic studies by social scientists.

The common beliefs that efficiency and, concomitantly, productivity, necessarily arise out of individual employee satisfaction or high group morale are shown to lack validity. Social scientists are concerned to discover the conditions under which high productivity and high morale are most likely to co-exist, since under such conditions the satisfaction of the needs of both the individual and the organization will be at its greatest. Evidence is increasing that fuller opportunities for self-development and a greater measure of self-determination in industry are the basic pre-requisites. This does not imply the need for more and more joint consultation; rather is it the day-to-day relationships on the job which are crucial in determining morale and attitudes. The pressing need is for the development of leadership ability and skills at all levels. Leadership at the supervisor–employee level should be integrative, seeking to elicit the maximum contribution from each member of the work team by increasing opportunities for participation and self-development, and by ensuring that the feelings and ideas of all are brought to bear on problems and decisions taken. This will not be achieved simply by developing elaborate schemes for the training of supervisors. Consultative leadership must become an accepted administrative practice at all levels.

The importance of a permissive or consultative, rather than an authoritarian, type of leadership in industry is emphasized by the differences between formal and informal social organization, which sociologists have clarified.

Formal organization defines the division of functions among persons or groups of persons and the relationships deemed necessary for their co-ordination.

It never quite works in the manner prescribed, however, owing to the growth of informal relationships which cut across formal lines at all levels.

In some departments supervisors and even employees may approach their manager directly, while in others a rigid observance of the 'channels' may be insisted upon; foremen in different departments may often arrange matters between themselves without 'going through' their respective managers; staff specialists may achieve a position in which they are regarded as executives, although formally they may have a purely advisory status. Other informal relationships are only indirectly connected with the formal organization, such as the groups which arise among employees who work in close proximity to one another or cliques which have a political or religious basis. It would be erroneous to regard this informal organization as unstable or haphazard, for it usually follows a very definite and persistent pattern, and, like all stable relationships, develops characteristic values, norms, beliefs and attitudes which tend to become stereotyped, to be resistant to change, and to be binding on the members of the group. In a real sense, therefore, the informal organization is the one which matters.

In conclusion, Scott suggests that the more the formal and informal organization can be brought into harmony, the more likelihood there is of achieving a system of social relationships which will be effective both in satisfying individual needs and in attaining common goals.

T. H. Hawkins

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## JOURNAL OF EMBRYOLOGY AND EXPERIMENTAL MORPHOLOGY

Growth and change in the needs of scientific publication can often be met by the expansion and alteration of existing learned periodicals, but circumstances may from time to time make the establishment of new journals desirable. In Europe, embryologists, and workers on problems of morphogenesis and developmental change in the adult, have felt the lack of a medium of publication that would both bring together closely related work at present scattered and facilitate the growth of a fruitful co-operation between the many different approaches to the central problems presented by developmental processes.

An attempt to meet this need is being made in the publication of a new quarterly, the *Journal of Embryology and Experimental Morphology*. In founding this journal, the original sponsors, a group of British workers in collaboration with Profs. Sven Hörstadius (Uppsala), Chr. P. Raven (Utrecht) and M. W. Woerdeman (Amsterdam) have taken the opportunity of ensuring a fuller measure of international control of its scientific policy than is generally regarded as practicable. The editorial board, which has at present representation from Belgium, Finland, France, Great Britain, Holland, Italy, Sweden and Switzerland, will determine long-term scientific policy as well as giving the editor (M. Abercrombie) active support in carrying it out.

The editorial board met for the first time on January 3 at University College, London. British members were joined by Profs. A. M. Dalcq (Brussels), A. Stefanelli (Rome) and E. C. Wolff (Strasbourg).

Reports from the chairman (Prof. J. Z. Young) and the editor showed that it would be possible to publish four parts in 1953 and that the first issue could be expected during the spring. As was to be expected of an inaugural meeting, a certain amount of discussion centred on problems of a technical and administrative nature; but perhaps the most important discussions were those in which the scientific policy and scope of the journal were defined. There was general agreement that studies on embryogenesis, on regeneration, on growth, and on developmental changes in the older organism as well as on the physiology of fœtal–maternal relations would all fall within the scope of the journal. Parts of other fields, notably sexual endocrinology, the cytology of gametogenesis, and developmental genetics, would, in their ontogenetic aspects, be served. On the other hand, studies in these subjects which were directed primarily to clinical ends, or were otherwise better published in existing journals, would not normally be taken.

Although English will be the usual language of articles in the journal, provision has been made for the acceptance of a number in French and German; and although articles will, for the most part, be reports of original researches, review articles of exceptional value may occasionally be accepted.

The editorial board will meet annually, and it is hoped that its future meetings will not only review the work of the journal but will also be the occasion of the interchange of scientific information. If this happens the journal may well come to serve its field of biology in two of the most important ways open to it: by providing a common public ground in its pages for research into developmental processes; and by encouraging the international exchange of opinion and knowledge through the less formal means of discussions associated with editorial board meetings.

Members of the editorial board are sensible of their indebtedness to the outside bodies who have made the journal possible. In particular, the Company of Biologists, Ltd., which will publish it, and the Clarendon Press, which will produce it, have provided the basis for the whole project, while the British Council has helped to realize one of its most important features, namely, the participation of workers from many countries in the work of the editorial board meeting.

D. R. Newth

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## VARIABILITY OF INTERNAL ENVIRONMENT AND THE MECHANISMS OF BIOLOGICAL* CORRELATIONS

By EUGENE SCHREIDER

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It is generally accepted that internal environment is practically constant. The theory of homeostasis reinforced this old belief, for in its original form it stressed the very narrow limits of biological variations. To-day we can read that in vertebrates even the blood pressure is constant. But variability can now be classified as 'narrow' or 'wide'; we can compare coefficients of variation taken from different biological fields. If we find that they are significantly lower for physiological than for other characters, the relative fixity of internal environment should be accepted; otherwise it must be rejected as a misleading formula.

Table 1 contains a selection from the data which have been assembled; it mentions also the authors from whose works coefficients of variation (or arithmetical means and standard deviations used for calculating them) were taken.

TABLE 1

| Sources | | Coefficients of variation |
|---|---|---|
| | *Stature* | |
| Schreider, 1950 | 73 French workers | 3·73 |
| " | 75 French soldiers | 3·73 |
| " | 100 natives of Indochina | 3·18 |
| " | 108 Otomi Indians (Mexico) | 2·98 |
| " | 124 Darod (Somaliland) | 3·77 |
| | *Chest depth* | |
| Schreider, 1950 | 73 French workers | 7·88 |
| " | 74 French soldiers | 6·96 |
| " | 100 natives of Indochina | 4·91 |
| " | 107 Otomi Indians | 6·00 |
| " | 122 Darod | 6·20 |
| | *Diastolic blood pressure* | |
| Schreider, unpublished | 72 French workers | 18·26 |
| " " | 80 French soldiers | 15·98 |
| " " | 110 Otomi Indians | 11·94 |
| | *Heart-rate* | |
| Schreider, unpublished | 80 French soldiers (sitting) | 14·13 |
| Schreider and Soula, 1951 | 163 French soldiers (standing) | 18·43 |
| " " | 163 French soldiers (lying) | 16·16 |
| Laugier and others, 1937 | 180 French workers | 14·31 |
| | *Respiratory rate* | |
| Whiting, 1915 | 255 Hungarian soldiers | 14·20 |
| Tanner, 1951 | 46 London students (2 occasions) | 17·38–21·88 |
| Schreider, unpublished | 65 French soldiers | 14·68 |
| | *Vital capacity* | |
| Schreider and Soula, 1951 | 163 French soldiers | 15·83 |
| Schreider, 1941 | 99 natives of Indochina | 11·27 |
| " unpublished | 109 Otomi Indians | 19·60 |
| | *Blood sugar* | |
| Pierce and Scott, 1928 | 141 healthy men | 6·90 |
| Schreider and Soula, 1951 | 90 French soldiers | 9·75 |
| | *Serum cholesterol* | |
| Goldstein, 1935 | 19 American students (3 occasions) | 12·60–17·20 |
| Tanner, 1951 | 46 London students (2 occasions) | 15·32–16·02 |
| Schreider and Soula, 1951 | 163 French soldiers | 14·46 |
| | *Free serum cholesterol* | |
| Schreider, unpublished | 148 healthy young men | 26·82 |
| | *Hæmoglobin level* | |
| Hornaffer, 1928 | 40 young men | 5·41 |
| Schreider, unpublished | 157 healthy young men | 6·46 |
| | *Plasma proteins* | |
| Schreider and Soula, 1951 | 163 French soldiers | 5·79 |
| Goldstein, 1935 | 19 students (3 occasions): | |
| " | *Plasma inorganic phosphorus* | 13·50–20·40 |
| " | *Whole blood creatinine* | 11·90–15·50 |
| " | *Serum calcium* | 6·70–10·80 |
| " | *Serum chlorides* | 4·00– 7·20 |
| | *Serum Cl⁻* | |
| Mme. Leschi, 1951 | 53 Europeans, Dakar | 2·70 |
| " | 79 Negroes, Dakar | 2·60 |
| | *Serum Na⁺* | |
| " | 43 Europeans, Dakar | 2·40 |
| " | 46 Negroes, Dakar | 3·00 |
| | *Serum K⁺* | |
| " | 54 Europeans, Dakar | 13·10 |
| " | 117 Negroes, Dakar | 11·60 |
| | *Serum Ca⁺⁺* | |
| " | 12 Europeans, Dakar | 15·10 |
| " | 18 Negroes, Dakar | 9·60 |
| | *Dogs* (n = 18): | |
| Schreider, unpublished | *Serum K* | 8·11 |
| " " | *Cerebrospinal fluid K* | 12·04 |
| " " | *Serum Ca* | 4·84 |
| " " | *Cerebrospinal fluid Ca* | 12·95 |
| " " | *Blood sugar* | 18·57 |
| " " | *Cerebrospinal fluid sugar* | 20·61 |

Among the anthropometrical data, stature is one of the least and chest-depth one of the most variable. It is clear that, with the exception of serum chloride and sodium, the variability of physiological and biochemical characters is as wide as, and often wider than, the variability of anatomical measurements.

Since in classical works variability is usually expressed in terms of 'limits', it may be useful to point out the following fact: The ratio maximum/minimum value for human stature rarely exceeds 1·25. The same ratio for hydrogen ion concentration in human blood is 1·51. Perhaps we should conclude that body-height is subject to 'infinitesimal variations' only.

There is another, perhaps more important, approach to the same problem. The large inter-individual variability does not mean that intra-individual variation is high. The latter can be tested indirectly by coefficients of reliability calculated between two sets of measurements taken on two successive occasions on the same individuals. The reliability of anthropometrical characters is well known to be very high. The position is very different with many physiological and biochemical characters (Table 2).

TABLE 2

| Sources | | Coefficients of reliability ($r$) |
|---|---|---|
| | (*a*) *Human subjects* | |
| Goldstein, 1935 | Cholesterol | 0·67 |
| Tanner, 1951 | Cholesterol | 0·85 |
| Salit and Tuttle, 1944 | Heart-rate | 0·63 |
| Tanner, 1951 | Heart-rate | 0·60 |
| " | Respiratory-rate | 0·59 |
| " | Rectal temperature | 0·59 |
| Shock and Yiengst, 1950 | Blood pH | 0·36 |
| Goldstein, 1935 | Blood sugar | 0·37 |
| " | Serum calcium | 0·15 |
| " | Blood creatinine | −0·02 |
| " | Serum chlorides | −0·08 |
| " | Plasma inorganic phosphorus | −0·16 |
| | (*b*) *Dogs* | |
| Schreider, unpublished | Blood sugar | 0·01 |
| " " | Serum potassium | 0·07 |
| " " | Serum calcium | 0·29 |
| " " | Cerebrospinal sugar | 0·24 |
| " " | Cerebrospinal potassium | 0·13 |
| " " | Cerebrospinal calcium | 0·06 |

The serum cholesterol level appears to be one of the most stable biochemical characters. But it is far from 'fixity'. The reliability of other characters is lower, and sometimes the coefficient is zero.

The direct study of intra-individual variability is very difficult because most individuals are unwilling to give a sufficient number of blood samples. Nevertheless, the few data I was able to collect show that for some biochemical characters as many as fifteen to twenty determinations on different days may be needed in order to find a distinct modal value, that is, the value which is really characteristic for a given individual.

It is obvious that the postulate of fixity must be rejected on biometrical grounds. Perhaps this conclusion is distressing for those who put their faith in the 'fixité du milieu intérieur'. But even in the present state of knowledge, it helps us to understand some biological facts.

The lack of correlation between two characters may mean that the intra-individual variability of one of them or both prevents their actual relationship from being detected. On the other hand, intra-individual variability (or low reliability) does not necessarily preclude a character from having obvious correlations. The result of a single determination can be fortuitous; but as there is a mode, there is also a probability that we shall obtain a value more or less characteristic for a given individual. For some characters real correlations must be higher than those actually observed when these are derived from a single determination.

Of course, the lack of correlation can also mean that two characters vary quite independently. We must also become accustomed to the idea that biological correlations are frequently low or non-existent. Survival needs 'elasticity', that is, rather wide variability of the internal environment; it needs also some physiological decentralization: it seems that, in the course of time, antistochastic mechanisms have evolved, for in many cases perfect correlations would be lethal.

Properly speaking, a living organism contains a score of internal environments more or less separated by 'barriers' the function of which partly consists in lowering and breaking down correlations. The figures of Table 3 illustrate this phenomenon.

TABLE 3 (adult men)

| Variates | $r$ |
|---|---|
| Blood sugar and cerebrospinal sugar ($n = 40$) | 0·48 |
| Serum calcium and cerebrospinal calcium ($n = 50$) | 0·51 |
| Serum potassium and cerebrospinal potassium ($n = 47$) | 0·51 |

For a single biochemical trait, the 'between environments' correlation is about 0·50. This means that only 25 per cent of cerebrospinal sugar (or potassium, or calcium) variance is tied to the variations of the same character in the blood. These results are very incomplete, but they suggest a most important line of research. Biometry is the study of variation and related phenomena. The biometrician tries to overcome the disorder of things with the help of statistical tools. But first of all, the disorder should be studied as such.

A more complete statistical treatment of all the data assembled, with detailed references concerning the sources of the figures used, will be published later. [July 10.

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# PREPUPAL MOULT IN THE BLOWFLY (*CALLIPHORA ERYTHROCEPHALA*)

By Dr. P. TATE

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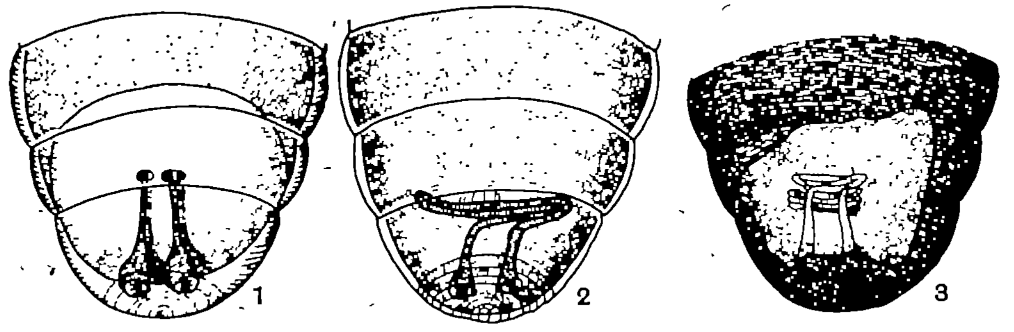
THE occurrence of a fourth, prepupal, moult in cyclorrhaphous dipterous larvæ was first established by Snodgrass[1] for *Rhagoletis pomonella* Walsh. This moult separates the so-called pre-pupa from the true pupa. Fraenkel[2] observed a similar moult within the puparia of *Calliphora*, *Lucilia*, *Phormia* and *Sarcophaga*; but he believed that the prepupal cuticle covered only the abdomen and did not extend forward beyond the line of cleavage between the third thoracic and first abdominal segments of the puparium.

The problem has been re-investigated in puparia of *Calliphora erythrocephala*, which were selected immediately the larvæ had become immobile (white pupæ) and were thereafter incubated in a thermostat at 24° C. to ensure uniform development and to make it possible to obtain the various stages of moulting at will. Under these conditions the fourth moult occurs between 22 and 28 hours from puparial formation. Puparia of the desired age were fixed to microscope slides by cellulose acetate cement and were dissected while alive by slicing off the top of the puparium with a razor blade. The fourth cuticle is extremely delicate; but with care the top half of the puparium can be dissected away to reveal the fourth cuticle enveloping the pupa and separated from the puparium by ecdysial fluid. If the exposed prepupa is flooded with indian ink, or Delafield's hæmatoxylin, the fourth cuticle, which is hydrophilic, takes up the stain, whereas the pupal cuticle is strongly hydrofugal and does not stain. Thus the fourth cuticle is made easily visible and it can be seen to envelop the pupa completely. The fourth cuticle remains attached to the puparium at the lines of cleavage and at the points of attachment of the mouth, anus, anterior and posterior spiracles and the non-functional 3rd thoracic and 7th abdominal spiracles of the third instar larva. In the thoracic region the moult occurs earlier than over the abdomen and, as it quickly becomes affixed to the inner wall of the puparium in this region, it is very difficult to detect.

A more interesting problem, however, and one which does not seem to have been considered hitherto, is how the pupa succeeds in casting the long main tracheal trunks, considering that this fourth moult takes place within the rigid puparium, which would prevent the enclosed pupa from withdrawing the tracheæ in a direct manner. Attempts to solve this problem by observation of the living pupa through 'windows' cut in the puparium were only partially successful; but it was found that if the puparia are coated with mineral oil, or still better, with immersion oil, the puparium becomes sufficiently transparent under intense incident illumination to allow the main features of the fourth ecdysis and, indeed, of the evagination of the head and the extrusion of the pupal respiratory horns, to be followed in the living pupa. Provided the spiracles are not occluded, this treatment with immersion oil does not interfere with the development of the pupa, and flies regularly emerged from coated puparia.

The most easily observed and most interesting part of the process of moulting is that associated with the withdrawal of the posterior part of the main lateral tracheal trunks. The first sign of moulting is the appearance of a bubble of air, surrounding the post-abdominal spiracles, between the pupa and the fourth (prepupal) cuticle. This air bubble enlarges and presses the cuticle against the puparium as the pupal abdomen contracts towards the anterior. During this contraction, which is not uniform but is accompanied by minor movements of contraction and relaxation, the main tracheal trunks are drawn out and extend in an oblique manner from the postero-dorsal surface of the 8th abdominal segment of the pupa to the point of attachment of the post-abdominal spiracles on the puparium (Fig. 1). The contraction reaches its maximum when the posterior end of the pupa is about level with the anterior margin of the 7th abdominal segment of the puparium. This is the maximum withdrawal that can be done by direct contraction, but it leaves much more of the tracheal trunks to be extracted. This phase lasts about an hour. The contracted pupa relaxes and then extends back to the posterior end of the puparium. Meanwhile, the air is transferred to the anterior end by the forward passage of bubbles owing to violent peristaltic contractions of the pupa, and, as it reaches the anterior end, the head is evaginated and the pupal horns are moved back to come beneath the windows in the puparium preparatory to being extruded through them.

The backwards movement of the pupa fills the posterior part of the puparium completely, and, as it does so, the stretched tracheal trunks shorten and are pressed against the inner surface of the postero-dorsal part of the fourth cuticle. Owing to the stickiness of the inner surface of this cuticle, they stick firmly to it whereas they do not adhere to the pupal cuticle, which is smooth and hydrofugal. The pupa then begins to make violent turning and



Figs. 1–3. Dorsal aspect of the three posterior segments of a puparium of *C. erythrocephala* during the fourth, or prepupal moult. The puparium was coated with immersion oil, and Figs. 1–2 show the pupa by transparency through the puparium. In Fig. 3 the dorsal wall of the puparium has been cut away to form a window which is spanned by the fourth cuticle, glued to which are the cast and folded tracheal trunks

Fig. 1 represents the maximum contraction of the pupa and direct withdrawal of the tracheal trunks at 28-hr. incubation at 24° C. Fig. 2, about twenty-five minutes later, shows the posterior parts of the tracheal trunks glued to the fourth cuticle and further lengths of the trunks being pulled out by the sideways writhing movements of the pupa. Fig. 3, about one hour later, shows the fully withdrawn tracheal trunks neatly folded against the inner surface of the fourth cuticle

writhing movements, swaying from side to side in a semi-rotatory manner within the puparium, and, with each lateral movement, a further length of tracheal trunk is drawn out and becomes stuck to the inner surface of the fourth moult to form loops overlapping transversely the portions drawn out by the first contraction which lie longitudinally (Fig. 2). Finally, the trunks are completely withdrawn and remain neatly folded on the inner surface of the fourth cuticle (Fig. 3). Details of the folding and final withdrawal of the tracheæ are difficult to observe as movements during this phase are rapid, and once the tracheæ come in contact with the fourth cuticle, they become wetted, lose their air contents, and are then not easily seen. The final stages can be seen best if the puparium is carefully cut away on the dorsal surface of the last two segments, leaving the fourth cuticle intact. In older puparia this is the only region where the cuticle remains separate from the puparium, and it forms a delicate iridescent membrane stretching obliquely across the postero-dorsal part of the puparium. The lateral abdominal tracheæ are withdrawn and folded in a similar manner by contractions and relaxations of the abdomen; but in them the folds are in line with the axis of the puparium and are not transverse as is the case with the posterior tracheæ.

The characteristic folded arrangement of the tracheæ from the posterior spiracles was noted by Snodgrass[1], who aptly described them as having "the form of a double-stalked T" and further states ". . . but it is difficult to understand how the posterior tubes can acquire their curious arrangement (Pl. 6.E) unless the pupa sways its abdomen sidewise to extract them". As has been shown above, this is in fact what happens in *Calliphora erythrocephala*. It may be noted, however, that in the figure cited by Snodgrass the overlapping of the tracheæ is wrongly shown, as in that figure the wide posterior parts of the tracheæ are shown to be ventral to the thinner, more proximal, parts which emerge last. In fact, it is the wide posterior parts which are withdrawn first and become glued to the fourth cuticle; and the thinner parts are then withdrawn and lie folded beneath, and transversely crossing-over, the wider posterior trunks. The swaying mechanism could not cause the folding to occur in the manner shown in Snodgrass's figure.

The time of onset of the fourth moult, at 24° C., from the so-called 'white pupa' stage is about twenty-two hours, and the whole process may take three hours or more. The first phase, to the maximum contraction of the pupa, takes about one hour; the pressing of the trunks against the cuticle by the backwards movement of the pupal abdomen may take as little as twenty minutes, and the final phase, the swaying of the abdomen and the withdrawal and folding of the remaining part of the tracheal trunks, may be completed in about forty minutes, although sometimes it takes much longer. During the whole of this period of at least several hours, the pupa is undergoing very active and vigorous muscular activity, the abdomen constantly performing contractions and relaxations and twisting and writhing movements. Thus, it is not correct to regard the puparial stage as an entirely quiescent one, as is often assumed in studies on the oxygen uptake of pupæ.

The essential features of the process of casting of the main tracheal trunks during the prepupal moult within the rigid puparium may be summarized as follows. (1) The persisting attachment of the tracheal trunks during the prepupal stage to the posterior spiracles of the puparium. (2) The contraction of the pupa and the appearance of an air space between the pupa and the fourth cuticle, resulting in the direct withdrawal of the first part of the main tracheal trunks. (3) The relaxation of the pupa and its movement backwards to bring the extracted parts of the tracheal trunks in contact with the inner surface of the fourth cuticle. (4) The 'stickiness' of the inner surface of the fourth cuticle, whereby the tracheal trunks become stuck to it when they are pressed against it. (5) The fixing of the cast parts of the tracheæ to the cuticle allows further lengths to be drawn out by the swaying and turning movements of the abdomen of the pupa. These lengths in turn become glued to the cuticle, so that the tracheal trunks are drawn out in relays and become fixed to the inner surface of the fourth cuticle in transverse loops to form a neatly folded mass crossing and recrossing the portions first drawn out which lie longitudinally against the fourth cuticle.

[Nov. 22.

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# LETTERS TO THE EDITORS

*The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications*

## Cephalosporin *N*: a New Type of Penicillin

A SPECIES of *Cephalosporium* has been found to produce two different kinds of antibacterial substance[1,2]. The first consists of a group of acidic antibiotics which are soluble in common organic solvents, are active mainly against Gram-positive organisms[3], and show similarities to helvolic acid[3-4]. The second consists of a substance (or group of substances) which is insoluble in most organic solvents and is active against a number of Gram-positive and Gram-negative organisms. This has been called 'cephalosporin *N*'. Evidence has now been obtained that cephalosporin *N* is a new type of penicillin.

The reasons for believing that the antibiotic is a penicillin are:

(1) It was inactivated by preparations of the enzyme penicillinase in high dilution, and, like benzylpenicillin[5], it stimulated the adaptive production of penicillinase by suspensions of *Bacillus cereus*.

(2) It was rapidly inactivated at room temperature in aqueous solution below *p*H 4 or above *p*H 9, and also at *p*H 7 in the presence of heavy metal ions such as those of copper, lead and tin.

(3) Acid hydrolysis of purified material resulted in the liberation of carbon dioxide. On addition of mercuric chloride to the hydrolysate a mercaptide was precipitated. Decomposition of the latter with hydrogen sulphide and reaction of the product with hot acetone yielded the hydrochloride of *iso*propylidenepenicillamine[6] (2,2-5,5-tetramethylthiazolidine-4-carboxylic acid), melting point 198°, $[\alpha]^{22}_{D} = +94°$ (found: C, 40·6; H, 7·7; N, 6·0; S, 12·4; Cl, 14·8 per cent; $C_8H_{15}O_2NS,HCl,1/2H_2O$ requires: C, 40·9; H, 7·3; N, 6·0; S, 13·6; Cl, 15·1 per cent). After boiling with dilute hydrochloric acid a solution of the *iso*propylidenepenicillamine hydrochloride showed a strong nitroprusside reaction, and evaporation *in vacuo* yielded the crystalline hydrochloride of penicillamine (β-thiolvaline)[6]. Oxidation of the latter with bromine resulted in the formation of penicillaminic acid (ββ-dimethylcysteic acid).

On addition of 2 : 4-dinitrophenylhydrazine in 2*N* hydrochloric acid to the supernatant from the mercaptide, only a very low yield of a precipitate consisting of a mixture of 2 : 4-dinitrophenylhydrazones was obtained. A small proportion of this precipitate was soluble in carbon tetrachloride and crystallized in orange-coloured needles from aqueous ethanol, melting point 183–185° (found: C, 48·2; H, 4·8 per cent). The 2 : 4-dinitrophenylhydrazone of *iso*butyraldehyde, melting point 182°, requires C, 47·6, H, 4·8 per cent. A further small proportion of the precipitate, which separated in crystalline form from cold pyridine, was glyoxal *bis*-2 : 4-dinitrophenylhydrazone[6].

The thiazolidine hydrochloride, penicillamine hydrochloride, penicillaminic acid and glyoxal *bis*-2 : 4-dinitrophenylhydrazone were kindly identified by X-ray powder photographs by Dr. D. Hodgkin, Miss P. Cowan and Dr. J. Robertson.

Cephalosporin *N* differs strikingly from the common penicillins in its hydrophilic character and its antibacterial activity. It behaves like an acidic substance on ion-exchange resins, and ionophoresis on paper shows that it carries a negative charge at *p*H 6–7. However, the purest preparations so far available contain a basic group titrating in the *p*H range 8–11, and the way in which the partition coefficient of the activity varies with *p*H in the phenol–water system indicates that a basic group, as well as acidic groups, may be present in the active substance itself. To explain the fact that the antibiotic is only soluble in highly polar solvents, it would seem necessary to assume that the essential core of the penicillin structure is linked to a residue which is rich in hydroxyl groups and/or contains a basic group which confers a zwitterionic character on the molecule. The nature of this residue is under investigation.

Cephalosporin *N* shows activity of the same order of magnitude against a number of Gram-positive and Gram-negative bacteria. For example, its activity against a strain of *Staph. aureus* is similar to that against a strain of *Salm. typhi*, whereas benzylpenicillin is more than a hundred times as active against the former as against the latter. An attempt has been made to obtain some idea of the purity of the present preparations of cephalosporin *N* by the application of two chemical methods for assaying penicillin[7,8] and by measuring the carbon dioxide evolved on hydrolysis. The results of these procedures agree in indicating that the preparations contain about 35 per cent of active material if the latter has the same molecular weight as sodium benzylpenicillin. Alternatively, they contain nearly 100 per cent of active material if the molecular weight is about 1,000. On the basis of these results, it appears likely that the activity of pure cephalosporin *N* against many Gram-negative bacteria will be of the same order as that of benzylpenicillin. The relatively low activity of the antibiotic against Gram-positive bacteria suggests that it reaches the sensitive part of these organisms much less readily than the other penicillins.

It is of interest that *Cephalosporium salmosynnematum* and certain other members of the genus *Cephalosporium* have been found to produce an antibiotic called 'synnematin', which is active against a number of Gram-positive and Gram-negative bacteria[9,10]. Although no evidence has been published to indicate that synnematin is a penicillin, the data which are available about its physical and chemical properties do not distinguish it from cephalosporin *N*.

We are indebted to the director and staff of the Antibiotics Research Station, Clevedon, Somerset, for the production of cephalosporin *N*.

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## A New Antifungal Substance of Fungal Origin

From a mould filtrate we have extracted a new substance with strong antifungal properties. The mould itself, which we were unable to classify completely, belongs to the species *Monosporium bonorden* and has been isolated from a sample of soil from the Belgian Congo. It develops white, almost sterile mycelia on Czapec-agar, with the reverse of the colonies varying from straw-yellow to brown with age.

The best production of active substance is obtained on Czapec–Dox medium after six days at 27° C. Extraction must be carried out by cold chloroform (5 per cent by volume of the filtrate) because the substance loses its activity rapidly when boiled in organic solvents during continuous extraction.

The residue of the chloroform extraction may be recrystallized from chloroform, alcohol or benzene, yielding about 250 mgm./litre of colourless crystals melting at 193·5° C.

By incorporating the active substance into Czapec-agar medium, growth of many moulds was completely inhibited at the following concentrations: at 25 p.p.m., *Penicillium brevi compactum*, *Aspergillus itaconitus* and *Ascochyta pisi*; at 50 p.p.m., *Botrytis cinerea*; and at 100 p.p.m., *Alternaria solani*. The substance shows a pronounced selectivity towards the mould species, for a concentration of 500 p.p.m. was not enough to inhibit the growth of *Penicillium rubrum* Stoll and *Fusarium solani phaseoli*.

By application of the 'slide germination method'[1] spore germination of *Penicillium cyclopium* Westling and *Penicillium stoloniferum* Thom was completely prevented by a concentration as low as 5 p.p.m.

At $p$H 7 the activity is not affected by sterilization for 5 min. at 105° C.

Against bacteria, concentrations of 200, 200 and 1,000 p.p.m. were required to inhibit the growth of, respectively, *Bacillus mycoides*, *T.B.C.* and *Staphylococcus aureus* during 24 hr. at 37° C. Seven other species of bacteria were not affected by concentrations up to 4,000 p.p.m. The substance is optically active, $[\alpha]_D^{20} = +203°$ in chloroform, and contains only carbon, hydrogen and oxygen. Molecular weight determinations gave, by different methods: 323, 332 and 337. Semimicro analyses gave: C, 60·40 and 60·41 per cent; and H, 4·81 and 4·75 per cent, leading to the empirical formula $C_{17}H_{18}O_7$.

The presence has been detected of two phenolic hydroxyl groups, one active hydrogen on an aromatic ring, one double link in a side-chain and a free carboxyl group. Ferric chloride produces a violet colour. The substance is almost insoluble in water but dissolves readily in dilute alkalis giving a yellow solution.

Acetylation and benzoylation give, respectively, a diacetate of melting point 189° C. and a dibenzoate of melting point 215° C., neither of which showed antifungal properties. Linking the substance with diazosulphanilic acid gives a brick-red pigment of melting point 123° C. with the same antifungal properties as the original substance. Oxidation with alkaline potassium permanganate breaks up the molecule, and one of the products isolated has been identified as succinic acid.

The analyses and chemical properties of the new antifungal substance we have isolated indicate that its molecular structure may be closely related to the structure proposed for mycophenolic acid[2], an antibiotic extracted from *Penicillium brevi compactum*[3]. Further experiments are being carried out to confirm this relationship.

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## Ribose and the Maillard Reaction in Fish Muscle

The occurrence and control of the Maillard reaction has been studied fairly thoroughly in dehydrated milk, eggs, fruits and vegetables; but little information is available concerning its prevalence in flesh foods. It has been shown in previous work that moist fish flesh usually becomes brown during exposure to high temperatures (for example, 120° C. for 1 hr.), and that this alteration is due to reactions of the Maillard type[1]. The nature of the sugar or substance contributing the aldehyde groups essential for these reactions was not ascertained. The present investigation indicates that ribose is responsible.

It was found convenient to determine the relative intensity of browning in heated muscle of white-fleshed fish by use of a Beckman model *DU* spectrophotometer equipped with a reflectance accessory attachment. As an arbitrary standard a 'white' surface made by blending 4 per cent high-viscosity carboxymethylcellulose and 2·5 per cent magnesium carbonate with water was used. The percentage of light reflected from the surface of heated fish samples was referred to this standard set as 100 per cent, a wave-length of 500 mμ being used.

It was found initially that the muscle of the sea fish examined had a total pentose content which often exceeded 1,500 μgm. per gm. of wet weight. This is probably associated with, or derived from, the nucleic acid of fish muscle nucleotropomyosin[2]. Since tests[3] of aqueous extracts of the muscle for deoxyribonucleic acid were negative, it was reasonably certain that deoxyribose was absent, thus verifying other work[3].

For comparative studies, muscle of halibut (*Hippoglossus stenolepis*), which browns very slightly on heating at 120° C. for 1 hr., was compared with that of lingood (*Ophiodon elongatus*), which, in common with local species of flounders and *Sebastodes*, browns markedly on heating. With lingood muscle, total pentose, as determined using a trichloracetic acid extract[2], decreased considerably after heating for 1 hr. at 120° C.; but there was no appreciable further loss after an additional 2-hr. heating. On the other hand, with halibut there was very little measurable loss of total pentose even after heating for 3 hr. When 1,000 μgm. of D-ribose was added per gm. of either halibut or lingood muscle, it could no longer be recovered from the heated flesh. These findings indicated that only free and not combined pentose was inactivated in heated muscle. In addition, it was found that the ribosides guanosine, uridine and adenosine did not occasion an increase in browning of heated muscle as did ribose itself.

Preliminary attempts to show that free ribose was responsible for browning in heated muscle were not successful, for only small amounts of ribose were found in extracts of muscle which had been dried *in vacuo* over sulphuric acid overnight. Apparently, most of the ribose combines with free amino groups during the brief drying period, and can no longer be extracted. Extracts of the muscle prepared as follows gave a satisfactory recovery of ribose. Fresh or thawed muscle was blended with 9 volumes of absolute ethanol for 1 min., and 30 ml. of the clear filtrate from the alcoholic extract was concentrated to dryness over sulphuric acid *in vacuo*. The residue, which contained lipoidal matter, was mixed with 1 ml. of water, and the solution applied directly to 28-cm. wide sheets of Whatman No. 1 filter paper for chromatographic separation of the ribose. It appeared that fairly satisfactory chromatographic separation could be effected without desalting the solutions.

In quantitative experiments it was found convenient to apply eight 0·02-ml. spots (in successive applications) of the above extracts at 2·5-cm. intervals along the starting line, qualitative control spots of ribose (5–20 µgm.) or muscle extract being placed near the edges of the paper as qualitative 'markers'. Recovery experiments with D-ribose alone and D-ribose plus the lingcod extract were also carried out. The papers were equilibrated and developed for 16 hr. at room temperature with ethyl acetate – acetic acid – water solvent[4]. After evaporation of the solvent at room temperature, the position of the ribosides present was determined by irradiating the chromatograms with ultra-violet light and marking the dark areas with pencil. It is essential that this be done, so that ribosides, which naturally interfere with the pentose determination, are not cut out with the strip used for determining ribose. Strips containing the 'markers' were cut from along the edges of the chromatograms and the location of the ribose ascertained by spraying with aniline oxalate[5] reagent. This qualitative development always gave very pronounced coloured spots with the lingcod extracts and only very faint spots with those of halibut. To determine the ribose quantitatively, strips 5 cm. wide were cut across the papers to include all the zones corresponding to D-ribose, a similar control strip being cut from another area of the paper which contained no riboside zones. The strips were eluted with 16 ml. of water, the solutions passed through ultra-fine 'Pyrex' sintered-glass filters to remove small particles of filter paper, and ribose determined by Mejbaum's method[6] using duplicate 1-, 2- and 3-ml. portions. The results of a typical experiment are given in the accompanying table, all figures being calculated on the basis of the wet muscle. It will be seen that the amount of ribose which was recovered from the unheated alcoholic muscle extracts after chromatographic separation corresponds closely with that which disappeared when the muscle was heated for 1 hr. at 120° C. The recoveries of chromatographed D-ribose, and of D-ribose plus lingcod muscle extract, were good.

FREE RIBOSE IN HALIBUT AND LINGCOD MUSCLE AND ITS RELATION TO THE BROWNING OF THE HEATED MUSCLE (HEATED HALIBUT MUSCLE = 64 PER CENT REFLECTANCE AND HEATED LINGCOD MUSCLE = 36 PER CENT REFLECTANCE AT 500 Mµ)

| Material chromatographed | Total muscle ribose (µgm./gm.) | Total muscle ribose after heating 1 hr. at 120° C. | Loss of ribose due to heating (µgm./gm.) | Ribose recovered after chromato-graphic separation (µgm.) |
|---|---|---|---|---|
| Halibut muscle extract (0·16 ml. = 0·48 gm. muscle) | 1580<br>1540 | 1530<br>1526 | | 40<br>31 |
| | 1560 | 1528 | 32 | 35·5 |
| Lingcod muscle extract (0·16 ml. = 0·48 gm. muscle) | 1460<br>1406 | 850<br>830 | | 585<br>525 |
| | 1433 | 840 | 593 | 555 |
| 180 µgm. of D-ribose | | | | 186<br>191 |
| | | | | 188·5 |
| 80 µgm. of D-ribose plus 133 µgm. (expected) ribose in lingcod muscle extract* | | | | 220 (213 expected) |

* Calculated from the average ribose content of the lingcod muscle as given in this table.

Though so far D-ribose has not been identified positively by isolation and chemical characterization, it has been observed that only a single spot can be developed when mixed lingcod extract and D-ribose are chromatographed together.

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## Myoglobin from Carp Muscle

THE occurrence of myoglobin in fish muscle has been postulated by several authors[1,2]; but no clear evidence for it has been given so far. A red muscular region made of cells rich in sarcoplasm[3] exists, however, in many teleosts underneath the skin; its width is greatest at the level of the lateral line and decreases progressively dorsally and ventrally[4] (Musculus lateralis superficialis Trunci).

Our experiments were carried out with the muscles of these lateral red bands from the carp (*Cyprinus carpio*). The muscles are removed and kept frozen at − 20° C. Before extraction, they are cut into slices 40 µ thick with an automatic freezing microtome and extracted twice for 1 hr. in the cold with 1 vol. water. The turbid reddish extract is easily clarified by dialysis against water and centrifugation; a clear cherry-red solution is obtained which contains all the coloured material of the extract. Electrophoretic analysis of this solution reveals that the red colour migrates as a single peak with a mobility of $-2\cdot5\ (\pm 0\cdot05) \times 10^{-5}$ cm.$^2$/V./sec. at ionic strength 0·15 (0·1 sodium phosphate and 0·05 sodium chloride) and *p*H 7·3. Addition of carp hæmoglobin to a similar extract prepared from white carp muscles shows that the hæmoglobin migrates much more slowly, with half the mobility of the coloured peak of the red muscles. The occurrence in our extracts of a carotenoid rendered water-soluble by attachment to a protein is unlikely; no such complexes appear to exist in fish[5]. It has been suggested by Banks[6] and Bechtold[7] on the basis of preliminary spectroscopic investigations that the cytochrome content of the lateral bands of herring and cod would be particularly high; but the gradient observed cannot correspond to cytochrome *c*, which has an isoelectric point of about 10 (Tint and Reiss[8]). It thus appears that we are dealing with myoglobin.

This identification has been confirmed by the use of Theorell's[9] isolation method. Fish myogen and globulin X are removed at 30° C. from the turbid extract previously mentioned by addition of 0·15 vol. of *M*/2 basic lead acetate, and the excess of lead is removed by solid tertiary phosphate, the *p*H being kept throughout between 7 and 8 by suitable addition of *N* sodium hydroxide or *N* acetic acid. The ionic strength is then increased by addition of a saturated neutral ammonium sulphate solution to a value corresponding to 75 per cent saturation. The amount of coloured material removed at this salt concentration is small. Solid ammonium sulphate is then added up to 95 per cent saturation. The red precipitate obtained is dissolved in water and dialysed against the buffer of ionic strength 0·15 and *p*H 7·3 previously mentioned. Electrophoretic analysis of these preparations reveals the presence of two gradients, the faster coloured one representing about 30 per cent of the total protein concentration. A similar separation is obtained in the ultracentrifuge, the slow-moving peak corresponding to a chromoprotein of a corrected rate of sedimentation of $1·7–1·8 \times 10^{-13}$. A preliminary examination of the visible spectra of these preparations gives three maxima of absorption, one very pronounced at 415 mμ and two much smaller ones at 540 and 575 mμ, in good agreement with the previous determinations of Theorell[10] and others[1] on myoglobin.

Carp myoglobin sediments therefore at approximately the rate of horse, ox and cat myoglobins[11]. Its electrophoretic mobility, however, is very different from that of horse[9] and whale[12] myoglobins and is similar to that of rabbit myoglobin[13], so far as we can judge from the very different experimental conditions used. Its electrophoretic behaviour thus agrees well with the well-known heterogeneity in amino-acid composition of the myoglobins, and its ultracentrifugal behaviour with their apparent similarity in size and shape. From the point of view of comparative biochemistry, it appears also to be widely distributed among fishes, in view of the frequent occurrence of the lateral bands in these primitive vertebrates[4].

Our thanks are due to Profs. M. Dubuisson and V. Desreux for facilities put at our disposal.

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## Structure of the Nucleic Acids

We have formulated a structure for the nucleic acids which is compatible with the main features of the X-ray diagram and with the general principles of molecular structure, and which accounts satisfactorily for some of the chemical properties of the substances. The structure involves three intertwined helical polynucleotide chains. Each chain, which is formed by phosphate di-ester groups and linking β-D-ribofuranose or β-D-deoxyribofuranose residues with 3′, 5′ linkages, has approximately twenty-four nucleotide residues in seven turns of the helix. The helixes have the sense of a right-handed screw. The phosphate groups are closely packed about the axis of the molecule, with the pentose residues surrounding them, and the purine and pyrimidine groups projecting radially, their planes being approximately perpendicular to the molecular axis. The operation that converts one residue to the next residue in the polynucleotide chain is rotation by about 105° and translation by 3·4 A.

A detailed description of the structure is appearing in the February 1953 issue of the *Proceedings of the National Academy of Sciences of the United States of America.*

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## Non-specific Precipitation of Proteins by Polyhaptenic Dyes

The proteins bovine γ-globulin and human serum albumin were found to give precipitates with the polyhaptenic dyes, 2-methyl-4,6-di(*p*-azobenzenearsonic acid) phenol (III), and 1,3-dihydroxy-2,4,6-tri(*p*-azobenzenearsonic acid) benzene (VI)[1], from *p*H 3·72 to *p*H 0·2–0·3 above the isoelectric points of the proteins, and in sodium acetate – acetic acid buffer of ionic strength either 0·20 or 0·10. Either 0·5 or 1·0 ml. protein solution was added to 0·5 or 1·0 ml. of each of a series of serially diluted dye solutions of initial concentrations of 0·57 (III) and 0·80 per cent (VI), the serial dilutions being made with buffer of the same *p*H and ionic strength as the protein solution.

In general, the amount of protein precipitated in each experiment increased to a maximum in the second or third—occasionally the fourth or fifth—of the eight tubes in the serial dilution. This suggests that the precipitation is due to the formation of a framework, as in the case of serological precipitation, particularly those in which the precipitating antigen is a simple substance[1].

On the assumptions that at *p*H 5·5–5·7 the dyes combine with the proteins as monomeric molecules, and that the haptenic groups interact with separate combining groups of the proteins, the number of combining groups per γ-globulin is calculated to be 44 for compound III and 36 for compound VI. Similarly, a value of 22 was estimated for albumin with compound III.

Further, it was found that at *p*H values from 5·0 to 5·4 at which neither compounds III nor VI produces a precipitate with albumin, the presence of albumin dramatically decreases the amount of precipitation of these compounds and γ-globulin. Apparently the albumin forms soluble complexes with either or both the dye and the γ-globulin.

These results are of interest in connexion with attempts to manufacture antibodies *in vitro*[2], and also with the observation that the reaction of polyhaptenic substances with purified hapten-homologous antibody is considerably different from that of these substances with antiserum[3].

This work was initiated in the laboratory of Prof. Linus Pauling, California Institute of Technology, whom I wish to thank for his assistance. A complete account of the work will be published elsewhere.

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## Influence of Temperature and Iron on Hæmoglobin Synthesis by *Daphnia*

*Daphnia*, in common with other branchiopod Crustacea, synthesizes hæmoglobin in response to a deficiency of dissolved oxygen in the surrounding water[1]. The hæmoglobin is in solution in the blood. In poikilothermal animals, chemical processes in the body normally proceed more rapidly at a high external temperature, and we have found that in *Daphnia* hæmoglobin synthesis is quicker in warm water. We wished, in addition, to know whether, at the lower of two temperatures, *Daphnia* would eventually acquire as much hæmoglobin as at the higher temperature (the low oxygen contents of the waters being maintained at the same level) or whether at the higher temperature a greater amount of hæmoglobin would be synthesized. The second alternative proved to be correct. In one experiment with *D. obtusa*, in water containing approximately 1 ml. dissolved oxygen per litre, the hæmoglobin content of the blood increased, in 28 days, five-fold at 17° C. but seven-fold at 28° C. After that there was no further increase. One cause of the greater synthesis at the higher temperature is probably the low oxygen content of the tissues, due to a high metabolic rate.

There are great differences in the iron content of natural fresh waters in which *Daphnia* lives. It has been found to vary between 50 mgm./l. and no iron detectable by dipyridyl (before or after reducing). The question thus arises as to whether the addition of iron salts to water containing little, or no, detectable iron would increase the quantity of hæmoglobin synthesized by *Daphnia* in response to oxygen deficiency. Our work has shown this to be the case. In one experiment, at 20° C., in water with no detectable iron and a low dissolved oxygen content of 0·9 ml./l., the blood hæmoglobin increased seven-fold in sixteen days (deriving its iron no doubt from algal food) and then remained steady for a further twelve days; whereas in similar water, to which 4 mgm./l. iron was added every other day, the increase in sixteen days was between nine-fold and ten-fold, with subsequent maintenance of this level for twelve days.

It was found that ferrous salts are more effective than ferric salts in augmenting hæmoglobin synthesis. This is curious for the following reason. A hæmochromogen is present in the gut lumen of *Daphnia*[2]. At the low oxygen content of the outside water necessary for hæmoglobin synthesis by *Daphnia*, this hæmochromogen can be seen with a spectroscope to be in the reduced state, the α-absorption band showing clearly. Now, the redox potential for the reduction of various hæmochromogens is known to be well below that at which the ferric ion is reduced to the ferrous state[3]. It is thus probable that in the gut lumen of *Daphnia* iron is in the ferrous state, even if swallowed as a ferric salt. The explanation of the greater effect of ferrous salts in increasing hæmoglobin synthesis seems to be as follows. The ferric salt added to the experimental water is gradually converted to ferric hydroxide and precipitated. The ferrous salt is also converted to ferric hydroxide, but in a more finely-divided state which remains longer in suspension, and is thus available to *Daphnia* for a longer time.

A full account of these results will appear in the *Proceedings of the Royal Society*.

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Dec. 17.

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## Role of Choline in the Oxidation of Fatty Acids by the Isolated Liver

THE lipotropic effect of choline has been interpreted most generally by assuming that fatty acids are carried out of the liver in the form of plasma phospholipides. However, the role of these compounds in the transport of fatty acids has been questioned[1]. The results presented here strongly suggest that choline acts by enhancing the oxidation of fatty acids in the liver.

In each experiment, slices or homogenates were prepared simultaneously from the liver of rats previously maintained on different diets, namely, (*A*) a choline-deficient diet (diet 26, containing 5 per cent casein[2] with added guanidoacetic acid 1 per cent), (*B*) a choline-supplemented diet (diet 26, with added choline-hydrochloride 0·4 per cent), or (*C*) a stock diet. In most experiments one or two animals received also 0·1 millimole of choline-hydrochloride, given in two intramuscular injections, 1·5 and 0·5 hr. before the rats were killed. The slices or homogenates were incubated with 1-$^{14}$C sodium stearate (obtained from U.S. Testing Co., Hoboken, N.J., on allocation from the U.S. Atomic Energy Commission) in a medium of Ringer-phosphate without calcium or magnesium[3]. Control flasks containing the same amounts of materials were kept at 100° for 10 min. before the addition of the isotopic stearate and then incubated. The carbon dioxide produced during the incubation was trapped in sodium hydroxide, precipitated as barium carbonate, and its radioactivity determined with a *Q* gas-flow counter. Total lipides, lipide phosphorus, and total nitrogen were determined on separate samples of the liver.

CARBON DIOXIDE PRODUCTION FROM 1-$^{14}$C-STEARATE

| Exper No. (and days on diet) | Preparation | Diet | Liver fat* (mgm./gm.) | Carbon-14 dioxide (counts per min.)† | |
|---|---|---|---|---|---|
| | | | | 1 gm moist tissue | Whole liver of a 100-gm. rat |
| 11 (0) | Slices‡ | Choline-def. | 83 | 1,985 | 8,340 |
| | | Choline-def.†† | 148 | 4,370 | 18,400 |
| | | Choline supp. | 30 | 3,413 | 13,400 |
| 16 (17) | Slices‡ | Choline-def. | 204 | 396 | 1,720 |
| | | Choline supp.†† | 27 | 2,600 | 12,100 |
| | | Stock | 26 | 1,754 | 6,450 |
| 9 (24) | Slices‡ | Choline-def. | 260 | 539 | 2,480 |
| | | Choline-def.†† | 135 | 1,440 | 10,250 |
| | | Choline supp. | 28 | 1,062 | 4,650 |
| 15 (28) | Homogenate‖ | Choline-def. | 166 | 278 | 1,520 |
| | | Choline-def.†† | 152 | 1,404 | 7,750 |

* Liver fat = total lipides, less total phospholipides (lipide phosphorus × 25)

† Each value is the average of 3–4 determinations on separate flasks, and has been corrected for the radioactivity in the control flasks.

‡ Liver slices (0·5–0·7 gm.) in Ringer-phosphate without calcium or magnesium (pH 7·4), incubated in air for 3 hr. at 37° (Warburg water-bath). Additions: 1-$^{14}$C sodium stearate (1–1·5 $\mu M$, 2–3 × 10$^{5}$ c.p.m.), penicillin and streptomycin (3 mgm. each). Total volume: 6–7 ml.

†† Rats injected with choline-hydrochloride (0·05 m$M$), 1·5 hr. and 0·5 hr. before death.

‖ 0·8 liver homogenized (1 : 5) in Ringer-phosphate without calcium or magnesium (pH 7·4). Additions: 1-$^{14}$C stearate (1 micromole, 2·0 × 10$^{5}$ c.p.m.), adenosine triphosphate (2 × 10$^{-3}$ m$M$), penicillin and streptomycin 3 mgm. each. Total volume: 6·5 ml.; 3 hr. incubation in air.

The results of a few representative experiments are reported in the accompanying table. Liver slices from rats on choline-deficient diet produced less carbon-14 dioxide than those from rats on the stock diet. Supplementation of the deficient diet with choline raised the values of the isotopic carbon dioxide. Differences in the amounts of isotopic acetoacetate paralleled those described for the production of carbon-14 dioxide.

The most marked and consistent increases were observed in the livers of rats injected with choline shortly before death. It may be suggested that a high rate of production of carbon-14 dioxide by the isolated tissue is dependent upon a certain level of choline (or of a choline derivative) at the beginning of the experiment, and that ingestion of a diet containing choline does not maintain at all times such optimum level in the liver cells, possibly because of a rapid destruction of the active factor. This would be consistent with the well-known rapid disappearance of choline introduced in the body. The possibility should perhaps be considered that, in the liver of choline-deficient animals, the isotopic stearate might have been diluted by the large amounts of fat accumulating in the tissue, with a consequent lowering of the specific activity of the stearate at the site of its oxidation. However, the lack of a quantitative inverse relationship between the fat content of the liver and the production of carbon-14 dioxide is not in favour of such a possibility. Furthermore, from the similarity of the results obtained in the experiments with slices and homogenates, it would appear that the action of choline cannot be explained simply by an increase in permeability of the cell membrane, and more probably consists of a stimulation of fatty acid oxidation in the isolated liver. Since *in vitro* addition of choline (in concentrations 0·003–0·015 $M$) was not effective, it is suggested that the active factor is not choline, but some substance formed from choline *in vivo*[4].

This work was carried out under contract *AT*(40–1)–288 with the United States Atomic Energy Commission. Technical assistance was given by H. Pollard. The interest and co-operation of Dr. M. A. Swanson are gratefully acknowledged.

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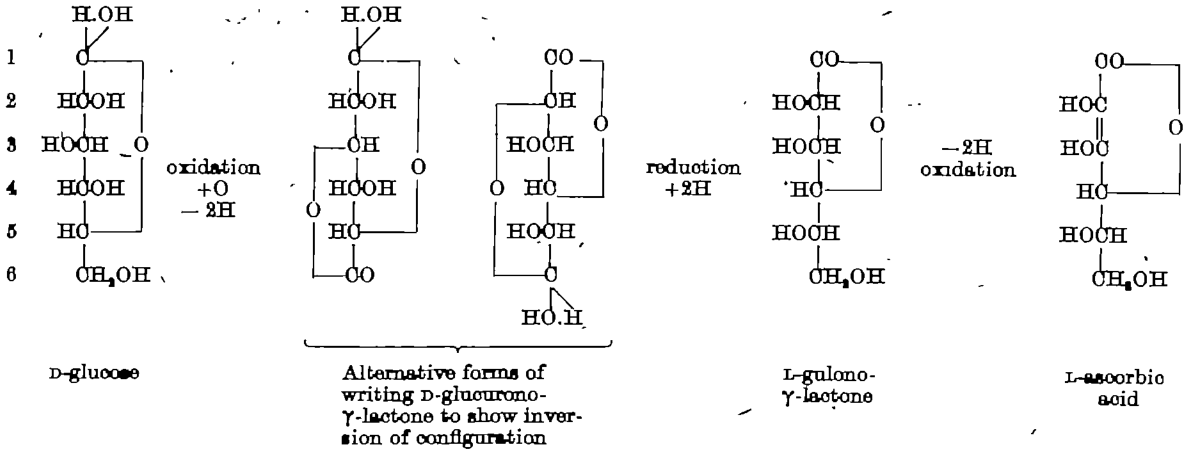
## Synthesis of L-Ascorbic Acid in Plants and Animals

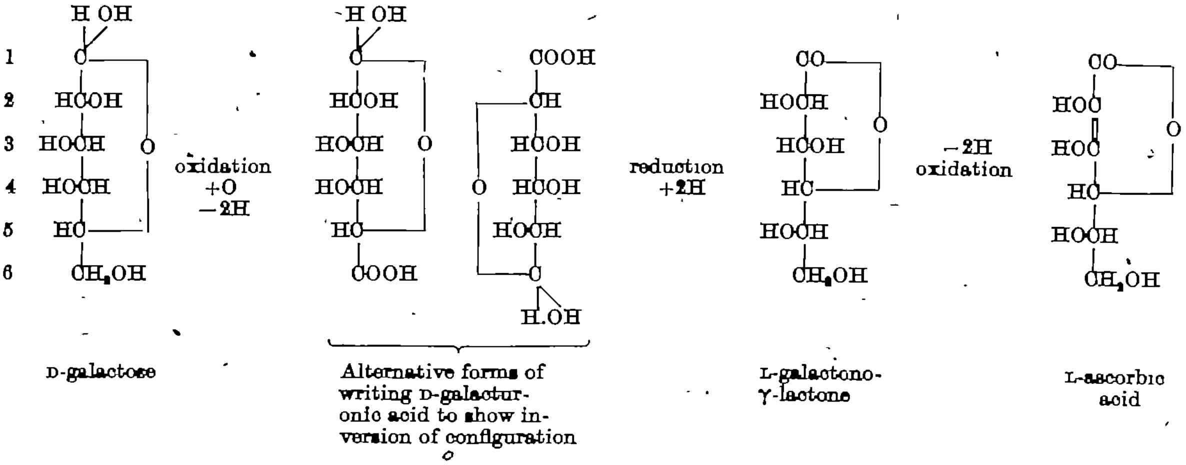
STUDIES in this laboratory have yielded evidence with both plants and animals that the conversion of D-glucose to L-ascorbic acid is by way of D-glucuronic acid and L-gulonic acid (or derivatives), and it seems that D-galactose may also pass to L-ascorbic acid through corresponding intermediates. The overall conversion of sugars (D-glucose, D-fructose and D-mannose) into L-ascorbic acid had, of course, been demonstrated previously, by Ray[1] and others in plants, and by Jackel, Mosbach, Burns and King[2] in animals.

The experimental facts are as follows. The γ-lactones of D-glucuronic acid and L-gulonic acid, when fed to cress seedlings or injected into rats, were found to be transformed into L-ascorbic acid. D-Galacturonic acid methyl ester, and L-galactonic acid γ-lactone behaved similarly. No other sugar acid γ-lactone yielded L-ascorbic acid when tested in the same way, although all the sugar acid γ-lactones, both D- and L-, were examined except those of L-allonic and L-altronic acids. The inactivity of L-idono- and L-talono-γ-lactones was particularly interesting, because these compounds respectively differ from the L-gulono- and L-galactono-γ-lactones solely in the configuration of carbon atom 2.

These facts suggest that two analogous sequences of reactions can take place, as indicated in the accompanying schemes. A fundamental feature of both schemes is the change, at the second step, from the D- to the L-series with inversion of the whole molecule; and it is significant here that Horowitz, Doerschuk and King[3] have just shown that, in the rat, feeding of D-glucose labelled with carbon-14 at position 1 produces L-ascorbic acid labelled only at position 6. It appears that the enzymes catalysing the transformation of the aldonic acid into L-ascorbic acid are specific for an L-configuration of the hydroxyl groups on carbon atoms 2 and 5 (referred to L-ascorbic acid) and for the D-configuration on carbon atom 4.

During the above investigation, we found that D-arabo-ascorbic acid (the configuration of which differs from L-ascorbic acid only at carbon atom 5) was produced from two of the lactones, in the rat from D-mannono-γ-lactone *only* and in cress seedlings from D-altrono-γ-lactone *only*, and here the configuration of the hydroxyl group on carbon atom 3 was specific. We have not found, however, that the corresponding difference between the L-gulonic and L-galactonic acid γ-lactones has any obvious influence on the synthesis of L-ascorbic acid in the plant or





the animal. There is thus no indication which of our postulated reaction sequences is the more important.

Other mechanisms whereby hexoses might be transformed into L-ascorbic acid, involving L-glyceraldehyde, L-sorbose, D-sorbitol and D-gluconic acid, have not been found in cress seedlings or in the rat.

This work will be published in detail elsewhere.

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## Light Pulses from the Night Sky associated with Cosmic Rays

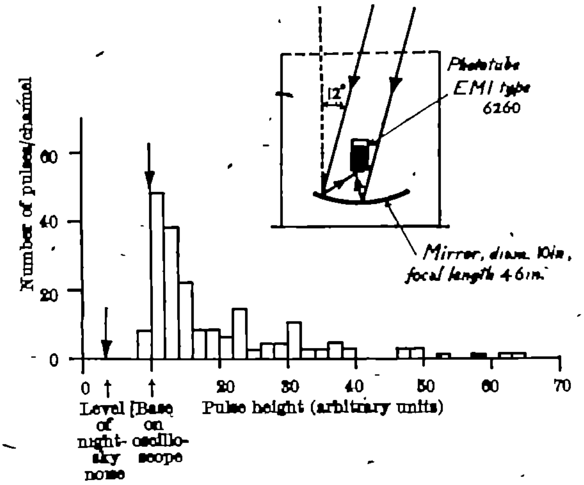
In 1948, Blackett[1] suggested that a contribution approximately $10^{-4}$ of the mean light of the night-sky might be expected from Čerenkov radiation[2] produced in the atmosphere by the cosmic radiation. The purpose of this communication is to report the results of some preliminary experiments we have made using a photomultiplier, which revealed the presence of light-pulses of short duration correlated with cosmic radiation.

A photomultiplier was mounted with its cathode at the focus of a parabolic mirror (see diagram, inset), the field of view of this 'telescope' being approximately ± 12° from the zenith. The output of the phototube was connected to an amplifier with equal differentiation and integration time-constants of 0·032 μsec. The apparatus was mounted in a field adjacent to this establishment at the centre of a square array of sixteen Geiger–Muller counters (each of area 200 $cm.^2$; the sides of the entire array were 180 metres) designed by Cranshaw[3] for studies of extensive air-showers. The results obtained were as follows.

(*a*) On the night of September 25–26, the pulses were first observed visually on the oscilloscope and were seen to be several times the mean height of the noise pulses due to the general night-sky illumination. Photographs of the pulses were taken and a pulse height distribution plotted (see graph). With the bias arbitrarily set at three times the night-sky noise, 97 pulses were recorded in 100 min.

Artificial night-sky noise was then produced by means of a small lamp inside a lid placed over the telescope. In 60 min., no noise build-up pulses were observed at the same bias and gain conditions.

(*b*) Three-fold coincidence pulses corresponding to showers detected by the extensive shower array were used to trigger the time-base of the oscilloscope, and the light pulses (if any) displayed on the *Y*-plates.



In nineteen such showers there was no evidence of any having associated light pulses.

(c) On the night of October 14–15, we decided to trigger the oscilloscope from the light pulses (again selected to be greater than three times night-sky noise) and display the pulses from all the sixteen single counters from the extensive shower array on the Y-plates. Out of fifty time-bases triggered (in 58 min.), eighteen had single Geiger–Müller pulses at the same point on the time-base; two had a coincidence between two Geiger–Müller tubes, one corresponding to three Geiger–Müller tubes and one to four Geiger–Müller tubes. This rate of observing Geiger–Müller pulses on the time-bases associated with light-pulses (when the association is to within 3 μsec.) is approximately a thousand times the accidental coincidence-rate. Moreover, the fact that all the Geiger–Müller pulses occur at the same point on the time-base and correspond in some instances to more than one counter being discharged strengthens the correlation between them and the light.

(d) On October 22, a night of complete cloud, when the cloud-base was known to be between 4,000 and 9,000 ft., pulses at about half the rate were observed under the same conditions of gain and bias.

The conclusions are: (i) a large fraction of the light pulses observed are directly correlated with the cosmic radiations; (ii) none of the light pulses may be attributed to spurious effects, for example, high-tension breakdown, electromagnetic pick-up or noise pile-up; (iii) from the steepness of the front of the electrical pulse, it is deduced that the duration of the light pulses is less than approximately 0·2 μsec.

The negative result of experiment (b), in which we observed no light pulses on the nineteen time-bases triggered from the showers, may be accounted for by the smaller angle of acceptance for the light by the telescope than for showers by the Geiger array.

Some of the light pulses observed may result from relatively soft showers high in the atmosphere from which only a few particles survive at sea-level. There is no evidence in the experiments carried out so far to show that the light is, in fact, Čerenkov radiation rather than light produced by ionization. A series of experiments is planned to investigate the exact nature of the phenomenon.

The above experiments were undertaken following a discussion with Prof. P. M. S. Blackett, to whom we are grateful for his continued interest. We wish to thank Mr. W. J. Whitehouse and Dr. E. Bretscher for their encouragement, and Dr. T. E. Cranshaw for the use of the extensive shower array.

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## Determinations of Size of Particles with the Electron Microscope

A method recently reported by Timbrell[1] for the determination of particle-size with the light microscope has been applied with slight modification to size-determinations of textile-bonding agents with the electron microscope. These materials are dispersions of spherical polymer particles having sizes in the range 0–0·2 μ. The normal method of size determination involves measurements on photographic plates obtained at known magnification using a transparent graticule. This method, which is tedious, may be subject to errors due to fatigue of the operator; and the method described has been found much more rapid and reliable.

The photographs of the dispersion are obtained in the usual way with the electron microscope, and the plates are trimmed with a glass cutter so that they can be placed in the holder of an ordinary slide projector. The projected beam is intercepted and deviated on to a screen by a front-aluminized glass mirror which can be oscillated about a vertical axis. Size discrimination can then be made as in Timbrell's method, by the number of overlapping areas present on the screen, each representing a particle with a diameter larger than the amplitude of the oscillation. All the determinations made to date with the instrument have been obtained by counting overlapping areas for various settings of the amplitude control, thus giving the cumulative size-distribution curves.

It has been found advantageous to increase the visual effect of an overlap area by introducing a colour contrast in the following way. A circular sheet of 'Perspex' was dyed in two operations so that one half was red and the other half green. This was then

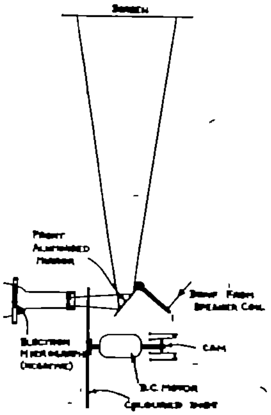

Fig. 1

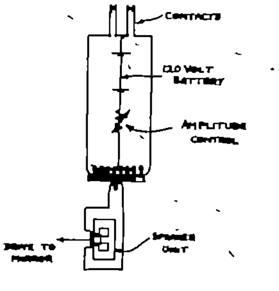

Fig. 2

mounted on the shaft of a small D.C. motor and placed in front of the projector. By rotating the disk in synchronism with the oscillation of the mirror, it could be arranged that the image of a particle at one end of its travel was red and at the other end green. When overlaps occurred they were formed by the additive combination of red and green light, and were yellow in colour and of a high visibility.

The synchronization of the motor and mirror was achieved by means of a rotary switch fastened to the motor spindle, which interrupted the current through the primary winding of a step-down transformer, the secondary winding of which was used to drive a small speaker-unit connected to the mirror. The power for the mirror drive was obtained from a 120-V. dry battery, and with this arrangement the amplitude of oscillation, which was controlled by a small rheostat in series with the battery, was independent of speed of motor over the range determined by fluctuations of the supply voltage. The rotary switch generated a square wave so that the mirror spent the greater part of the time at the ends of its travel. The definition was further improved by blacking out a sector of the 'Perspex' disk corresponding to the region of the oscillation cycle in which the mirror was moved.

The amplitude of oscillation for any setting of the rheostat was easily determined by measuring the movement of grains on the photographic plate, which when related to the scale on the plate gave the amplitude directly in microns. The optical arrangement used is shown in Fig. 1, and the circuit in Fig. 2.

If the rotating disk was omitted, the only unmodulated regions of illumination on the screen would be the overlaps (assuming the projector lamp to be supplied with direct current), and this property might be used as a basis for counting such areas automatically. This development is at present being investigated.

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## Coincidence and Overlap Errors in the Automatic Counting and Sizing of Particles

IN the automatic counting and sizing of a population of particles on a glass slide or a photograph[1] errors arise when adjacent particles are closer than the limit of resolution of the counting apparatus or when they overlap along the scanning track: in both cases the two particles are counted as a single particle of larger size. If the centres of the particles are randomly distributed along the scanning track and the number counted is large, the probability that two successive centres will be less than a distance $Z$ apart is

$$1 - \exp(-\alpha Z), \qquad (1)$$

where $\alpha$ is the mean number of particles per unit length of track. If the order in which particles are encountered along the scanning track is random with respect to size and their projections on the plane of the track are circular, the probability that the sum of the radii of two successive countable particles is between $u$ and $u + \mathrm{d}u$ is:

$$Q(u)\mathrm{d}u = 2\,\mathrm{d}u \int_{D_1/2}^{u-D_1/2} P(x)\, P(u-x)\, \mathrm{d}x, \qquad (2)$$

where $P(x)\mathrm{d}x$ is the probability of a particle with radius between $x$ and $x + \mathrm{d}x$, and $D_1$ is the diameter of the smallest particle counted. The condition for resolution of the two particles is $Z > R_0 + u$, where $R_0$ is the limit of resolution of the counting apparatus. The coincidence error is given by the joint probability of (1) and (2), namely,

$$\varepsilon = 2\int_{D_1}^{D_2} \left[ \left\{ (1 - \exp(-\alpha\, \overline{R_0 + u}) \right\} \int_{D_1/2}^{u-D_1/2} P(x)\, P(u-x)\mathrm{d}x \right] \mathrm{d}u, \qquad (3)$$

where $D_2$ is the diameter of the largest particle present. This expression does not allow for coincidences arising from particles that protrude into the scanning track although their centres lie outside it. If necessary, this allowance can be made by adding to $P(x)$ in the analysis the probability of an intercept length $2x$ when the particles are scanned by a line[2], given by the equation:

$$\varphi(2x) = x/(2\bar{r}). \int_{x}^{D_2/2} P(r)\, (r^2 - x^2)^{-1/2}\, .\, \mathrm{d}r.$$

The particle radius $r$ is a variable independent of $x$, and $\bar{r}$ is the mean particle radius.

Result (3) may be applied, for example, to a thermal precipitator sample of an airborne coal-mine dust. $P(x)\mathrm{d}x$, the probability of a particle the projected area of which equals that of a circle of radius between $x$ and $x + \mathrm{d}x$, is approximately $K \exp(-\lambda x)\mathrm{d}x$, where $\int_{D_1/2}^{D_2/2} K \exp(-\lambda x)\mathrm{d}x = 1$, and $D_1$ and $D_2$ lie within the range 0·5–10 microns.

By substitution in (3),

$$\varepsilon = 2\int_{D_1}^{D_2} \left[ \left\{ 1 - \exp(-\alpha\, \overline{R_0 + u}) \right\} \int_{D_1/2}^{u-D_1/2} K^2 \exp(-\lambda u)\mathrm{d}x \right] \mathrm{d}u. \qquad (4)$$

If $\lambda > \alpha$ ($\lambda = 0{\cdot}8$, $\alpha < 0{\cdot}02$ in this case), $D_2$ is much greater than $D_1$ and $\varepsilon > \varepsilon^2/8$, equation (4) simplifies to give:

$$\alpha = \varepsilon/\{2(D_1 + R_0)\}. \qquad (5)$$

The mean number of particle centres per unit length of track, $\alpha$, is also $W\rho$, where $W$ is the track width and $\rho$ the mean number of particles exceeding $D_1$ in diameter per unit area of sample. The number exceeding 0·5 micron in diameter, here written $\rho_0$, is easy to measure, and $\rho = \rho_0 \exp\{-\lambda(2D_1-1)/4\}$. By substituting for $\alpha$ in (5),

$$W = \varepsilon \exp\{\lambda(2D_1 - 1)/4\}/\{2\rho_0(D_1 + R_0)\}.$$

No account has been taken of the irregular shapes of coal-mine dust particles, for which it can be shown that a rough allowance can be made by multiplying $\lambda$

by a factor of 0·8. Optical considerations place a lower limit of 1 micron on $D_1$. Typical values are $\rho_0$ is equal to one particle per 150 square microns, $\lambda$ is 0·8, $R_0$ is 0·5 micron. To confine the coincidence error to 5 per cent of all particles greater than 1 micron, the permissible track width, $W$, is approximately 4·5 microns.

Equation (3) does not make a complete correction for coincidence effects when there are particles present which are smaller than the smallest particles that are to be counted, that is, particles the diameter of which is less than $D_1$. Coincidences in the size-range $D_1/2$–$D_1$ may give a signal above the threshold-level corresponding to $D_1$ and so a spurious count. This effect may be estimated by substituting the appropriate limits of integration in (3). In the case of the coal-mine dust above, these spurious counts would amount to about 0·4 per cent of the total count of particles greater than $D_1$. Similarly, an allowance is required if there are particles greater than $D_2$ present but not counted.

Where it is not necessary to size particles, the signals may be differentiated and a count made of the pulses corresponding to the leading edges of particles. The probability that the radii of two successive particles differ by an amount between $v$ and $v + dv$ is:

$$2\,dv \int_{D_1/2}^{D_2/2 - v} P(x)\,P(x + v)\,dx, \qquad (6)$$

and the condition for their resolution is $Z + v > R_0$. The coincidence error is then given by the joint probability of (1) and (6):

$$\varepsilon = 2\int_{0}^{(D_2 - D_1)/2} \left[ \left\{1 - \exp\left(-\alpha\,\overline{R_0 - v}\right)\right\} \int_{D_1/2}^{D_2/2 - v} P(x)\,P(x + v)\,dx \right] dv. \qquad (7)$$

If (7) is applied to a coal-mine dust sample with the assumptions $\alpha \ll \lambda$, $D_2 \gg D_1$ and $\varepsilon \gg \varepsilon^2/8$, it simplifies to:

$$\alpha = \varepsilon/R_0. \qquad (8)$$

This is the same as the formula obtained by taking (1) as the coincidence error for a random distribution of leading edges with mean interval $1/\alpha$ and the condition $Z > R_0$ for resolution, where $Z$ is now the interval between two successive leading edges. From (8) it is found that, when the coincidence error must be confined to 1 per cent of a count of all particles greater than 1 micron in a coal-mine dust sample, and when an allowance is made for irregular shape of particle, the permissible track width is approximately 5·5 microns.

I wish to thank the Director of the Safety in Mines Research Establishment, and the Ministry of Fuel and Power, for permission to publish this communication.

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## Scattering of 56-Mc./s. Radio Waves from the Lower Ionosphere

Incidental to radar studies of the aurora at Saskatoon, Canada (52·1° N., and 106·6° W.), with frequencies of 56 and 106·5 Mc./s., a persistent scatter echo is observed with the lower frequency. This echo arises apparently from the lower ionosphere. As viewed on a conventional range-amplitude display, the scattered signals appear extremely diffuse, but are quite evident on photographs of the display with exposures of a minute or more. A similar type of echo has never been detected at the higher frequency, although both radar units have about the same sensitivity and scan simultaneously the same parts of the sky.

For the 56-Mc./s. equipment, the aerial array-gain relative to a Hertzian dipole is about 16; the direction of maximum radiation is 6° above the horizontal; the peak power of the transmitter pulse, 50 kW.; the duration of the pulse, 16 μsec.; and the receiver sensitivity, $5 \times 10^{-13}$ W. The following statements concerning this echo are based on fairly regular but not continuous operation of the radar units between February 23 and June 6, 1952. Since the primary purpose was to investigate radio echoes from the aurora, the normal operating period covered only the hours of twilight and darkness. However, a sufficient number of runs were made in the daylight hours at least to indicate the diurnal characteristics of the scatter echo.

The echo was strongest during March, decreasing in amplitude during April and May until finally it could only be detected by increasing the power output of the transmitter. It exhibited a minimum value in the late afternoon and increased steadily in amplitude throughout the night. The signal was strong in the morning hours; but the time that it reached a maximum is uncertain. There was no evident relationship between the scatter echoes and the occurrence of either visible aurora or radio echoes from the aurora.

The mean distance of the region from which the echoes arose was invariably about 400 km., extending over a range of about 100 km. for weak signals to about 200 km. for particularly strong ones. The photographic records showed a sharp minimum in the signal amplitude for distances of about 370 km. If this minimum in amplitude corresponds to the first minimum in the radiation pattern of the aerial (about 12° above the horizontal), the scattering region was about 85 km. above the earth's surface. The echoes showed no consistent variation with azimuth of the radar beam, although for periods of several minutes the signals from one direction would be slightly greater than those from other directions.

A similar type of signal has been observed at various times since 1948 by McKinley and Millman (private communication) in connexion with their meteor investigations at a frequency of 33 Mc./s. Their echoes arise apparently in a region directly above their station (Ottawa, Canada) at heights of 80–90 km. If, as seems very likely, the Saskatoon and Ottawa signals have a common origin, it must be one involving scattering rather than reflexion from horizontal stratifications of ionization in the lower ionosphere. It is also likely that these echoes arise in the region responsible for the long-range propagation of very high-frequency signals. If, as has been suggested recently by Booker *et al.*[1], such signals are due to scattering of the radio waves by ionic inhomogeneities, the detection of back-scatter echoes indicates that the scale of the fine structure in the active region is a few metres rather than the hundreds of metres usually attributed to the *E*-region.

Grants and personnel (P. A. F.) from the Defense Research Board of Canada have made this work possible. The radar equipment was made available through the co-operation of the Geophysical Research Directorate, Air Force Cambridge Research Center, Cambridge, Mass.

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## A New Method of Light Microscopy

Using annular apertures made in a thin layer of candle soot on a microscope objective lens and corresponding apertures in the condenser, an ordinary microscope can be made very suitable for the study of unstained specimens. There are two different procedures.

To make higher refracting objects appear dark against a light background, it is necessary to find the objective lens surface nearest to the image of the condenser aperture and soot it by short contacts with the flame, until the transparency has diminished by one-half. On a watchmaker's lathe, using a sharp tip of some soft material, a narrow ring-shaped area is freed from soot, the diameter of the ring being greater than half the exit pupil of the objective, that is, at least twice as wide as the phase ring in conventional phase-contrast objectives. When compared with the latter, there are freedom from halo effects, increased resolving power and a pleasing gradation for objects having different refractivity.

Images of greater contrast and with light values similar to those to which we are accustomed in the macroscopic world are achieved if a partly reversed procedure is followed. The sooting is continued until the transparency has decreased to 8–9 per cent, after which the soot is wiped off, except for an area covering the image of the condenser ring aperture. As a result, the background of the microscope image appears in an agreeable sepia tone, often giving the illusion of sky-illuminated objects lying on the sand floor of a shallow sea. Many features which are generally invisible with the normal use of the microscope are rendered visible; for example, influenza virus on red cell ghosts, bacterial flagella, sperm tail pencil, and delicate membranous margins in living thrombocytes (see photographs). Apparently the method can be adapted to ultra-violet microscopy and mirror optics as well.

The theoretical explanation of what occurs in each of the alternative procedures may not be an easy one, since the phase effects in microscopical observation are still incompletely understood[1]. The arrangements described above are the result of some hundreds of trials, in which the conditions were varied one at a time.

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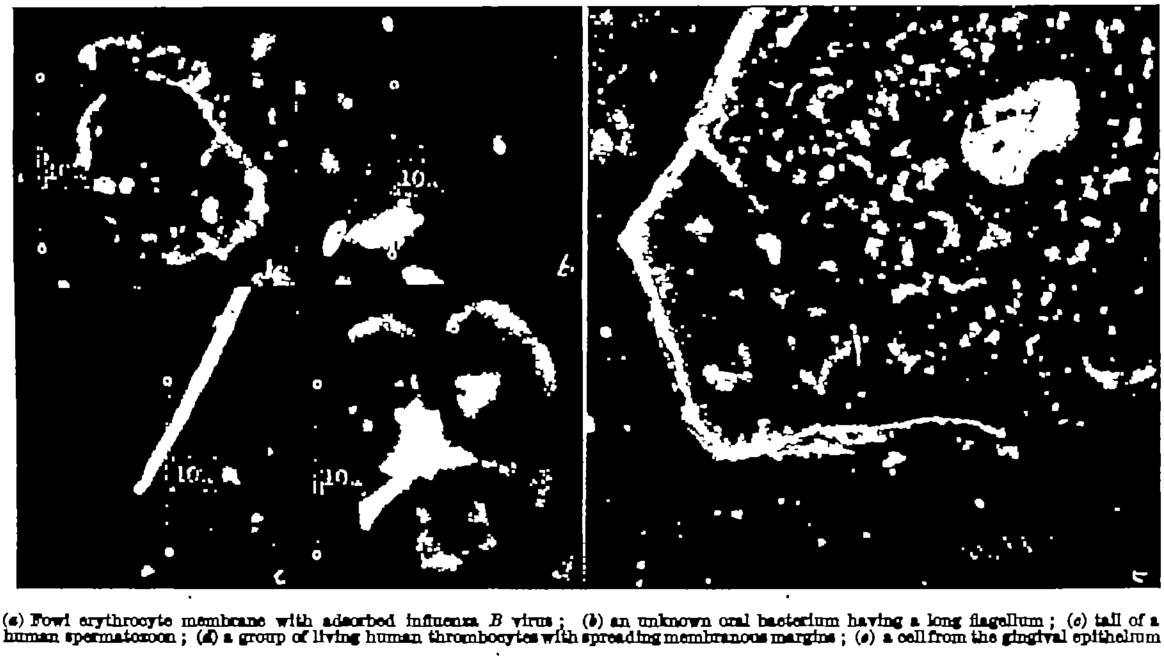
[1] See Proceedings of the London Conference on Optical Instruments, 131 (Chapman and Hall, 1951).



(*a*) Fowl erythrocyte membrane with adsorbed influenza *B* virus; (*b*) an unknown oral bacterium having a long flagellum; (*c*) tail of a human spermatozoon; (*d*) a group of living human thrombocytes with spreading membranous margins; (*e*) a cell from the gingival epithelium

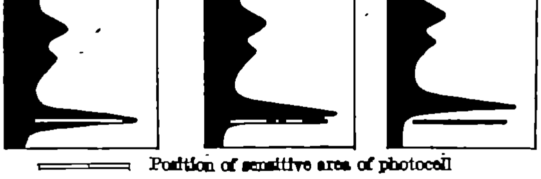
## Photoelectric Control of the Compensator in Electrophoresis

Various types of compensator[1-3] are used in electrophoresis to bring the initial boundaries into view, or to bring a particular boundary into the correct position for isolation of a sample. Manual control of the compensator is quite convenient in these cases. However, it is sometimes necessary to keep a boundary stationary during a long run, either for analytical purposes[4], or in the course of preparative work[5]. The obvious type of automatic control is one based on a photoelectric device; but no such application seems to have been described in the literature.

The main difficulty encountered in applying this principle arose from the very low intensity of the light which reaches the camera screen in the diagonal *Schlieren* optical system[6] of the Tiselius apparatus[1]. This prevented the use of ordinary photoelectric relays. Different ways of increasing the effective light intensity were considered and rejected for various reasons. Instead, it was decided to use a photoconductive cell of the type described by Schwarz[7]. Although the sensitive area is only 0·1 mm. × 10 mm., the sensitivity is very high (10 A./lumen). Moreover, the whole cell is compact (1 cm. diam. × 5 cm.) and can be operated from a small dry battery.

The following arrangement was finally adopted. The cell is situated with its photosensitive area in the focal plane of the camera (see Figs. 1–3), and connected in series with a 4·5-V. dry battery and a 'Cambridge' spot galvanometer, the latter being fitted with a variable shunt. A second Schwarz[7] photocell is held against the scale of the galvanometer, where it is illuminated by the light spot under particular circumstances. It is connected in series with a 13·5-V. dry battery and the coils of a small relay, the contacts of which control the supply of current to the compensator. It is particularly convenient to use the electrolytic type of compensator[5] here. The intermediate galvanometer relay is essential, because the very low light intensity differential between the bright and dark parts of the field ($10^{-7}$ lumens) produces a current of the order of 1–2 μA., quite insufficient to operate a relay directly. The second photocell gives rise to a current of 3 mA., which is ample for the purpose.

The cycle of operations may be described as follows. With the system as shown in Fig. 3 the photocell in the *Schlieren* system produces its maximum current, causing the galvanometer light to fall on the other photocell. The relay is thereby actuated, and prevents the compensator from functioning. The current through the Tiselius apparatus then moves the boundaries until (Fig. 2) the first photocell is partly obscured and the light spot moves away from the second photocell, indirectly bringing the compensator into action. This is usually set to a rate 50–100 per cent greater than that which would, by continuous operation, keep the boundary stationary. Thus the boundary actually moves back while the compensator is in action until the original situation (Fig. 3) is restored, and the cycle recommences. Success is dependent on the stability of the maximum current from the first photocell. A superior arrangement, in which a certain amount of drift is permissible, is when the second photocell is between the positions the light spot occupies when the first photocell is fully illuminated (Fig. 3) or in the dark (Fig. 1). Before the compensator is connected to the photoelectric control the boundary is brought to the appropriate intermediate position (Fig. 2), so that the galvanometer light falls on the second photocell. The system then cycles reliably, the boundary moving a small distance on each side of a mean position. It is necessary to bring the initial boundary to the correct level because, if the system is allowed to start from the extreme position shown in Fig. 1, the spot of light may sometimes swing completely past the second photocell. In order to prevent any failure due to the distortion or obscuring of the peak by condensed moisture it is the practice, particularly under humid conditions, to leave a current of air blowing over the external surfaces of the windows of the electrophoresis bath.



▭ Position of sensitive area of photocell

We wish to thank Mr. E. Schwarz, of Hilger and Watts, Ltd., for helpful advice.

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## A Crystalline Hydrated Magnesium Silicate formed in the Breakdown of a Concrete Sea-wall

During an investigation of a serious breakdown of a concrete sea-wall, a small amount of a finely divided soft white deposit has been found which gives an X-ray diffraction pattern not unlike that of $4CaO.Al_2O_3.13H_2O$. However, the chemical composition of the material, after allowing for 23 per cent impurity of calcium carbonate and 3 per cent of silica, can be expressed ideally as $4MgO.SiO_2.8\cdot5H_2O$. This is thought to be the first reported occurrence of a crystalline hydrated magnesium silicate formed at ordinary temperatures in the breakdown of a cement. Steopoe[1] has given indirect evidence of the formation of such a compound through the action of magnesium hydroxide on silica gel present in cement mortars decomposed by sulphate attack. The material reported on here has probably formed in a manner similar to that discussed by Steopoe. The magnesium hydroxide arises from the breakdown of calcium sulpho-aluminate through the presence of soluble magnesium salts derived from the sea-water[2]. The calcium sulpho-aluminate is, as is well known, a common product of reaction between calcium sulphate solutions and calcium aluminate. Silica gel can be expected to form readily from the poorly crystallized hydrated calcium silicates of the set cement under the decomposition conditions.

The X-ray diffraction pattern of the new material can be indexed to a hexagonal unit cell of spacings $a = 8\cdot95$ A., $c = 8\cdot10$ A. (cf. $a = 8\cdot8$ A., $c = 8\cdot2$ A. for $4CaO.Al_2O_3.13H_2O$ found by Wells, Clarke and McMurdie[3]). The $c$-axis has dropped by 0·16 A. over several years, being originally 8·26 A. No weight is lost on heating from 110° to 160° C., but from here to 1,000° C. the material shows a continuous loss of close on 40 per cent of its air-dry weight. X-ray powder photographs show that the hydrated magnesium silicate, after losing 10·7 per cent structural water (3·1 molecules), is replaced at 340° C. by periclase (MgO) and a hydrated magnesium silicate of lower MgO content than the original material. The structure of the last is stable until about 650° when it, too, is destroyed. At 700° C. the reaction products recrystallize as periclase and forsterite ($2MgO.SiO_2$), together with a little unidentified material. These experiments suggest that the structural formula of the original material can be written as $3Mg(OH)_2.MgSiO_3.5\,5H_2O$.

Further work is proceeding on the properties and synthesis of the new material and its relation to other low-temperature forms of magnesium hydrated silicate, and a more detailed account will be published at a later date.

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## 'Parathion' and Ultra-violet Light

Pure 'Parathion' is not at present considered to be an inhibitor of cholinesterase *in vitro*[1-3]. It is probable that those who first reported[4-6] to the contrary were using samples contaminated with one or more of the following: O-S-diethyl *p*-nitrophenyl thiophosphate, diethyl S-*p*-nitrophenyl thiophosphate and diethyl *p*-nitrophenyl phosphate ('Paraoxon'), all of which possess anticholinesterase activity *in vitro*[3].

We have found that when emulsions of 'Parathion' in aqueous salt solutions are exposed to ultra-violet light (wave-length 1850–4000 A.), they develop anticholinesterase activity progressively (Fig. 1,*c*). This activation occurred first at room temperature in emulsions and solutions (Fig. 1,*a* and *b*; Fig. 2) exposed to daylight. It did not occur in the dark (Fig. 1,*d*), or in electric light.

Estimation of the anticholinesterase activity developed has been carried out manometrically by the Warburg method. A homogenate of rat brain, or washed rat erythrocytes, has been used as source of cholinesterase, and 0·03 *M* acetyl-β-methylcholine chloride as substrate. The total volume of the flask contents has been 3·0 ml., and 'Parathion' solutions ($6·9 \times 10^{-5}$ *M*) and emulsions ($3·45 \times 10^{-4}$ *M*) have been sampled at the rate of 1·0 or 0·1 ml. per flask. The cholinesterase and 'Parathion' were incubated for 30 min. before addition of the substrate.

Activation of 'Parathion' in this way occurs in any of the following solvents: 0·85 per cent sodium chloride, *M*/40 sodium bicarbonate, *M*/15 phosphate buffer mixtures over the *p*H range 5·5–7·5, and in an *M*/20 borate buffer mixture, *p*H 8·5 (Fig. 2).

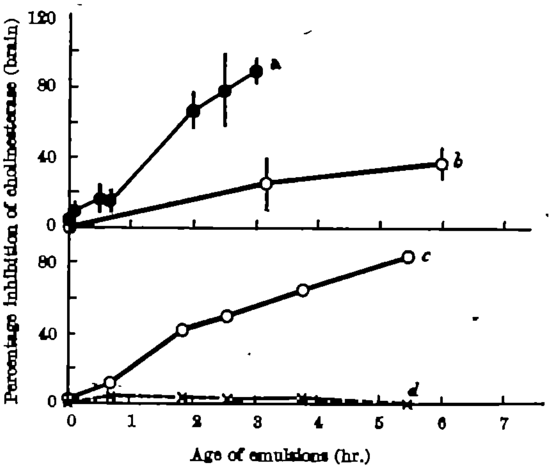

Fig. 1. Influence of light upon the development of anticholinesterase activity by emulsions of 'Parathion' (concentration $3·45 \times 10^{-4}$ *M*) in 0·067 *M* phosphate buffer mixtures, *p*H 6·5. (*a*) and (*b*) Emulsions kept in daylight, sampling 1·0 ml. and 0·1 ml. respectively per Warburg flask. The vertical lines indicate the standard errors of 2–9 observations. Sunlight highly variable (August): room temperature range, 20–26° C. (*c*) Emulsions exposed at a distance of 2 ft. from an ultra-violet lamp. (*d*) Emulsions kept in darkness. Emulsions sampled at the rate of 0·1 ml. per flask. Room temperature, 25° C. ± 1°

The active inhibitor present in irradiated emulsions is destroyed by rat blood (that is, the plasma fraction) at a greater rate than that at which it combines with cholinesterase. For example, a volume of emulsion which caused 75 per cent inhibition of 20 mgm. brain caused no appreciable inhibition of 0·22 ml. whole blood, although these two quantities of enzyme preparations possess approximately equal cholinesterase activities. It is only when this same quantity of brain was completely inhibited that 10 per cent inhibition of blood could be detected.

At least three possibilities exist to account for this development of anticholinesterase activity in 'Parathion' emulsions or solutions exposed to sunlight or artificial ultra-violet radiation under the conditions stated: (1) 'Parathion' itself is being transformed

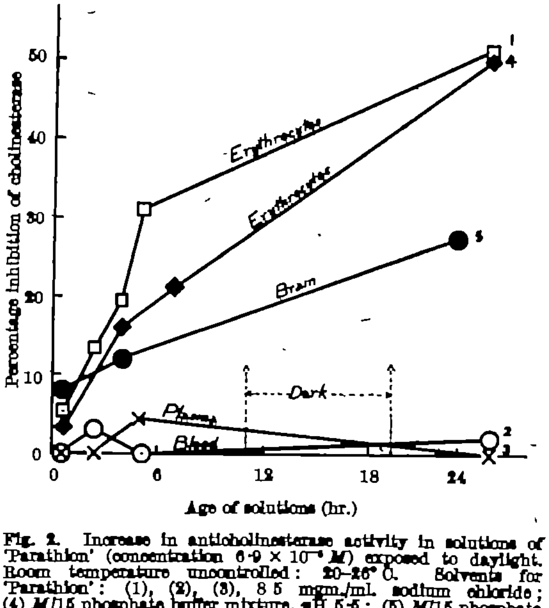

Fig. 2. Increase in anticholinesterase activity in solutions of 'Parathion' (concentration $6·9 \times 10^{-5}$ *M*) exposed to daylight. Room temperature uncontrolled: 20–26° C. Solvents for 'Parathion': (1), (2), (3), 8·5 mgm./ml. sodium chloride; (4) *M*/15 phosphate buffer mixture, *p*H 5·5; (5) *M*/15 phosphate buffer mixture, *p*H 7·5

to an active inhibitor, for example, an active isomer; (2) some impurity is activated to an inhibitor of cholinesterase; (3) some factor which prevents 'Parathion' itself from being inhibitory is being progressively removed from the field of interaction by ultra-violet light.

The first of these possible explanations appears to be the most likely. The transformation of 0·3 per cent of the 'Parathion' present to an anticholinesterase equal in activity to 'Paraoxon' could have accounted for the 50 per cent inhibition found when sampling 0·1 ml. of an emulsion exposed to ultra-violet light for 2½ hr. (see Fig. 1,c).

The small amount of *p*-nitrophenol liberated in the emulsions exposed to ultra-violet light is totally inadequate to account for the inhibitory activity developed.

The mechanism of this transformation is being further investigated in these laboratories.

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## Effect of a Copper Supplement to the Rations of Milking Cows

THE prevention of symptoms of swayback in the offspring of ewes grazing on affected pastures in Britain has been shown to be effective when the pregnant ewe receives an additional supply of copper[1]. Sufficient copper for the proper metabolism of nervous tissue in the young animal appears to be provided if a single dose of copper is administered to the mother ewe within an hour or two of the birth of its lamb[2].

The widespread appearance of swayback in lambs on farms in the west of Scotland during the war years, following the application of lime to the grazings of the pregnant ewes, raised the question of the effect of copper on the production of other farm animals. Cows are not known to produce swayback-affected offspring, but it appeared possible that the conditioned deficiency of copper in animals grazing swayback pasture might cause a reduction in the butterfat production of lactating cows.

Cunningham[3] has already shown that dairy cows grazing on the peat lands of New Zealand, where copper-deficiency symptoms appear in the lambs of many sheep flocks, produce a larger amount of butterfat when their ration contains extra copper. Before treatment the butterfat production of the herds was disappointingly low.

The problem of copper deficiency affecting dairy cows has not been examined in Great Britain. As a preliminary, it was decided to determine the effect of copper on the butterfat production of cows in west of Scotland herds during the winter period of stall feeding.

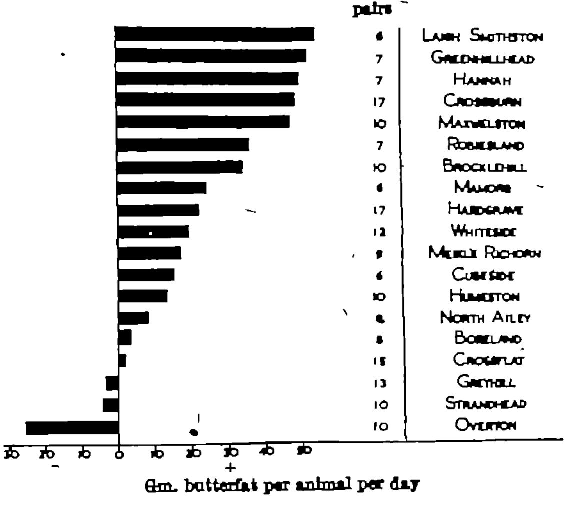
Milk recorders trained by the Scottish Milk Records Association at the West of Scotland Agricultural College determine the yield and the fat content of the milk produced by each lactating animal in the herds of all the members on at least one day during each month of the year. The results obtained by the recorders have been used in this investigation, which was conducted in nineteen different herds in nine counties in the south and west of Scotland.

In each herd two groups of animals were drawn up according to: (1) month of calving, (2) daily yield of milk, and (3) fat yield during the previous lactation. Two tests of the new lactation were regarded as minimal before an animal was put on experiment. Animals nearing the end of their lactation—all on experiment had calved less than eight months previously—were rejected if the yield of fat had dropped to less than 150 gm. of butterfat per day. One group was given supplementary copper, and the other served as control. To the production ration of each animal in the treated group one teaspoonful copper sulphate (10 gm. $CuSO_4.5H_2O$) was added. The inclusion of the full supplement of 10 gm. of the salt in less than a dairy scoopful of the meals (about 3½ lb.) was found to lead on many occasions to refusal of food. In such cases it was found necessary to administer the salt supplement in two doses (5 gm. per feed).

Addition of the supplement in the manner described to the rations of the experimental animals was made within one week of the visit of the recorder. In one herd—Crossburn—the addition of copper sulphate to the meal was delayed as late as the afternoon before the recorder's visit, that is, about 25 hr. before the recorder commenced his measurement of the yield of milk and of fat produced by the cows. Even when the supplement was fed at this late period the response elicited was most marked[4].

After the recorder had entered the results of the tests in the herd milk record book, the experimental results for the animals in the nineteen herds were examined statistically (see histogram). The observations were examined at Rothamsted Experimental Station, with the following result: weighted mean increase (gm.) butterfat per cow per day, 20·1; standard error, 5·22 (18 d.f.).

The treatment has, therefore, a real effect, although apparently not large enough to be detected on most single farms. The standard error is calculated from $SW(y - \bar{y}_w)^2$, where $W$ is the number of pairs at a farm and is appropriate if the weights are inversely proportional to the within farm variances.



Gm. butterfat per animal per day

The results show that a significant increase in butterfat production has been obtained when additional copper is fed in the manner described to herds selected at random in the west of Scotland.

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## Incidence of Meiosis in the Life-cycle of *Halidrys siliquosa* Lyngb.

SEAWEEDS belonging to the Fucales are diploid, and the reduction division has been shown to occur during the first nuclear divisions in both oogonia and antheridia[1–3].

During a recent investigation of the Fucales on the Northumbrian coast, we have found eight chromosomes in the vegetative cells of plants of *Halidrys siliquosa* Lyngb. The same number of chromosomes is present at both the first and second divisions in both oogonia and antheridia. This shows that in *Halidrys siliquosa* meiosis does not take place at the same stage of development as reported for other members of the Fucales. A detailed account of the cytology of this species will be published at a later date.

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## Embryology of the Emperor Penguin (*Aptenodytes forsteri*)

E. A. WILSON[1] wrote in 1907, "The possibility that we have in the Emperor penguin the nearest approach to a primitive form not only of a penguin but of a bird, makes the future working out of its embryology a matter of the greatest possible importance". With this aim in mind he set out on June 27, 1911, with Bowers and Cherry-Garrard on a terrible journey[2] in the antarctic winter, during which three embryos were obtained from the Cape Crozier rookery on July 20. These specimens were described by Parsons[3], who considered that the smallest one corresponded to a chick embryo of ten days incubation, whereas the two larger specimens corresponded to chick embryos of thirteen days incubation.

It was not until 1949 that Stonehouse[4] collected a series of Emperor penguin embryos from a rookery fifty miles from one of the bases of the Falkland Islands Dependencies Survey. As a result of this expedition we now possess a new series of sixteen embryos collected between June and August and extending from the primitive streak stage to hatching. All the embryos, with one exception, are in an excellent state of preservation. The poorly preserved specimen was frozen before fixation. The embryos have been compared with and classified according to the normal stages of development in the chick[5]. The smallest nine specimens which were younger than those brought back by Wilson have been sectioned serially and confirm the observations made by Parsons[6] on the Gentoo penguin (*Pygoscelis papua*) and the Ring penguin (*Pygoscelis antarctica*). However, comparison of the development of the external form of the Emperor penguin with that of the chick and with that of other penguins already described, namely, Gentoo and Ring penguins by Parsons[6] and Gentoo and Adelie penguins (*Pygoscelis adelia*) by Waterston and Geddes[7], reveals a fact not yet recorded and worthy of note. In the earlier embryos the head region is relatively smaller, the neck and tail regions relatively longer, and the curvatures less well marked in penguin than in chick embryos. These features are more marked in Emperor penguin embryos and result in early penguin embryos resembling early reptilian embryos more closely than do early chick embryos.

| Serial No. | Date of collection | Corresponding stage in chick | Incubation period in chick | Greatest length of curved embryo | Length from beak or maxillary process to tail |
|---|---|---|---|---|---|
| H 532 | 11.6.1949 | 3 | 12 –18 hr. | — | — |
| H 528 | 9.6.1949 | 16 | 51 –56 " | 8 mm. | 11·7 mm. |
| H 525 | 7.6.1949 | 19 | 3 – 3½ days | 11·5 " | 24 " |
| H 529 | 10.6.1949 | 22 | 3½– 4 " | 10·6 " | 35 " |
| H 530 | 10.6.1949 | Poor state of preservation | | 10·4 " | 34 " |
| H 536 | 18.6.1949 | 25 | 4½– 5 " | 13 " | 47 " |
| H 534 | 14.6.1949 | 27 | 5 – 5½ " | 15 " | 53 " |
| H 537 | 22.6.1949 | 29 | 6 – 6½ " | 18·5 " | 59 " |
| H 535 | 17.6.1949 | 30 | 6½– 7 " | 18·5 " | 63 " |
| H 533 | 12.6 1949 | 36 | 10 " | 32 " | 85 " |
| H 538 | 26.6.1949 | 37 | 11 " | 35 " | 92 " |
| H 541 | 6.7.1949 | 37 | 11 " | 35 " | 93 " |
| H 540 | 26.6.1949 | 38 | 12 " | 40 " | 99 " |
| H 539 | 26.6.1949 | 38 | 12 " | 41 " | 110 " |
| H 544 | 1.8.1949 | Hatching | 20 –21 " | 105 " | 290 " |
| H 545 | 2.8.1949 | Hatching | 20 –21 " | 122 " | 290 " |

All measurements taken after fixation

It should be pointed out that the embryos collected on June 26 and July 6, 1949, have reached a stage of development similar to that reached by Wilson's largest specimens. This observation seems to confirm the ones made by Stonehouse[4] on measurements of hatched chicks by which he concluded that the chicks of the rookery at Cape Crozier were hatched about three weeks after the ones from the rookery from which the present series was obtained. A detailed description of the embryos is being written for publication in the near future in the Falkland Islands Dependencies Survey Scientific Reports.

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[7] Waterston, D., and Geddes, A. Campbell, *Trans. Roy. Soc. Edin.*, 47, 223 (1909).

# FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

## Monday, February 23

UNIVERSITY OF LONDON (in the Physiology Theatre, University College, Gower Street, London, W.C.1), at 4.45 p.m.—Prof. Jean Roche (Paris): "Comparative Biochemistry of Iodoproteins".*

BRITISH SOCIETY FOR THE HISTORY OF SCIENCE (in the Lecture Room, Science Museum, Exhibition Road, London, S.W.7), at 5.30 p.m.—Mr. J. A. Chaldecott: "The Zograscope, a Forgotten Name in Optics"; Dr. H. Heywood: "A Brief Description of 18th Century Scientific Instruments recently discovered at Longleat, the Home of the Marquess of Bath".

UNIVERSITY OF LONDON (at Birkbeck College, Malet Street, London, W.C.1), at 5.30 p.m.—Prof. P. Fallot (Paris): "The Tectonics of North Africa".* (Further Lectures on February 24 and 27.)

ROYAL SOCIETY OF ARTS (at John Adam Street, Adelphi, London, W.C.2), at 6 p.m.—Mr. G. Anthony Gardner: "The Safety Factor in Construction", 1. (Cantor Lectures.) (Further Lecture, by Prof. F. C. Thompson, on March 2.)

ROYAL GEOGRAPHICAL SOCIETY (at 1 Kensington Gore, London, S.W.7), at 8.15 p.m.—Dr. S. M. Manton, F.R.S.: "Progress of Soviet Planning in Central Asia".

## Tuesday, February 24

UNIVERSITY OF LONDON (in the Anatomy Theatre, University College, Gower Street, London, W.C.1), at 1.15 p.m.—Dr. G. H. Brown: "Is there a Philosophy of Science?"*

INSTITUTION OF BRITISH AGRICULTURAL ENGINEERS (at the Institution of Electrical Engineers, Savoy Place, Victoria Embankment, London, W.C.2), at 2.15 p.m.—Mr. W. H. Cashmore: "Recent and Present Work at the N.I.A.E.".

CHADWICK PUBLIC LECTURE (at the Royal Society of Tropical Medicine and Hygiene, 26 Portland Place, London, W.1), at 2.30 p.m.—Dr. Georges Decharneux: "Industrial Medicine and Hygiene in Belgium".*

ROYAL SOCIETY OF ARTS, COMMONWEALTH SECTION (at John Adam Street, Adelphi, London, W.C.2), at 5.15 p.m.—Mr. K. R. S. Morris: "Tsetse Fly Control".

BRITISH POSTGRADUATE MEDICAL FEDERATION (at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 5.30 p.m.—Dr. P. L. Mollison: "The Life-Span of Red Cells" ("The Scientific Basis of Medicine", 15).*

SOCIETY OF CHEMICAL INDUSTRY, CHEMICAL ENGINEERING GROUP (joint meeting with the PLASTICS AND POLYMER GROUP, at the Chemical Society, Burlington House, Piccadilly, London, W.1), at 6.30 p.m.—Mr. H. K. Earp, Mr. S. Shapiro and Mr. A. H. Wiggs: "Resin Cements in Chemical Engineering"; Mr. V. Evans: "Corrosion-Resisting Properties of some Synthetic Resin Cements".

SOCIETY OF INSTRUMENT TECHNOLOGY (at Manson House, 26 Portland Place, London, W.1), at 6.30 p.m.—Mr. D. T. Germain-Jones: "Geophysical Prospecting for Oil".

## Wednesday, February 25

ROYAL SOCIETY OF MEDICINE, ENDOCRINOLOGY SECTION (joint meeting with the SOCIETY FOR ENDOCRINOLOGY, at 1 Wimpole Street, London, W.1), at 10 a.m.—Symposium on "Thyroid Gland".

ROYAL SOCIETY OF ARTS (at John Adam Street, Adelphi, London, W.C.2), at 2.30 p.m.—Mr. E. H. Browne: "Improving Coal Production" (Cadman Memorial Lecture).

GEOLOGICAL SOCIETY OF LONDON (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Scientific Papers.

ROYAL STATISTICAL SOCIETY (at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 5.15 p.m.—Mr. G. F. Peaker: "A Sampling Design used by the Ministry of Education".

ILLUMINATING ENGINEERING SOCIETY (at the Lighting Service Bureau, 2 Savoy Hill, London, W.C.2), at 6 p.m.—Discussion on "The Lighting of Pedestrian Crossings".

## Thursday, February 26

ROYAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 10.30 a.m.—Discussion on "The Floor of the Atlantic Ocean" (to be opened by Dr. E. C. Bullard, F.R.S.).

ROYAL INSTITUTE OF PHILOSOPHY (in the Assembly Hall, Institute of Education, Malet Street, London, W.C.1), at 5.45 p.m.—Viscount Samuel: "Man's Ideas about the Universe".

ROYAL AERONAUTICAL SOCIETY (at the Institution of Mechanical Engineers, Storey's Gate, St. James's Park, London, S.W.1), at 6 p.m.—Mr. H. J. Pollard: "New Materials and Methods for Aircraft Structure".

SOCIETY OF CHEMICAL INDUSTRY, MICROBIOLOGY GROUP (joint meeting with the FOOD GROUP, at the Institution of Electrical Engineers, Savoy Place, Victoria Embankment, London, W.C.2), at 6.15 p.m.—"Pathogenic Organisms in Food" (Dr. C. Cockburn: "Epidemiology of Food Poisoning"; Dr. R. E. O. Williams: "Staphylococci and other Gram Positive Cocci"; Dr. Joan Taylor: "Enterobacteriaceae").

SOCIETY OF CHEMICAL INDUSTRY, LONDON SECTION (joint meeting with the LONDON SECTION of the ROYAL INSTITUTE OF CHEMISTRY, at the South-East Essex Technical College, Longbridge Road, Dagenham), at 7 p.m.—Dr. K. G. A. Pankhurst: "The Physics and Chemistry of Detergent Solutions".

CHEMICAL SOCIETY (at the Royal Institution, 21 Albemarle Street, London, W.1), at 7.30 p.m.—Prof. A. Tiselius: "Some Applications of the Separation of Large Molecules and Colloidal Particles" (Centenary Lecture).

SOCIETY FOR VISITING SCIENTISTS (at 5 Old Burlington Street, London, W.1), at 7.30 p.m.—Discussion on "The Chemistry and Interrelationship of Endocrine Systems and their Psychological Effects" (Chairman: Dr. A. S. Parkes, F.R.S.: Speakers: Prof. F. G. Young, F.R.S., Prof. Jean Roche, Prof. G. W. Harris).

## Friday, February 27

ASSOCIATION OF APPLIED BIOLOGISTS (in the Mining Lecture Theatre, Imperial College of Science and Technology, Prince Consort Road, London, S.W.7), at 10.30 a.m.—"The Assessment of Plant Pests and Diseases".

ROYAL ASTRONOMICAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.15 p.m.—Geophysical Discussion on "Ocean Swell and Microseisms" (Chairman: Dr. G. E. R. Deacon; Speakers: Dr. M. S. Longuet-Higgins, Mr. J. Darbyshire, Prof. Maurice Ewing).

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS (at the Mining Institute, Newcastle-upon-Tyne), at 6.15 p.m.—Dr. J. F. Allan: "Wake Studies of Plane Surfaces".

BRITISH ASSOCIATION OF CHEMISTS (in the West Hall, Royal Society of Medicine, 1 Wimpole Street, London, W.1), at 6.30 p.m.—Dr. Herbert Levinstein: "Our Changing Chemical Industries—an Appraisement" (Hinchley Medal Address).

TELEVISION SOCIETY (at the Cinematograph Exhibitors' Association, 164 Shaftesbury Avenue, London, W.C.2), at 7 p.m.—Mr. D. McMullan: "The Scanning Electron Microscope".

## Saturday, February 28

BRITISH PSYCHOLOGICAL SOCIETY, EDUCATION SECTION (in Room 151, Institute of Education, Malet Street, London, W.C.1), at 2.30 p.m.—Prof. P. E. Vernon: "The Personality of the Teacher" (Chairman's Address).

# APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

ASSISTANT ADVISORY OFFICER IN BACTERIOLOGY (with a degree in science or agriculture with bacteriology)—The Secretary, North of Scotland College of Agriculture, 41½ Union Street, Aberdeen (February 27).

ASSISTANT PHYSICIST (with a good honours degree in physics) to work on the 15 MeV. Linear Accelerator—The Clerk to the Governors, St. Bartholomew's Hospital, London, E.C.1, endorsed 'Physicist' (February 28).

DIRECTORSHIP OF STUDIES IN MEDICINE (combined with a Lectureship (or Assistant Lectureship) in a relevant subject, preferably physiology or anatomy)—The College Secretary, Girton College, Cambridge (February 28).

GENERAL ASSISTANT ENGINEER (Efficiency and Testing) at Divisional headquarters—The Divisional Secretary, British Electricity Authority, London Division, Generation House, Great Portland Street, London, W.1 (February 28).

HEAD OF THE CIVIL AND MECHANICAL ENGINEERING DEPARTMENT—The Clerk to the Governors, Woolwich Polytechnic, Woolwich, London, S.E.18 (February 28).

LECTURER (Grade II or III) IN THE DEPARTMENT OF MECHANICAL ENGINEERING—The Registrar, The University, Bristol 8 (February 28).

MATHEMATICIAN at a Ministry of Supply Research Establishment near Sevenoaks, to work in research team on advanced problems in fluid mechanics or on application of high speed electronic computers to mathematical research—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting A.20/53A (February 28).

PHYSICIST with experience of X-ray diffraction, at a Ministry of Supply establishment at Aldermaston—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting A.21/53A (February 28).

RESEARCH OFFICER (Senior Scientific Officer grade) (with membership diploma of the R.C.V.S. and a university degree, preferably in veterinary science)—The Secretary, Research Institute (Animal Virus Diseases), Pirbright, Surrey (February 28).

SCIENTIST, Grade II (with an honours degree in science or equivalent) in the No. 4 (Burnley) Area—The Divisional Establishment Officer, National Coal Board, North-Western Division, 40 Portland Street, Manchester 1 (February 28).

LECTURER IN MECHANICAL ENGINEERING—The Registrar, Queen Mary College, Mile End Road, London, E.1 (March 2).

DEPUTY WORKS ENGINEER FOR ATOMIC ENERGY factory at Sellafield, for maintenance of nuclear piles and associated chemical plant with particular responsibility for steam, water and electricity supplies, workshops and instrumentation—The Ministry of Supply, Division of Atomic Energy (Production), Risley, Warrington, Lancs, quoting Ref. 423.

LECTURER (with an honours degree in electrical engineering, and practical experience in the field concerned) IN ELECTRICAL ENGINEERING concerned either with the application of automatic control systems to electrical machines or with electrical power system engineering—The Head of the Electrical Engineering Department, City and Guilds College, South Kensington, London, S.W.7.

MECHANICAL AND ELECTRICAL ENGINEERS for design, operation and maintenance of ground mechanical and electrical works services on R.A.F. and Civil Aviation Stations at home and overseas—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting D.290/52A.

MECHANICAL ENGINEER IN THE PUBLIC WORKS DEPARTMENT, Sudan—The Sudan Agent in London, Sudan House, Cleveland Row, London, S.W.1, quoting 'M/Engineer 1824'.

METALLURGIST (Scientific Officer grade) at the Ministry of Supply London headquarters, to assist in research and development on metallic materials for aircraft construction, etc.—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting F.33/53A.

NATURE

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# IMPACT OF TECHNOLOGY ON SOCIETY

THOSE familiar with Mr. Lewis Mumford's earlier works will find little that is new in the six Bamford Lectures which, originally delivered at Columbia University, have now been published under the title "Art and Technics"*. Into this little volume, however, he has distilled the quintessence of that major undertaking to which he set his hand in "Technics and Civilisation" in 1934 and only completed last year in a fourth volume, "The Conduct of Life". In doing so, he has discarded the jargon and neo-dramatization of some of the larger books, and his thought and argument flow in sparkling manner, refreshing and stimulating. His theme, the manner in which man must come to terms with his environment, is expounded with a freshness and vivacity as if he had never handled it before; and, when he deals further shrewd blows against the weaknesses or abuses that he has already attacked, there is no hint of repetition or staleness in his words.

Readers of "The Culture of Cities" will recall, for example, Mr. Mumford's passionate plea in that volume for imaginative thinking about the whole purpose of design, and for a determined effort to think out and discover appropriate forms of expression for the new materials and powers now at our disposal. That forthright condemnation of our practice of clinging to obsolete methods and of attempting to force new material into the forms used for earlier products and other purposes is matched in this volume by two further attacks: in one, his lecture on "From Handicraft to Machine Art", Mr. Mumford castigates purposeless change in the machine; and in the other, when discussing symbols and function in architecture, he condemns the abuse of the doctrine that form follows function. The meaningless annual re-stylings of the less essential parts of a motor-car, he points out, largely nullify advances in technical efficiency which would enable manufacturers to lengthen the life and lower the cost of their models. Instead, he writes: ". . . You know that the canons of conspicuous waste, dear to the business man, and to the newly rich, have gotten the better of the canons of economy and function; and that somebody is picking your pocket of money you might use for better purposes, under the pretext that he is furnishing you with art. The current name for that particular perversion is industrial design".

That was worth saying, for waste of that order goes far beyond the production of styles in motor-cars. It might also be remarked that those in industry who have inclined to take a more conservative attitude, in agreement with the principle of stability which Mr. Mumford invokes, have sometimes been attacked for being unprogressive and withholding the advantages of technical and scientific advance. The position is, in fact, more complex than Mr. Mumford here indicates, and, while there is clearly room for the elimination of technological waste, the great merit of his criticism is the emphasis it places on the need for greater attention to the human factor in technological change. Apart altogether from the economic waste at present often incurred, the impact of technology on society requires fuller consideration from the point of view of the rate of innovation which mankind can endure, without detriment to human personality or the service of human needs as a whole.

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* Art and Technics. By Lewis Mumford. Pp. v+102. (London: Oxford University Press 1952.) 15s. net.

In Mr. Mumford's own view, the greatest developments to be expected of technics in the future will consist in using machines on a human scale, directly under human control, to fulfil with more exquisite adaptation and with a higher refinement of skill the human needs that are to be served. He does not call for the rejection of the machine, but for its use to better purpose, so that it extends the rational and operative parts of the personality and does not wantonly trespass on areas that do not belong to it. "If you fall in love with a machine," he remarks, "there is something wrong with your love-life. If you worship a machine there is something wrong with your religion." A fuller degree of self-understanding and the restriction of the machine to its proper field would restore to life its freedom and creativeness.

This forthright challenge to the doctrine of 'faster, faster' and the assertion that, once the machine has achieved the power and economy of a good type, it should stand still at least until the creator again places himself above the level of his mechanical creature, is derived from Mr. Mumford's belief that the great problem of our time is to restore modern man's balance and wholeness. He believes that we must give man the capacity to command the machines he has created, instead of letting him become their helpless accomplice and passive victim; and we must bring back into the very heart of our culture a respect for the essential attributes of personality, its creativity and autonomy which Western man lost when he turned to the improvement of the machine. The great triumphs in music and painting of the nineteenth century, for example, depended not merely on the linking of art and technics but above all on the dominance of a belief in the creative human person. The new mechanical order of life made possible by the advance of technics should have released mind and energy for creative processes; but, in fact, it has impoverished our inner life because the machine so largely tends to replace the person and to subordinate his decisions to its mechanical needs.

Nor is this true simply of working hours. The impact on leisure hours has been no less stultifying, as a recent inquiry into the effect of television on social life and habits in Great Britain has indicated. Mr. Mumford's whole purpose in these lectures is to combat this mechanical environment and to restore order, value and purpose on the widest scale to human life. This means finding out how to make our subjective life more disciplined and resolute, endowed with more of the qualities that we have poured into the machine; and it means, also, as already indicated, instead of the pragmatic adaptation of human personality to the machine, a re-adaptation of the machine to the human personality. A human pattern, a human personality, a human tempo and a human goal must transform the activities and processes of technics, curbing them when they become dangerous to man's development and even suspending them until the appropriate political instruments and social institutions have been created.

In his attempt to formulate a working relationship between art and technics, as two essential sides of life, Mr. Mumford next challenges the belief that for the greater part of his existence man is concerned with improving the physical condition of his life, in particular his needs for food, clothing, shelter, security and physical care. The original great contribution of technics, he points out, was not merely to man's physical life, but also to his sanity and general balance. It also gave him a certain respect for the nature of the materials and processes with which he worked. Such respect did not come easily; but, from the beginning, a willingness to accept the hard facts and an understanding of the impersonal nature of things have been a condition of man's success both in dominating Nature and in coming to terms with himself.

Besides this, however, man's success in technics has been associated with a mechanical uniformity and repetitive order. This in itself tends to give man a sense of security, thus turning him towards technics and the object, just as his need for creative expression inclines him to art and the symbol. The problem of our time is that of restoring the appropriate balance between the two needs and tendencies—of establishing the dynamic equilibrium between art and technics, and between spontaneity and necessity, which has always marked the peaks in the development of any civilization. This problem, which is the very opposite of that which faced mankind at the end of the Middle Ages, demands for its solution the restoration of primacy to the human person, and the nurture of those aspects of human nature which have been repressed or displaced by mechanical developments.

Mr. Mumford does not make the mistake of prescribing a simple return to the handicraft processes of earlier centuries, though he considers that in the more advanced Western countries, even until the middle of the nineteenth century, handicraft itself was the mediating factor between pure art and pure technics. Leaving on one side the economic and social consequences of any such large-scale retreat from power production, even if it were practicable, the damage already done to the nature of man by mechanization is too widespread and deep-seated for handicraft alone to offer more than a very limited contribution. Any recent study of the use of leisure testifies to the loss of selectivity and of our powers of assimilation, as is noted by Mr. Mumford. To foster the personal discipline which he considers necessary for the restoration of effective control over the machine is no easy task and may well be a prolonged one.

Despite his skilful diagnosis, Mr. Mumford, like so many before him, is less satisfactory when it comes to prescribing the remedy. He adds little, if anything, to what he suggested in "The Conduct of Life". He sees clearly enough what is to be done; but there is little here to tell us how to do it. He recognizes the value of much that is already being done in industry to give new scope and importance to the workers as human beings. The studies being carried out by the British Institute of Management, the Acton Society Trust and the National Institute of Industrial Psychology are as much in line with the trend of his thought here, as are the earlier investigations of Elton Mayo, to which he refers specifically.

It would appear, however, that Mr. Mumford does not believe that the situation is hopeless, even if he presupposes the rejection of our gratuitous assumption that the existence of a mechanism for manifolding or mass production carries with it an obligation to use it to the fullest capacity. Mankind's mistake has been the reckless multiplication of such mechanisms without forethought as to the ultimate purpose to be served or the effects on man himself. Once this is recognized, claims Mr. Mumford, we achieve freedom.

To recognize and act on this view, however, demands a discipline that cannot itself be based on a new philosophy of freedom. To achieve the integration without which neither art nor technics can prosper is ultimately a matter of will. The recovery of wholeness and balance, and the regaining by man of his creativity and freedom, are essential if mankind is to contain the destructive forces that are now conspiring, almost automatically, to destroy.

Civilization in its present state, Mr. Mumford concludes, is not self-perpetuating. Nevertheless, though he gives no clear lead as to the way back to sanity and control, he is not without hope. Trends towards the renewal of life are indicated, and the ultimate objectives are defined. Nor are these essays on the theme of the impact of technology on society very different in spirit or approach from that of Lord Stamp—they insist that something more than a mere science of social adjustment is required. Like Lord Stamp, Mr. Mumford maintains unhesitatingly that behind all attempts to attune the pace of technological advance to the capacity of human beings for adjustment lies the belief in the value of human persons, and the conviction that failure to respect the human person, and the continued subordination of the individual to organization and to the machine, involves inevitably the downfall and destruction of civilization itself. While Mr. Mumford does not formulate the issue as a conflict of loyalties, like Herbert Read in his address on "Sign and Symbol" at the Present Question Conference last August, he insists quite as strongly that all turns on whether we continue to acquiesce in a civilization that proliferates anxiety in the mind and ugliness in street and factory, or whether we are willing to make the material sacrifice required for man to give expression to his creative nature and restore balance and harmony to life.

# A CLASSIC OF PALÆO-ANTHROPOLOGY

## Les hommes fossiles

Éléments de paléontologie humaine. Par Prof. Marcellin Boule et Prof. Henri V. Vallois. Quatrième édition. Pp. x+584. (Paris: Masson et Cie., 1952.) 4400 francs.

THE second and third editions of this now classic work on fossil man were separated by an interval of twenty-three years. The fact that a fourth edition has now appeared after a further interval of only six years is an indication of the important accessions to the subject which have been made in that short time—accessions which have in some instances strengthened, and in others modified, views previously widely held on human evolution. For example, the remarkably rich finds of the British–Kenya Miocene Expedition in East Africa include remains demonstrating that the Early Miocene anthropoid apes had not yet acquired some of the aberrant specializations of the modern apes, and they have thus now removed one of the main theoretical difficulties which have been raised against the conception of man's derivation from an anthropoid ape ancestry. The discoveries in South Africa by the late Dr. Robert Broom and his colleagues have brought to light a group of extinct hominoids approximating to the apes in the size of the brain but resembling *Homo* in numerous morphological and metrical details of the dentition, in many items of skull structure, and in characters of the pelvis associated with the erect posture. In this new edition these points are now emphasized, and the opinion is expressed that the South African fossils have narrowed to a very considerable extent the morphological hiatus between man and ape which appeared to exist before their discovery, and they also demonstrate that in the course of hominid evolution the expansion of the brain followed (rather than preceded) the adoption of an upright posture and gait. The discovery of further remains of pre-Mousterian man (for example, the Fontéchevade calvaria and the Quinzano occipital bone) confirms the implications of the Swanscombe cranial fragments and the Steinheim skull that the extreme varieties of Neanderthal man were actually preceded by a type of man more closely akin to *Homo sapiens*. On the other hand, the development by Dr. K. Oakley of the technique for estimating the fluorine content of fossil bones has led to the final rejection of great antiquity for the famous Galley Hill skull—a specimen which, because of its 'modern' character and supposed geological age, has led in the past to many speculations regarding the antiquity of *Homo sapiens*.

Marcellin Boule died ten years ago, and the new edition of "Les Hommes Fossiles" would perhaps be more accurately represented as his original book 'edited and revised' by Prof. H. V. Vallois. Prof. Vallois is an eminent authority on palæo-anthropology, and he has accomplished his task well, for he has preserved the individual character of Boule's masterly presentation of the subject of human evolution while at the same time giving adequate representation to those changing points of view which necessarily call for modification from time to time in any rapidly developing subject. There are, however, certain statements and conclusions which still find their place in this edition although it is doubtful if they could to-day withstand a critical analysis. For example, probably little reliance can be placed on the inference as to intellectual functions drawn from the endocranial cast of the fossil skull found at La Chapelle-aux-Saints. The conclusions regarding the alleged simian characters of the foot in the Chancelade skeleton are difficult to accept in the absence of more detailed comparative studies (particularly if the evidence of a footprint of palæolithic man described by Dr. Casteret from a grotto in the Department of Herault is accepted as valid). The facet on the upper canine of the Talgai skull, which was at first taken to indicate an interlocking tooth of simian type, has been demonstrated by Prof. A. N. Burkitt to be nothing more than a facet of contact with the adjacent premolar tooth. The statement that the dingo in Australia was contemporaneous with *Nototherium* and *Diprotodon* is not based on really secure stratigraphical evidence. Finally, it may be suggested that the invention and use of group terms such as "les Préhominiens" and "les Préssapiens" are bound to lead to confusion of thought, since they involve a certain misuse of taxonomic terminology. It has become abundantly clear during recent years that, in discussions on the evolutionary sequence of the Hominidæ, colloquial terms are to be avoided wherever possible, and only the scientific terms proper to taxonomy employed. The terms 'man' and 'human', for example, have come to assume, in popular usage, a very special connotation, and their rigid exclusion in discussions of the evolutionary origin of *Homo sapiens* would no doubt permit a much more objective approach to this problem and also avoid unfortunate misunderstandings.

I have referred above to "Les Hommes Fossiles" as a classic. Under Vallois's editorship it remains a classic—compendious in substance, clear in style, and judicious in its main conclusions. It is also beautifully illustrated. W. E. LE GROS CLARK

# STRUCTURE OF POLLEN

## Plant Morphology and Plant Taxonomy

Angiosperms (an Introduction to Palynology, 1). By G. Erdtman. Pp. xii+539. (Stockholm: Almquist and Wiksell; Waltham, Mass.: Chronica Botanica Co., 1952.) n.p.

THE term 'palynology' was coined in 1944 for the science of pollen grains and other spores, and this recent invention of a name indicates the increasing importance of the subject. Work in this field is proceeding in at least two directions. Pollen grains (and some other kinds of spores) are almost indestructible, so far as their external morphology is concerned, by the ordinary processes of decay as met with under natural conditions. Consequently, they are easily preserved as fossils in peat and other kinds of deposits. During the past two or three decades, the pollen content of peat has been intensively studied in Europe, North America and, to a less extent, in other continents. Spore content of older rocks is also receiving some attention. As a result, the structure of pollen and other spores of existing plants has had to be studied to provide standards for the nomenclature of fossil pollen. Angiosperm taxonomists have long recognized the value of pollen grain characters for classifying genera within certain families such as the Acanthaceæ. Recent researches prove that such characters can be used with advantage much more widely. The careful investigation by improved methods, combined with the examination of the pollen grains of many more species, genera and families, is providing new and extensive data for consideration by taxonomists.

Dr. G. Erdtman has rendered angiosperm taxonomists a great service in providing them with an up-to-date reference text-book to pollen structure. In this work the families of angiosperms are in alphabetical sequence—an arrangement that makes for easy reference and, for the time being probably wisely, avoids any commitments to a phylogenetic or other scheme of classification. There are excellent and numerous illustrations to illuminate the condensed descriptive text. The diversity of size, form, 'markings' and detailed structure of angiosperm pollen grains is extremely striking as one glances through these illustrations. It may be that a new descriptive terminology is unavoidable when a subject is studied extensively and intensively for the first time. One does, however, wonder if the invention of terms has not been carried to unnecessary extremes by some palynologists. In the glossary of this book more than two hundred terms are defined. The great majority of these have been proposed quite recently with direct reference to pollen morphology and are probably of only very specialized use.

The possibilities of pollen morphology throwing light on 'affinities' are evident in Dr. Erdtman's text. After the description of family pollen-grain characters, and diagnoses of special specific examples, valuable comparisons are made with the pollen grains of other families supposed by a previous author or authors to show relationships with the family under consideration. These comparative statements are matters of fact, not matters of speculation. They must in the future receive due attention in any attempt at a general classification of angiosperm families. In addition, there are significant suggestions that some widely accepted taxa are not homogeneous. It would be very valuable to have a classification of angiosperm families, sub-divided or amalgamated as considered necessary, based solely on pollen grain characters. Such a classification would, of course, be a special one serving limited, though important, purposes. With such a classification one could readily utilize pollen characters for improving a general classification and clearly see the taxonomic limits of palynology.

Taxonomists will look forward to further publications by Dr. Erdtman and to a general summary of the theoretical results of his painstaking researches.

W. B. TURRILL

# THE CIVIL SERVICE IN GREAT BRITAIN

## The Fountains in Trafalgar Square

Some Reflections on the Civil Service. By C. K. Munro. Pp. x+202. (London: William Heinemann, Ltd., 1952.) 12*s*. 6*d*. net.

MR. C. K. MUNRO'S reflexions constitute a sensible, and possibly the most successful, exposition of the nature and mind of the Civil Service that we have yet been given. In a very readable book, which should appeal to the man of science though not especially addressed to him, writing under the name he used as a dramatist, Mr. Munro explains lucidly and easily, not simply the work and responsibilities of the Civil Service, and more especially of the administrative class of the Service, but even more of the outlook and mind of the Civil servant and the circumstances which determine his attitude to and his habits of work. Even this can scarcely be called a popular book in the sense of one intended to reach that wider section of the public which most requires to have its misconceptions removed, and to be enlightened as to the close connexion between the activities the Civil Service is required to pursue and the services which that public demands of the State.

A recent B.B.C. inquiry into television has made it only too clear that the chances of reaching that section of the public by means of the printed word is slender. For those who do read his book, Mr. Munro should dispel a good many popular misunderstandings and remove the basis of some ill-informed and unfair jibes. Even more important, by his interpretation of the attitude of the Civil Service and explanation of the reasons behind its practice and procedure in handling such matters as complaints, planning, and the operation of controls, he goes far to promote the understanding and goodwill that are essential for the smooth functioning of government organization and the efficient service of the purposes of the State.

The success of this book is mainly due to the fact that, unlike so many other writers on the Civil Service, Mr. Munro confines himself to the one aim and does not allow himself to be beguiled into examining the problems which are being created for the Civil Service by the demands of a Welfare State. Nevertheless, he shows himself well aware of those problems, and he discusses with humanity as well as imagination such questions as those of controls and planning, the organization of government departments and their relations with Ministers.

Mr. Munro's very success induces the hope that, having explained so clearly the Civil Service as it is, he will now, in another book, discuss the ways in which the Civil Service could find answers to the new problems which are facing us all in the Welfare State and give us his view of the new public service which this new conception of the State requires. That hope is the more warranted because Mr. Munro displays to the full in this book the very qualities that can contribute most to bridging the gap between Civil servants and the community they serve, and to stimulating the circulation between the Civil Service and other professions which is now so desirable.

R. Brightman

# COMPARATIVE ANIMAL PHYSIOLOGY

## Comparative Animal Physiology

By Prof. David W. Bishop, Prof. Frank A. Brown, Jr., Prof. Theodore L. Jahn, Prof. C. Ladd Prosser and Prof. Verner J. Wulff. Prof. C. Ladd Prosser, Editor. Pp. ix+888. (Philadelphia and London: W. B. Saunders Co., 1950.) 63s.

In physiological research, difficulties of technique or of interpretation may sometimes be overcome by extending the investigation to include other methods or different species. It is natural that mammalian physiology should be studied intensively, but in fact the investigation of other forms has contributed greatly to the solution of many fundamental problems, and continues to do so. The advances recently made in the knowledge of nerve impulse transmission show how various methods can profitably be brought to bear on a problem.

In view of the outstanding intrinsic interest and possible wider complications of many aspects of non-mammalian physiology, it is surprising how few are the texts devoted to comparative animal physiology. This book provides a notable contribution in this field, and it should be of value to many classes of readers.

Prof. C. L. Prosser appropriately begins by stating his concept of the functions and aims of comparative physiology: "Comparative physiology treats of organ function in a wide range of groups of organisms. Comparative animal physiology integrates and co-ordinates functional relationships which transcend special groups of animals. It is concerned with the ways in which diverse organisms perform similar functions. Genetically dissimilar organisms may show striking similarities in characteristics and response to the same environmental stimulus. By the same token closely related animals frequently react very differently to their surroundings. While other branches of physiology use such variables as light, temperature, oxygen tension, and hormone balance, comparative physiology uses, in addition, species or animal type as a variable for each function. The generalisations which emerge from this experimental approach are important as biological principles which often aid in solving problems of cellular or special group physiology".

In presenting animal physiology from this point of view, the authors do not deal exhaustively with mammalian or cellular physiology, but these are included in enough detail to present an adequately balanced picture. The book is intended for advanced undergraduate or graduate needs, and to "introduce investigations to particular branches of the subject". In view of this, descriptive physiology of the various species is, of course, a prominent feature of the book, while ecological and evolutionary implications and biological generalizations are introduced at appropriate places, and emphasized at the end of chapters.

The whole book bears evidence of much thought and care, and the declared objectives are kept well in evidence throughout. The scope of this extensive text is very wide, so wide, in fact, as almost to defy a truly critical detailed appraisal by one person. The inclusion of so much material demands a concentrated type of exposition, which in this book is shown to be compatible with admirable clarity and precision. There are many excellent tables of quantitative data on various physiological and biological aspects of many kinds of animals; the variety and scope of these add appreciably to the value of the book. Throughout the text, attention is directed to numerous important questions in need of solution.

The bibliography is stated to be selective rather than comprehensive, and if occasionally an apparently important paper is not included, this fact must be remembered. Also, the student of mammalian physiology must be reminded that this branch is not intended to be stressed, although in fact most of mammalian physiology is very satisfactorily covered. The bibliography contains more than three thousand references.

The text is almost free from typographical error; on p. 121 of my review copy, however, part of the text seems to have been omitted.

The authors are to be congratulated on the ambitious conception of this book, its originality, wide scope and excellent balance. Their work has made easily accessible a mass of information useful to student and specialist alike, and the book should provide an added stimulus to the study of animal physiology on a comparative basis.

W. Burns

## Mind and Life

An Essay in Simplification. By A. G. Tansley. Pp. xi+172. (London: George Allen and Unwin, Ltd., 1952.) 15*s*. net.

THE author of this book is an ecologist who has previously written an exposition of psychology. He now presents this further volume, which he describes in a sub-title as "an essay in simplification". This is a discussion of various aspects of psychology, and its scope is shown by the chapter headings, some of which are: the structure of the mind; the energy of the mind; the functions and limitations of psychological concepts; instinct, heredity and environment; causation, determinism and free will; love and sex; the strength and weakness of psycho-analysis; the family and the community; the individual and the community; psychological reality and spiritual values; etc.

There is nothing new in this book—it is mainly a re-statement of the views of Freud, McDougall, Trotter and others. Its value, therefore, must lie in the clarity of exposition. This is very good, and the author does state clearly and intelligibly the theories which he describes. Mainly he accepts the Freudian point of view, and his descriptions of mental structure, and so on, are excellent. Not everyone would accept his views on free will, which he regards as possible within a limited sphere, since many would insist that every action is determined. He suspects the idea that the mother–child relationship is a sexual one, but admits (p. 103) that "it may, as in the Oedipus situation, run into the specifically sexual channel". This timidity is shown especially in his discussion on religion. Here he takes a leap into the dark and, abandoning any psychological basis, states (p. 106) that "The best evidence for the belief in spirit as the ultimate reality is derived from the phenomena of religious mysticism".

Those unacquainted with modern psychological theories will find the book of interest. It is well printed on non-shiny paper and is attractively bound in apple-green cloth. There is no index.

CLIFFORD ALLEN

## Hydroponics

The Bengal System. By J. Sholto Douglas. Pp. xii+147+17 plates. (Bombay and London: Oxford University Press, 1951.) 10*s*. 6*d*. net.

THE growing of plants in sand, gravel or other inert medium with the aid of nutrient solutions has now become firmly established as a commercial method in many countries. In Great Britain its use has been confined, for obvious reasons, to the cultivation of glasshouse crops; but in other parts of the world, where shortage of water or unsuitable soil makes normal outdoor growing impossible or uneconomic, soilless cultivation holds out promise as a means of production, especially of food crops.

Mr. J. Sholto Douglas, an immensely enthusiastic amateur, became fired with the idea of using simplified techniques for food production in North India and, during some years of work in Bengal, produced results which, if not quite so startling as his enthusiasm might lead one to believe, were at least of great interest. He has embodied in this small book an account of the practical systems he developed, which are workable, so he claims, by Indian labour.

While he confines himself to this practical description of his own experiences, the book is interesting and useful. Unfortunately, he runs outside his brief and attempts in a short space to give an account of the underlying principles of plant nutrition in general and of soilless cultivation methods in particular. Here he is on unsafe ground and perpetrates some major errors of principle and fact. His lists of "suitable" solutions, for example, are entirely uncritical and in some cases absurd, while when he attempts to deal with certain unrelated scientific findings, such as colchicine treatment and the use of plant hormones, he goes entirely off the rails. If the book should see a second edition, it is to be hoped that the author will delete these irrelevant and unnecessary parts.

R. H. STOUGHTON

## Exercises in Experimental Physics

Edited by N. C. B. Allen and Dr. L. H. Martin. Pp. xiii+237. (Melbourne: Melbourne University Press; London: Cambridge University Press, 1951.) 30*s*. net.

THIS book is specifically written to supplement the lecture courses in the second year of the B.Sc. in the University of Melbourne; but, of course, it could be used equally well by students of any university pursuing a similar course.

It is gratifying to know that the students at Melbourne are encouraged to read about the experiments before carrying them out, and to this end sufficient theory is given in the book to enable the experimenter to have an intelligent understanding of what he is about to do; in addition, references are made to suitable texts for further reading—a good feature.

The course is a very comprehensive one, if, as it seems, it is to cover one year of work only, and this latter fact probably explains the apparent lack of balance between subjects. For example, only four pages are devoted to the heat section, and a similar number to sound; presumably, courses for other years restore the correct balance. The work is thoroughly up to date in its approach and execution, and includes a section on the Geiger counter as well as work on radioactivity. The first chapter is devoted to an account of observations and statistical theory, which, it is hoped, students will thoroughly digest, and there is a useful appendix dealing with units.

## Annual Review of Physical Chemistry

G. K. Rollefson (editor), R. E. Powell (associate editor). Vol. 3. Pp. x+416. (Stanford, Calif.: Annual Reviews, Inc., 1952.) 6 dollars.

WITH the publication of this, the third volume of the "Annual Review of Physical Chemistry", the venture begun under the capable editing of G. K. Rollefson and R. E. Powell in 1950 may be said safely to have passed the experimental stage. The general pattern is now clear: the articles can be divided broadly into two classes—the perennials, or annual reports proper, in which each year the progress over the year is given; and the special topics, varying from year to year, in which the reviewer is allowed to develop his subject more fully to cover a longer time period. The perennial review is perhaps the more difficult to do well, but some safeguard is provided by the policy which brings a new author to each subject annually.

Vol. 3 contains an essay on the quantum theory of valence (C. A. Coulson), topical reviews on polymeric electrolytes (P. Doty, G. Ehrlich) and on bond energies and distances (G. Glockler), a masterly summary of the theory of liquid solutions (G. Scatchard), a discussion on some aspects of photosynthesis (M. Calvin *et al.*), and fourteen other articles, in which virtually the whole field of physical chemistry is covered.

H. A. SKINNER

# ROBERT HOOKE, 1635–1703

By Prof. E. N. da C. ANDRADE, F.R.S.

ROBERT HOOKE, one of the most inventive and far-seeing minds in the history of physical science, was born at Freshwater, in the Isle of Wight, on July 18, 1635, and so was some six years senior to Newton. He was a weakly child and, throughout his life, was afflicted by poor health. His diary for the years 1672–80, edited by H. W. Robinson and W. Adams (see *Nature*, 136, 358; 1935), is full of records of suffering and of the divers medicines which he took in the hopes of alleviating his distresses—catarrh, terrible headaches, vomiting, sleeplessness and fearful dreams. Chronic inflammation of the frontal sinuses was probably one of his troubles. If it is abundantly clear that he was often sharp-tempered and irritable, generally under provocation, it must be remembered that a night when he slept well was for him a matter worthy of special record.

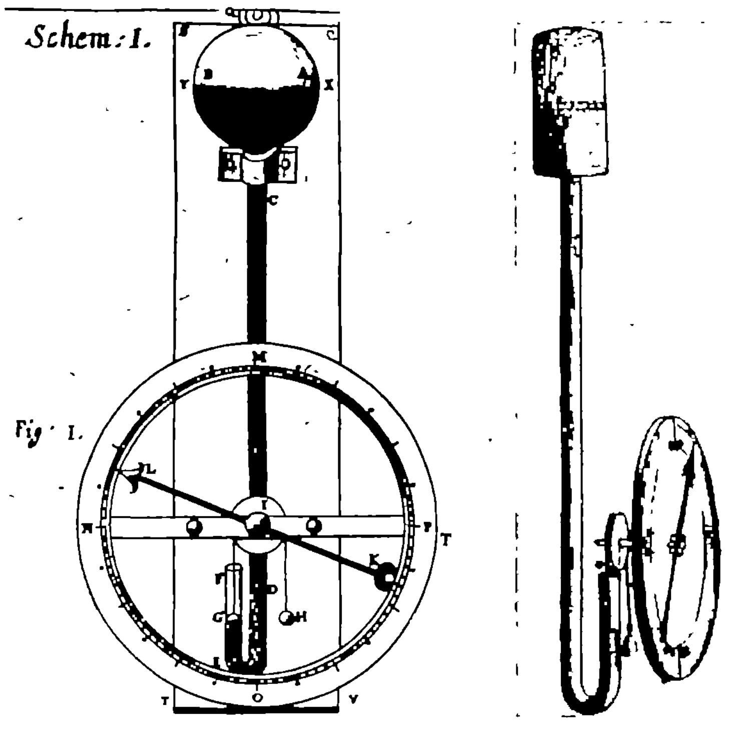

Fig. 1. Hooke's wheel barometer; on the left is the diagram as given in the "Micrographia"; on the right Hooke's original sketch, in the possession of the Royal Society[*]

He went to school at Westminster, one of the best schools in the country, at the time under the famous Dr. Busby, with whom he was in later life on very friendly terms. For example, he designed for his former headmaster the church at Willen in Buckinghamshire, which reminds us that Hooke was a rather more than competent architect, an example of his astonishing versatility. From Westminster he went to Oxford, where he had a chorister's place at Christ Church, which presumably implies that he had a good singing voice[*]. Oxford at that time, with such men as John Wallis, Seth Ward and John Wilkins, was a great centre of the new "Experimental Philosophy", the revolt against the authority of the ancients in matters of science which was soon to find its expression in the formal foundation of the Royal Society. Here Hooke became assistant to Robert Boyle, probably recommended in the first place to that wealthy and gentle young genius by his extraordinary manual skill. He made, for example, for Boyle the pump figured in "New Experiments Physico-Mechanical", 1660, which was the first air pump constructed in England and a great improvement on the earlier Guericke pump. In 1661, while still with Boyle, he published a little book dealing with capillary phenomena, which contains no capital discovery, but many acute observations and suggestions. In the following year he was appointed 'curator' by the newly-founded Royal Society, a poorly paid post with heavy duties. From then until 1682 his name and work were closely connected with the Society: he furnished it with abundant experimental demonstrations, with a variety of papers, some of them embodying original work of first importance, and, in general, did much to invigorate the Society and hold it together. His financial circumstances were much improved after the Great Fire of 1666 by the lucrative work which he carried out as City Surveyor, in which capacity he was chief assistant to Christopher Wren in the matter of rebuilding the City of London. Incidentally, Wren was one of the great men who were on very good terms with Hooke: Evelyn and Sydenham were others.

Hooke acted as secretary to the Royal Society from 1677 until 1682, and in the period 1679–82, when the *Transactions* were in abeyance, produced the *Philosophical Collections*, a record of scientific work at home and abroad. After giving up the secretaryship he still made frequent communications to the Society, until about 1696, when his health broke down completely. He died, after some wretched years, on March 3, 1703.

Hooke's scientific work covers an astonishingly wide range and most of it bears the stamp of a powerful genius. If any single man deserves to be called the originator of the modern scientific instrument, it is Hooke. He invented all the meteorological instruments. His wheel barometer was long the standard instrument and can still be seen in use. He made a properly calibrated thermometer, with the freezing point of water as zero and a standard volume expansion. He invented the first hygrometer with an index, based upon the properties of the beard of the wild oat, and the first good wind gauge, as well as a self-measuring rain gauge. He also devised recording instruments, which worked, if but inter-

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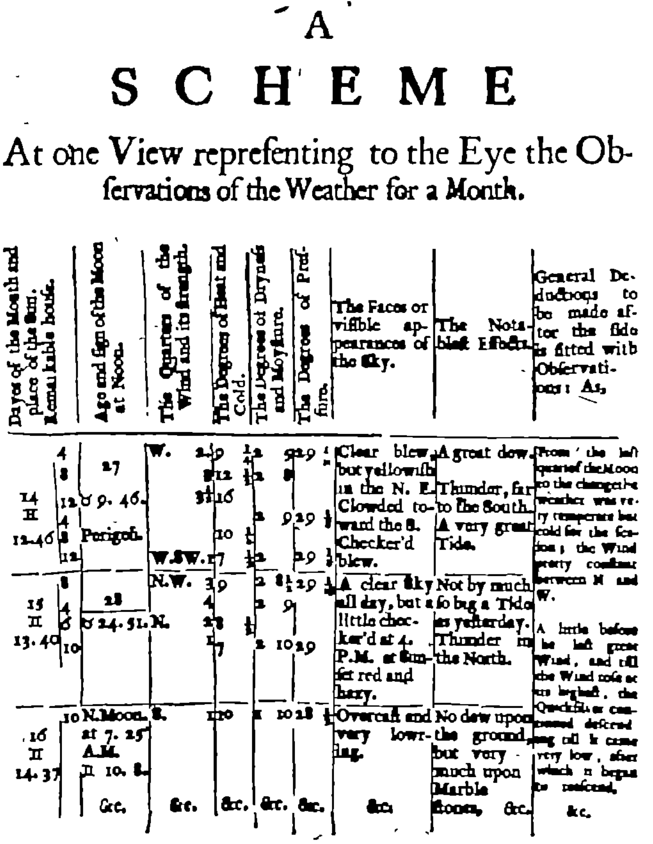
[*] It had occurred to me that possibly "a chorister's place" could be a surviving name for some kind of a sizarship, but Canon Jenkins, who is a great authority on the subject, assures me that the place does imply that Hooke had a good singing voice.

[*] Figs. 1, 2 and 3 are reproduced by courtesy of the Royal Society from the Wilkins Lecture delivered by Prof. E. N. da C. Andrade on December 15, 1949 (*Proc. Roy. Soc.*, A, 201, 439; 1950).



A

SCHEME

At one View repreſenting to the Eye the Obſervations of the Weather for a Month.

| Dayes of the Month and place of the Sun. Remarkable houſe. | | Age and ſign of the Moon at Noon. | The Quarters of the Wind and its ſtrength. | The Degrees of Heat and Cold. | The Degrees of Dryneſs and Moyſture. | The Degrees of Preſſure. | The Faces or viſible appearances of the Sky. | The Notableſt Effects. | General Deductions to be made after the ſide is fitted with Obſervations: As, |
|---|---|---|---|---|---|---|---|---|---|
| 14<br>♊<br>12.46 | 4<br>8<br>12<br>4<br>8<br>12 | 27<br>♉ 9. 46.<br>Perigeo. | W. 2<br>W.S.W. 1 | 9<br>8 12<br>3½ 16<br>10<br>7 | ½<br>½<br>2<br>½<br>½ | 9 29 ½<br>8<br>9 29 ⅓<br>29 ⅓ | Clear blew, but yellowiſh in the N. E. Clowded toward the S. Checker'd blew. | A great dew. Thunder, far to the South. A very great Tide. | From the laſt quarter of the Moon to the change the weather was very temperate but cold for the ſeaſon; the Wind pretty conſtant between N and W. |
| 15<br>♊<br>13.40 | 8<br>4<br>8<br>10 | 28<br>♉ 24. 51. | N.W. 3<br>N. | 9<br>4<br>28<br>7 | 2<br>2<br>½<br>2 | 8½ 29 ¼<br>9<br>10 29 | A clear ſky all day, but a little checker'd at 4. P.M. at Sun-ſet red and hazy. | Not by much ſo big a Tide as yeſterday. Thunder in the North. | A little before the laſt great Wind, and till the Wind roſe at its higheſt, the Quickſilver continued deſcending till it came very low, after which it began to reaſcend. |
| 16<br>♊<br>14.37 | 10 | N. Moon. at 7. 25 A.M.<br>♊ 10. 8. | S. | 10 | 2 | 10 28 ¼ | Overcaſt and very lowring. | No dew upon the ground, but very much upon Marble ſtones, &c. | |
| | | &c. | &c. | &c. | &c. | &c. | &c. | | &c. |

Fig. 2. From Hooke's paper on "A Method of Making a History of the Weather"

mittently, and planned an excellent scheme for proper meteorological records. In particular, he viewed the study of the weather quite in the modern spirit, as a matter of physical law applied to solar radiation, the rotation of the earth and other factors, and was quite clear that the behaviour of the barometer was an important factor in foretelling storms.

In astronomy he invented telescopic sights and clearly pointed out their advantages, treating the question of resolving-power with great understanding. His instruments were furnished with screw controls and were of excellent design, embodying many pioneering features. He proposed, and published a figure of, the first clock-driven telescope. In connexion with his astronomical instruments he invented the universal, or Hooke's, joint.

In horology there seems to me little doubt that he invented the modern spring-controlled balance wheel, although there is a long history of dispute in this connexion. On the other hand, there seems to me insufficient evidence for ascribing to him the anchor escapement, with which he is usually credited.

He invented the efficient compound microscope and devoted particular attention to methods of illumination for microscopy, which enabled him to obtain the striking results illustrated in the plates to his renowned "Micrographia". With this microscope he made a number of fundamental discoveries in the biological field, such as the structure of a feather and the cellular structure of plants: he introduced the word 'cell' into biology. The impressive figures of the gnat, the flea and the louse show great observation and great precision and he carried out fundamental work on the life-cycle of the gnat. He was the first to propose immersion lenses, pointing out clearly their advantages. The 'Micrographia' contains a great body of work in fields quite outside the microscopic world, to some of which reference is made elsewhere in this account.

Hooke has to his credit a large number of other instruments—the iris diaphragm, the refractometer for liquids, helioscopes, sounding machines and a device for bringing up samples of sea water from depths. It seems that he invented a multiplying and dividing machine. The spirit level which he made was not the first, but quite likely he had not heard of that of Thevenot, which anticipated his. His mind was so fertile, however, that it is not easy even to list the devices which he poured out, usually with only brief notes.

His contributions to scientific observation and thought form an equally impressive collection. In fundamental astronomy his services were completely overshadowed by Newton, but in 1674, before Newton had published anything on the subject, Hooke, with his extraordinary acuteness, had stated clearly that the problem of the planetary motions was one of simple dynamics, and that the closed orbits were due to gravitational forces deflecting the planets from the straight-line courses that they would otherwise pursue. A little later he put forward the inverse square law. He was, however, not sufficient of a mathematician to prove that this would lead to elliptic orbits, as Newton did; nor, of course, if he had been able to do this, had he the preternatural genius and application of Newton to develop the theme as Newton did. His speculations on the structure of the universe show his accustomed perception—"To me indeed the Universe seems to be vastly bigger than 'tis hitherto asserted by any writer". He was a brilliant observer: his astronomical observations alone would have secured his name a place in the history of science.

As a geologist he was a noteworthy pioneer, who clearly realized that fossils were a record of times past, and he treated the evolution of the globe in a modern spirit, in strong contrast to the fantasies prevailing in his time. It will perhaps suffice here to cite Sir Archibald Geikie, who speaks of his work in geology in the highest terms, referring in particular to "his remarkable powers of acute observation and sagacious reflection", terms which can be applied to all his work.

Hooke's work on combustion and respiration, if small in volume, was fundamental: with his usual perspicuity he realized the connexion between them and also the function of oxygen, although he did not further identify the gas than to say that it was copiously contained in saltpetre. He actually tried experiments with his own person on breathing at reduced pressure, enclosing himself in a tun surrounded by water.

Turning to physics, we have the familiar Hooke's law, demonstrated experimentally in a variety of ways; but that he also pointed out that, if the restoring force is proportional to the displacement, the vibrations must be isochronous, is less familiar. He treated crystal structure in a modern manner, building up crystal forms out of spheres. He was clear as to the nature of heat: it was "nothing else but a very *brisk* and *vehement agitation* of the parts of the body", a conception which he amplified. In light he made striking observations on the colours of thin plates. His theory of light contains much that is strikingly novel for the time, but when he treats of colour he does not show his usual clarity. It is not usually known that he carried out fundamental experiments in sound, but he did so, inventing, for example, Savart's wheel some hundred and forty years before Savart.

Any short account of this kind dealing with Hooke's achievements tends to become a list, but this is almost inevitable. He did so much, and all of it was interesting, most of it astonishing for the date. He would take up a subject, work intensely at it for a short time—on occasion for a very short time—make an essential advance and then find his attention absorbed by some other subject. In character he was a complete contrast to Newton: whereas Newton would, as he said, keep the subject (usually one of fundamental significance) constantly before him until the first dawnings opened little by little into the full light, Hooke never concentrated on any one subject for long and the subject might be anything to which his attention had been drawn. Newton felt no need to communicate his discoveries and abhorred controversy of any kind: Hooke seems to have taken a lively pleasure in describing his latest advance and certainly did not shun the arena. Newton's was, of course, the greater mind, but Hooke was a very great man, of immense inventiveness and industry, the greatest experimental skill and rare intuition, who covered a prodigious range. As Lalande, considering his books, says: "Dans ces ouvrages on trouve les idées de la plupart de nos instruments modernes: c'était le Newton de la mécanique".

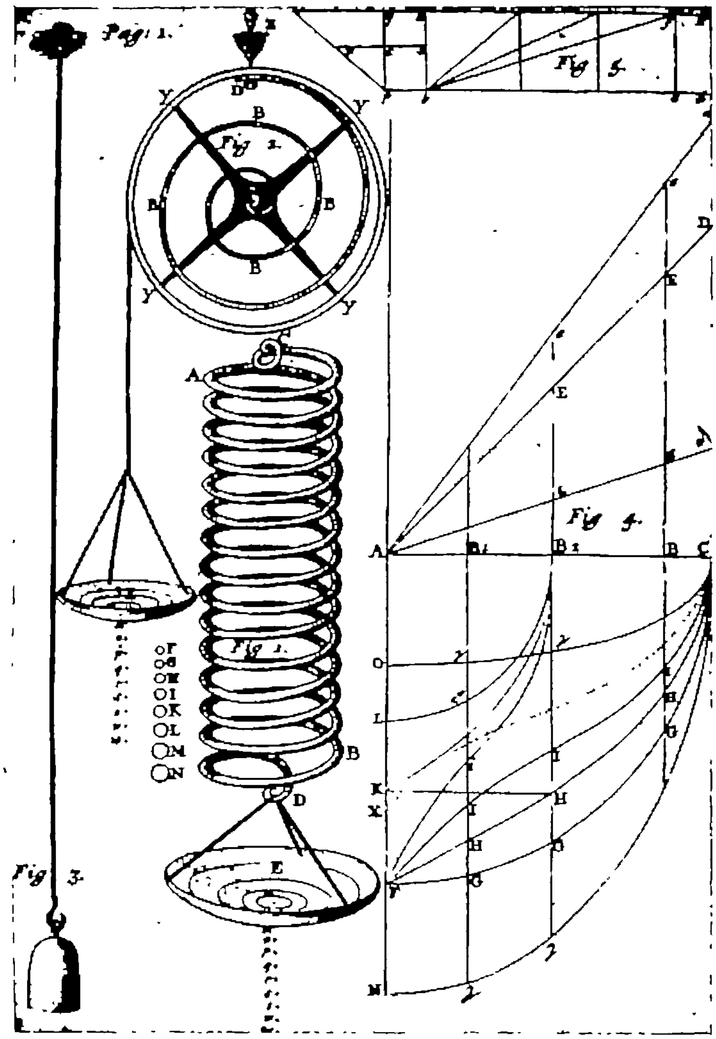


Fig. 3. The plate which illustrates Hooke's "Lectures de Potentia Restitutiva or of Spring"

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# HABITAT, VEGETATION AND MAN*

By Prof. W. H. PEARSALL, F.R.S.

University College, London

THOSE of us who have to deal with the out-of-the-way parts of Britain are aware that there are two problems which merit more consideration than they normally receive. These problems are those associated with production and with preservation.

It is still not generally appreciated that a large part of Great Britain, almost a third, is still biologically unproductive, supporting little but a deer or a sheep on thirty or forty acres of surface. One problem arises as to whether it is possible to raise the production of these areas to one more in keeping with our present economic position, for the day is past when we can afford to keep so large a part of our island in what is practically a sterile condition. Along with this problem there is a related one, of preserving for scientific study some of the remnants of the original native flora and fauna. This is one of the roles of the newly created Nature Conservancy—a function which could, no doubt, most easily be fulfilled by re-creating vanished units of vegetation and animal life on the less-valuable areas.

Both of these problems, however, involve a detailed knowledge of the natural trends of soil and vegetation in these islands and particularly in the unproductive areas. It is noteworthy that many of these wastelands, for example, the heaths of south-east England from Yorkshire south, are associated with the signs of occupation by early man, and it becomes pertinent then to ask whether they were always as inhospitable and unproductive as they may be to-day or whether they have changed since they were first occupied by man. Different sorts of evidence suggest that most of these areas were once forest-covered and that since man first occupied them their soils and general productivity must have greatly diminished. An area of particular interest is the Breckland in East Anglia. The pollen-analytical studies of Drs. Godwin and Tallantyre on mud-cores from Hockham Mere show clearly that this area was forest-covered for much of the post-glacial period. However, after the date of human occupation the area became deforested so that grass and herb pollen replaced that of trees. In addition, the appearance at this time of the pollen of plants such as *Plantago* and *Artemisia*, weeds of cultivation, suggests here, as elsewhere in Europe, that forest clearance was associated with human occupation. Similar evidence is available for Danish heaths, while deforestation of the heather moors in Yorkshire appears also to have taken place since the Bronze Age.

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* Substance of a Friday Evening Discourse delivered at the Royal Institution on December 12.

Apart from the debased condition of existing Breckland soils (which were described by Dr. A. S. Watt) there is, at present, no direct evidence of changes in soil conditions in this case; but results in the similar climate of eastern North America have given abundant evidence of the soil degeneration following deforestation, shown both by the lower nitrogen content which results and also in the greater soil erosion which has left its mark in the more inorganic character of recent lake sediments.

The study of lake sediments promises, indeed, to throw valuable light on post-glacial trends in soil conditions, for in many cases sediments of this type must be samples of the actual soil materials. The difficulty will be to allow for changes which take place in transit, or during and after deposition. Some evidence is already available from the English Lake District which poses the problems and suggests intriguing solutions.

In general, the post-glacial sediments in lakes like Windermere and Esthwaite Water appear to have been uniform in character during at least the first half of the post-glacial period or rather more. Later, and particularly during the past three thousand years, there are various types of change in the character of the sediments. If each of these changes were considered alone, several possible causes for each might be suggested, but if, as seems probable, all are connected one to the other, then all seem to run parallel to the onset and development of deforestation, and it remains for further inquiry to elucidate the connexions and to analyse the basal controlling influences.

Deforestation in the Lake District appears to have started in the second millennium B.C. Apparently it proceeded rapidly after the Norse occupations (say, from A.D. 1100 onwards) and reached a maximum in the sixteenth century. Following this, the lake muds corresponding in time show a minimum of organic matter which is attributed to soil erosion following deforestation. Parallel changes which apparently became intensified at this time include such features as a diminution in the electrical conductivity of the mud, and an increase in its acidity. The latter is particularly well shown in mud cores from the Esthwaite Fen, where it can be closely correlated with the diminishing base-saturation of the mud colloids.

The three features of the more recent mud-layers, decreased conductivity, decreased base-saturation and increased acidity, suggest that the soils from which the muds were derived may have suffered pronounced leaching in the course of time. The existence of rapid soil leaching under present-day climatic conditions was, of course, first demonstrated by Salisbury on various British dune systems and has since been shown elsewhere, especially by Hissink for Dutch 'polders'. The evidence from lake-muds apparently confirms the existence of this tendency in the past; it may also show that leaching proceeded at widely different rates at different times. If the present indications on this point are confirmed, leaching appears to have been extremely slow under the continuous forest-cover of the earlier half of the post-glacial period and to have been greatly accelerated as deforestation became more and more pronounced. There is, however, no evidence which serves to decide whether deforestation and soil deterioration in the Lake District were the results of 'natural' changes or of human action. The climatic deterioration known to have occurred just before the Christian era in north-west Europe may well have been a decisive factor in these changes, and it may be a matter of chance that its action should have coincided somewhat closely with the time of extending human settlements. Certainly one must be reluctant to ascribe the earliest deforestation of so many different parts of Britain to Neolithic man—until more is known of the numbers of individuals in each locality.

Any general conclusion which can be drawn from this type of work seems only to confirm the general impression reached by ecologists, that many types of 'marginal' land can only be really productive under forest. Undoubtedly much of northern Britain at least should never have been deforested, and it seems that the simplest biological method of re-creating lost fertility in such areas may be by afforestation. Further, these areas are now invariably of low nitrogen status and it seems to follow that alternative forms of land-use, if any exist, should properly aim towards products chemically different from the bread and beef of our lowland agriculture. A sound policy should aim first at the redevelopment of a more stable and productive soil status, and only later at high yields.

# THE FIGHT AGAINST FILARIASIS IN THE PACIFIC

By Sir PHILIP MANSON-BAHR, C.M.G.

FILARIASIS remains the dominant scourge of the Pacific, especially in those islands mainly inhabited by Polynesians. These palm-covered coral-reefed atolls constitute what are popularly known as South Sea Islands and are made familiar to many in the film of the "Blue Lagoon" or by the vivid writings of Robert Louis Stevenson. There amidst fantastic and beautiful surroundings the filaria is rampant, finding conditions ideal for its propagation. Malaria, which in other parts of the tropics and indeed throughout Melanesia is the greatest bar to prosperity and progress, is here quite unknown. It is now more than seventy years since the transmission of the filaria (*Wuchereria bancrofti*) through the mosquito was proved by Sir Patrick Manson, and some forty years have elapsed since the Pacific filaria[1] was recognized as possibly a separate entity and its spread by a special distinct species of mosquito peculiar to the Pacific islands proved by me. Nevertheless, comparatively little had been done up to the present to transform these scientific facts into practice.

Filariasis and its maximal expression, elephantiasis, have existed in Polynesia for many centuries, and the disease appears to have been spread from one island to another by migrating Polynesians during the fifteenth century. In the Central Pacific the area dominated by filariasis is enormous: an area delimited by long. 170° E. to 130° W. and lat. 10° N. to 24° S. in a vast oblong some 3,500 miles in length and 2,200 in breadth containing well over a thousand islands and a population of about 370,000 Polynesians.

In 1912 I was able to show that the chief vector of the non-periodic filaria in the Fiji Islands was the prevalent black-and-white striped mosquito which had been described by Theobald as *Stegomyia scutellaris* from specimens sent to him by F. P. Jepson[1]. This species has had a chequered career as regards terminology, being renamed *A. variegatus* and now finally *Aedes scutellaris pseudoscutellaris* by F. W. Edwards. The ecology and bionomics of the species have been thoroughly studied since by O'Connor[3], by Buxton and Hopkins[4], by R. W. Paine[5], and by Byrd, St. Amant and Bromberg[6].

Now the surprising discovery has been made by E. N. Marks[7] that, in what was thought to be a homologous species, two morphologically similar identities exist and that a new species, *Aedes scutellaris polynesiensis*, has to be recognized as valid, distinguished from *Aedes s. pseudoscutellaris* by the shape of the lobe of the coxite of the male. *Polynesiensis* is the most important and widespread species in that area of the Pacific now under consideration. This entomological problem is further complicated by the presence of a third, closely similar and related species of *Aedes* in Fiji, *Aedes scutellaris horrescens*, the female of which is indistinguishable from *pseudoscutellaris*, which was described by F. W. Edwards in 1935[8]. This is a forest-frequenting form and breeds in tree holes of coconut palms, tree ferns and other forest trees. The main distinction lies in the larvæ, which are readily separable as being more hairy.

The recent researches in Fiji by P. Manson-Bahr and W. J. Muggleton carried out in 1950 have now been published[9], supporting the arguments originally proposed in 1912 that the Pacific filaria should be considered as a separate species, for which the name *Wuchereria pacifica* has been proposed. From the work of J. J. C. Buckley[10] on the adult worms collected from Samoa and Fiji, it appears that some morphological differences can be recognized. In *W. pacifica* the head is oval in outline; in *W. bancrofti* it is round. The tail of the female lacks the bulbous swelling seen in *W. bancrofti*, and the length of the adult specimens, both male and female, is considerably smaller. Added to this, the non-periodic habit in the blood of the microfilaria of *W. pacifica* is adapted to the biting habits of its insect intermediaries *A. polynesiensis* and *A. pseudoscutellaris*. The fact that it does not develop normally in *Culex fatigans* or in *Aedes ægypti* reinforces the argument of distinct specificity. In contrast, the nocturnal microfilariæ of *W. bancrofti* are adapted to the night biting habits of *C. fatigans* and *Anopheles punctulatus farauti*, mosquitoes which act as the optimum intermediaries in Melanesia.

The geographical distribution of these two forms of filaria appears to be quite distinct, and *W. pacifica* is to be found in those Pacific Islands east of 170° E. It has been further suggested by me[11] that wherever *W. bancrofti* occurs it is the result of a domiciliary infection acquired during the night hours. Therefore, women and children are infected almost as heavily as the males, whereas in *W. pacifica* it is contracted in the daytime in the bush and plantations away from habitations and therefore this form of filariasis should be regarded as a rural infection. Men are consequently more heavily infected than women owing to their occupations in the open air in gardens and plantations. That the site of the infecting bites may also be important is shown by the frequency of elephantiasis of the arms in the Pacific as compared with British Guiana, where *W. bancrofti* is common and elephantiasis of the legs the rule. Repressive measures have to be based on these premises. In the nocturnal form the infecting mosquitoes must be attacked inside dwellings; in the non-periodic form in the immediate surroundings of dwellings and in the bush. The former (the nocturnal form), as has been shown by Giglioli[12] in British Guiana, is comparatively easy to eradicate.

Little repressive work against filariasis had been undertaken prior to 1942 in Fiji. In that year D. W. Amos[13], a retired business man who was an amateur entomologist, undertook an educational survey of the mosquito pest within the town of Suva. In 1943, appointed senior mosquito inspector, he commenced to train Fijian assistants in anti-mosquito measures and this scheme has since developed into the Mosquito Control Service. By these means the Fijians themselves have been made responsible in their villages and townships for the conduct of the anti-filariasis campaign. At the Central Institute in Suva Amos, and since Amos's death in 1949, Isimeli Rakai, his chief assistant, have trained classes of selected Fijian youths in this work, which comprises the structure and identification of the adult and larval stages of Fijian mosquitoes, and many other allied subjects. Up to 1948, more than 45,000 blood examinations had been made and an overall microfilaria rate of 18 per cent established. A training manual on mosquito control[14] by D. W. Amos was published in 1944 and revised in 1947. A shorter edition in the Fijian language and embellished with original cartoons was produced by Isimeli M. Rakai[15] in 1950.

There is no doubt that the Mosquito Service has done, and is doing, great work for Fiji, and the results of this campaign are already apparent. This was evident during my visit to Fiji in 1950. In the field, the Mosquito Service teams have been most active in clearing up the surroundings of villages, in filling in tree holes, burning coconut shells and debris, cutting down jungle, burying refuse heaps and generally making the village Fijians 'mosquito conscious'.

Now the battle has been joined by American workers in Tahiti and the preliminary results of their work have been published.

The anti-filariasis campaign in the Pacific has also received a great stimulus by the creation of the South Pacific Commission in 1949 and of which the first conference assembled in Suva in May 1950; afterwards a select group met in Tahiti during August 21–September 1, 1950, and a summary of the proceedings has been issued[16]. This was composed of delegates from French Oceania, New Zealand, Australia, Fiji, New Caledonia, Cook Islands, Samoa, Hawaii, University of California and other American interests.

Filariasis work in Tahiti is being conducted at the Institut de Récherches Médicales de l'Oceanie Française, Papeete, Tahiti. In July 1951, an annotated bibliography on filariasis, elephantiasis and related aspects in the South Pacific area was issued[17] by E.

Massal, executive officer, and D. J. Kerrest, research officer, Health Department of the South Pacific Commission.

### Mosquito Control

In addition to the work in Fiji, medical officers in Samoa have been investigating methods of mosquito control in suppressing filariasis. In their paper, Jachowski and Otto[18] endeavoured to determine the maximum zone of infectivity in native villages by dissecting specimens of *Aedes pseudoscutellaris* (probably *A. polynesiensis*) at selected collecting stations situated at various measured distances from the living quarters. In doing so, they examined more than 2,300 specimens of *A. polynesiensis*. They were surprised to find that the highest incidence of filarial infection (in the thorax) was not in the immediate vicinity of the huts inhabited by the Samoans, as might well have been expected; but the 'index of transmission' was very high in the bush and garden trails 175–275 yards from the centre of all the villages investigated. The age and sex distribution of microfilaræmia in Samoans, added to the habits of the villagers, and the well-ascertained biting habits of the mosquito vectors, which coincide with the visits of the gardeners to their plots, all support the conception of the non-domestic transmission of this filariasis. In some details their findings differ somewhat from similar researches by Byrd, St. Amant and Bromberg some few years earlier (1945), when they found the highest rate of mosquito infection at a range of 25 yards from the village centre.

The merits of mosquito control and drug suppression combined and contrasted have been employed on the grandest scale so far in Tahiti, where Beye[19] and his colleagues have now issued their preliminary report upon the suppressive measures they have initiated for the control of filariasis, covering the period November 1948–September 1950. Their schemes were carefully planned and the total area was divided into nine divisions, including the adjacent island of Maiao. They, too, employed collecting stations for adult mosquitoes in order to determine their densities. There were no less than three 'resting' and an equal number of 'biting' stations in each selected area, where recordings were made two to three weeks prior to the establishment of control measures.

Next, the microfilariæ-rate per 20 c.mm. of blood had to be determined for each area, both before and after treatment with 'Hetrazan'. In order to obtain reliable data upon which to base their conclusions, measures varied in different areas, keeping as a control one with a microfilaria-rate of 38·6. In other areas different methods of suppression were instituted, some with 'Hetrazan' prophylaxis, others with sanitation and DDT. The effect of the several methods on the percentage of persons with microfilariæ was estimated at six and twelve months after the measures were commenced, and thus it was ascertained that a noticeable drop occurred in each of the four areas where 'Hetrazan' was administered, whereas wherever anti-mosquito measures were instituted there was a drop in the numbers naturally infected to 0·6 per cent.

### 'Hetrazan' Prophylaxis

Clinical work on 'Hetrazan' in human filariasis was initiated by Santiago-Stevenson and others[20] on twenty-six persons harbouring *W. bancrofti* in Puerto Rico. When it was given by the mouth, in doses of 0·5–2·0 mgm. per kgm. body-weight three times daily, the number of microfilariæ was greatly reduced by the second day and in some 34·6 per cent they disappeared entirely. Afterwards, work was continued in British Guiana[21] and on the Island of S. Croix[22], and again substantial reductions of microfilariæ were obtained which persisted for three to twelve months.

The exact dosage of 'Hetrazan' and the length of the course necessary to banish microfilariæ from the blood has not even yet been finally determined. I found[23] in Fiji that, if the deep venous blood is examined, although no microfilariæ may be present in the peripheral circulation, they can usually be demonstrated. This leads to a consideration of the mode of action of 'Hetrazan'. Hawking, Sewell and Thurston[24] have shown that microfilariæ (*W. bancrofti*) in enclosed cavities, such as the pleura, or in a hydrocele sac, are not affected by 'Hetrazan'; but that, after treatment, they congregate in the liver, where they are attacked and devoured by leucocytes. It appears probable that 'Hetrazan' modifies the microfilariæ in some manner so that the leucocytes are attracted to them as if by some opsonizing effect.

It would seem that a very considerable reduction in numbers results from comparatively small doses of 'Hetrazan', but that larger ones are more lasting. Halawani[25] in Egypt treated ambulant cases (*W. bancrofti*) with 'Hetrazan' in doses of 0·9–2 mgm. per kgm. three times daily. In Indian nocturnal filariasis (*W. bancrofti*), Raman and colleagues[26] gave 0·45–2·2 mgm. per kgm. similarly for twenty-one days with a similar result. In East Africa, Laurie and associates[27] have given 'Hetrazan citrate' in doses as high as 12 mgm. per kgm. every twelve hours for three days to banish microfilariæ from the blood. Nine moderately infected patients received a single dose of 20 mgm. per kgm., and it was found that microfilariæ were absent from the blood two years later; but it is laid down that those patients with greater numbers of microfilariæ are definitely more difficult to sterilize than those with smaller numbers.

The most detailed account so far of the control of filariasis with 'Hetrazan' has been published by McGregor, Hawking and Dean Smith[28] at the Medical Research Council's Field Station in the Gambia. The dosage of 'Hetrazan citrate' was 25 mgm. per kgm. daily for five days. Of 154 infected persons who completed the prescribed course, 64 per cent had their blood free from microfilariæ so long as ten months later. In the remainder who did not respond so satisfactorily the parasitæmia was substantially reduced.

It is not surprising to learn that these large doses were not well tolerated and toxic effects appeared in one quarter. This form of medication soon became unpopular and it was only with great difficulty that the trial was completed.

In non-periodic Pacific filariasis, the microfilariæ are possibly more difficult to exterminate. In addition to the work of Beye and colleagues in Tahiti, Gaillard and Mille[29] gave small doses—2 mgm. per kgm. three times daily for seven days—and microfilariæ were banished in 87 per cent for about four months. It is still open to question whether one large loading dose is more effective in reducing microfilaræmia than a more prolonged course of smaller ones.

It would thus seem probable that the disproportion of the severer manifestations in the two forms of filariasis, nocturnal and non-periodic, discussed in this article reinforces the argument that, in the former (*W. bancrofti*) infections and in the latter (*W. pacifica*), we are dealing with separate entities which necessitate different methods of prophylaxis and possibly of treatment as well. (The statement made by McGregor and colleagues that out of 603 Gambians examined there were only six with signs of filarial disease and that the people regard it as altogether of minor importance must also be borne in mind.)

Owing to the uncertainty of the dosage and length of treatment with 'Hetrazan' in order to banish microfilariæ from the peripheral blood for a sufficient time to render mass application a practical proposition, added to the almost insuperable difficulties which arise in carrying through such a programme in Polynesians, there exists at present a prejudice against this form of causal prophylaxis. The minimal infective microfilarial concentration in the blood (after 'Hetrazan' treatment) for *A. pseudoscutellaris* and *A. polynesiensis* has yet to be determined. According to my observations[23] it is about four microfilariæ per 20 c.mm. of blood.

It appears probable that 'species sanitation' against the main vector, as had been practised in Fiji and Rarotonga, and now in Tahiti, promises to be the most effective measure in the ultimate eradication of Pacific filariasis, and that the actual carrying out of repressive measures should be left to specially trained teams of Polynesians.

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# OBITUARIES

## Dr. C. S. Hudson

THE death occurred suddenly on December 27, 1952, of Dr. C. S. Hudson at the age of seventy-one, and carbohydrate chemists all over the world mourn the passing of one of their greatest leaders.

Claude Silbert Hudson was born in Atlanta, Georgia, and spent a happy boyhood in Mobile. He entered Princeton University in 1897 in order to study for the Presbyterian ministry. He became so interested in chemistry during his course for the B.S. degree that eventually he decided to become a scientist. After graduation (1901) he was elected into an endowed fellowship in experimental science at Princeton and began an investigation on the mutarotation of milk sugar, under W. F. Magie, then professor of physics. This first investigation, published in 1902 when he was twenty-one, marks the beginning of his brilliant series of more than two hundred and fifty publications on the carbohydrate group.

Hudson's first leanings were towards the physical side of chemistry, and he spent a profitable year with Nernst at Göttingen (1902–3). On returning to the United States he became a research assistant to A. A. Noyes in Boston, and then he held an instructorship in physics at Princeton (1904–5) and at Illinois University (1905–7); after holding several other posts he was appointed chemist to the Bureau of Chemistry at Washington, where he stayed until 1919. He then became a consultant chemist for four years, afterwards joining Frederick J. Bates at the National Bureau of Standards, where he carried out many notable researches up to 1929. In this year he was invited to the professorship of chemistry in the U.S. Public Health Service, where he remained until his retirement at the age of seventy. During his tenure of this latter post he was enabled to secure the assistance of a succession of brilliant young scientists who, inspired by his able leadership, have achieved world-wide distinction.

Among his many great works on carbohydrates, Hudson's contributions to preparative methods and to the relationship between rotatory power and structure stand out, while his famous 'lactone rule' was perhaps his greatest single personal contribution and was one of the most notable landmarks in carbohydrate chemistry. He was a brilliant experimentalist and his writings bear the stamp of a master mind. He infused his passion for the sugars into his many pupils, who bore him great respect and devotion.

In the late 1920's he engaged in a notable controversy with the late Sir Norman Haworth regarding the ring structure of certain of the sugars, and following his eventual acknowledgment of the correctness of Haworth's views the two began a friendship which both greatly treasured. The results of this friendship were seen in the founding of the "Advances in Carbohydrate Chemistry", to which Hudson as the senior editor particularly devoted the last few years of his life and from the guidance of which he will, indeed, be sadly missed. He was largely instrumental also for founding the "Starch Round Table", which provides an annual forum for discussions on this important foodstuff.

Many honours came to him, particularly from the American Chemical Society. He received the Borden Medal and Award (1941), the Nichols Medal of the

New York Section (1916), the Willard Gibbs Medal of the Chicago Section (1929), the Richards Medal of the North-Eastern Section (1940) and the Hillebrand Prize of the Washington Section in 1931, etc. He was a member of the National Academy of Sciences, and the Chemical Society in London elected him to honorary fellowship. He received the major share of the Sugar Research Foundation Grand Award in 1950.

Hudson loved life and lived it to the full. He was a delightful companion with an inexhaustible fund of 'true' stories, and he engaged the affection of all who knew and admired his wisdom. He is survived by his wife (Erin Gilmer) and by two married daughters. M. STACEY

## Prof. C. J. Hawkes, O.B.E.

CHARLES JOHN HAWKES commenced his professional career in the engine rooms of the Navy, and from there, in 1912, he became joint secretary of the Royal Commission on Fuel and Engines under the chairmanship of Admiral of the Fleet Lord Fisher. Thenceforward, Commander Hawkes was in the forefront of naval research at a crucial period in naval history, and as the first superintendent of the Admiralty Engineering Laboratory he did much to develop the heavy-oil engine for submarines.

His reputation as a leading authority on the heavy-oil engine accompanied him when, in 1920, he was appointed professor of mechanical, marine and civil engineering in the University of Durham. His work at King's College, Newcastle upon Tyne, was paralleled by his zealous participation in the activities of the North East Coast Institution of Engineers and Shipbuilders. Of this important body he eventually became president, gold medallist and honorary fellow, and his papers, including the fourth Andrew Laing Lecture, were outstanding contributions to the Institution's *Transactions*. Prof. Hawkes's work was well known abroad and his knowledge of his subject won the regard of many engineering bodies. He was elected an honorary member of the American Society of Naval Architects and Marine Engineers, and, in 1938, had the unusual experience of making an after-dinner speech by radio on the occasion of the Society's annual dinner in New York. His research was not confined to heavy-oil engines. In Newcastle upon Tyne he inspired and superintended university research and served on the Heat Engines Trial Committee of the Institution of Civil Engineers, of which he was a full member. Insistent always on the importance of practical training as a basis for academic studies, he underlined this belief by distinguished work on the Board of Trade Departmental Committee on Marine Engineers' Certificates, for which service he was awarded the O.B.E.

To the younger generation of engineers and to his university colleagues in Newcastle upon Tyne, Hawkes will be remembered for his buoyant and witty spirit, and for his sincere interest in the good of his students and mechanics. He was always approachable and was as much at home, and greeted with as much affection, in the workshops as in the lecture theatre. His rich store of naval anecdotes, through many of which he recalled his work under Admiral Fisher, are still remembered along Tyneside. Though coming relatively late to university work, he did much on Faculty and Senate to raise standards, and it fell largely to his credit that Armstrong College was well known as a centre of progressive engineering education. Prof. Hawkes helped to carry the College through to its new status of King's College, and it was for his valuable work over a period of twenty-six years that the University of Durham conferred on him the title of emeritus professor, and the honorary degree of doctor of science. His death on January 30 at the age of seventy-two represents a loss to his many friends on Tyneside, and to the related spheres of engineering and education.

W. FISHER CASSIE

## Prof. Nathan Banks

PROF. NATHAN BANKS, emeritus curator of insects in the Museum of Comparative Zoology, Harvard University, died on January 24 at the age of eighty-four. Prof. Banks was born at Roslyn, N.Y., on April 13, 1868. He received a B.S. degree from Cornell University in 1889 and an M.S. from the same University in 1890. He was employed by the Division of Entomology, U.S. Department of Agriculture, during 1890–1916. In 1916 he was appointed curator of insects in the Museum of Comparative Zoology, Harvard University, a post which he held until 1944. Banks was one of the best-known entomologists of his time. He published extensively on Neuroptera and other orders of insects and also on spiders, and he built up and maintained in the Museum of Comparative Zoology at Harvard one of the finest collections of insects in America. He is noted also for his bibliographical work on the literature of insects. We, his associates at the Museum of Comparative Zoology, feel his loss very deeply.

P. J. DARLINGTON, JUN.

## Mr. Rhys Jenkins

WITH the death at Hastings on January 27 of Rhys Jenkins, the engineering world loses its oldest and its foremost historian. Born so long ago as September 29, 1859, in the village of Mountain Ash, Glamorganshire, Jenkins served an apprenticeship in the engineering works of Richard Nevill at Llanelly and then was a draughtsman in well-known works in Leeds, Grantham and Gainsborough; in 1884 he joined the examining staff of the Patent Office, from which he retired as a senior examiner in 1920 after thirty-six years service. He had joined the Institution of Mechanical Engineers in 1880 and had therefore been a member for more than seventy years.

Immersed as he was at the Patent Office in the history of inventions, he devoted his leisure to the systematic study of a great variety of industries, visiting many localities, collating material from manuscripts, local histories, State records and the like, and thus amassed a wealth of information which was critically examined and arranged. His first work of note was his book "Power Locomotion on the Highway" (1896), followed six years later by his "Application of Mechanical Power to Road Vehicles" —a mine of information for researchers. These were followed by a succession of historical surveys published in the technical press and various journals.

With other engineers and students of engineering history, he attended the Watt centenary celebrations at Birmingham in 1919, and on the formation next year of the Newcomen Society for furthering the study of the history of engineering and technology, became one of its most active members and served as president during 1924–25. He enriched its *Transactions* with paper after paper, dealing with such matters as the iron industry, the steam engine, fire engines, the work of Savery, Newcomen, Jonathan Hornblower, Arthur Wolff, and others. At nearly every summer meeting of the Society in its earlier days he was able to review the industries of the district visited. A major work was his "James Watt and the Steam Engine" (1927), written in collaboration with the late Dr. H. W. Dickinson. The esteem with which he was held by his fellow members was shown by the re-publication by the Council in 1936 of his miscellaneous papers which had appeared before 1920.

E. C. Smith

We regret to announce the following deaths:

Father A. Gatterer, *S.J.*, director of the Astrophysical Laboratory, Specola Vaticana, Castel Gandolfo, on February 17, aged sixty-seven.

Prof. Justin Jolly, professor of histophysiology in the Collège de France and *académicien libre* of the Paris Academy of Sciences, on February 1, aged eighty-two.

Prof. N. A. V. Piercy, professor of aeronautical engineering in the University of London (Queen Mary College), on February 1, aged sixty-one.

# NEWS and VIEWS

## Botany at Oxford:

### Prof. T. G. B. Osborn

Prof. T. G. B. Osborn, who has been Sherardian professor of botany in the University of Oxford since 1937, is retiring from that chair. He went to Oxford from the University of Sydney, Australia, where his researches in the ecology of natural and semi-natural vegetation laid a firm foundation for later work. Under his guidance the Department of Botany remained happy during a period when botany in Oxford was expanding in the cramped surroundings of the old building. It was owing to his initiative that the Department moved to the new laboratory in the Museum, and there close co-operation with the Botanic Gardens, first begun by him, is still maintained. Indeed the great improvements in the Gardens which have occurred in recent years owe much to his expert supervision and advice. Prof. Osborn has been active in University business and, especially during the War, in advisory work for the Agricultural Research Council and other public bodies. These calls upon his time and especially those associated with the design of the new laboratory were so great that his own researches inevitably suffered. The solid achievement of causing the new laboratory to be built will be found, perhaps, to be a greater contribution to botany than any series of laboratory experiments. Oxford will regret the departure of a professor who has advised and guided his colleagues with tact and forbearance.

### Prof. C. D. Darlington, F.R.S.

Prof. C. D. Darlington, who is to succeed Prof. T. G. B. Osborn, was born in 1903 and educated at St. Paul's School and Wye College. On graduating he joined the staff of the John Innes Horticultural Institution, of which William Bateson was then director. A year or so earlier Bateson had returned from a visit to the United States, where he had seen evidence which convinced him that the proper study of genetics required also study of the chromosomes. He then appointed W. C. F. Newton to his staff as a cytologist, and when Darlington went to the Institution he also joined in this new line of work. Newton's early death in 1927 put an end to their collaboration and left Darlington to continue, at first virtually alone. Soon aided, however, by a growing body of research students he then began that remarkable series of advances which turned cytology from a descriptive into an analytical study, with its own principles, and taking its place as an essential part of the greater structure of genetical science. The new cytology was expounded in the now famous "Recent Advances in Cytology", and it reached its zenith with the smaller though no less important book "The Evolution of Genetic Systems", which discussed and presented the chromosome mechanism, in all its great variety of forms, as the product of evolution by natural selection.

During this period Darlington had been appointed first head of the Cytology Department and later, when Sir Daniel Hall retired in 1939, director of the 'John Innes'. He saw the Institution through the difficult period of the War, during which the old buildings at Merton suffered serious damage, and then through its removal to a new and very much larger home at Bayfordbury. He was elected to the Royal Society in 1941 and received a Royal Medal in 1946. At the same time his interests extended to cover genetics as an even wider discipline, well exemplified by his writings on cytoplasmic heredity, viruses and cancer which he presented as part of the broader picture in which heredity, development and infection were all joined together for the first time. Prof. Darlington takes a wide knowledge and understanding of plants, horticultural as well as botanical, to his new appointment at Oxford, which will provide opportunity for presenting, in a broader field, genetical science as the firm base from which so much in modern biology can be seen to spring.

## Society for Visiting Scientists

Prof. A. V. Hill and Sir Harold Spencer Jones, president and past-president respectively of the Society for Visiting Scientists, have issued an appeal for funds to enable the Society not only to extend but even to maintain its activities. In 1944, when many Allied scientists were working in Britain, the Society was established in London, on the initiative of the British Council and in consultation with the Royal Society, as a centre where overseas and British scientists could meet. The Society has expanded rapidly; it has become widely known abroad, and considerable goodwill towards science in Britain has been built up and fostered through its 1,730 overseas members—a number which is constantly increasing. It enjoys the esteem and encouragement of organized international science, as represented by Unesco and the International Scientific Unions, as well as of Government science in Britain and of many learned societies. It is on friendly and co-operative terms with the scientific liaison officers of the Commonwealth countries and with the science representatives of other countries. At the Society's House, there is at the disposal of scientific institutions and of individual scientists a body of information about science and scientists not easily available elsewhere, and this is drawn on by many at home and overseas. The

Overseas Science Students Association, formed in 1952 to welcome postgraduate science students from other countries and to bring them into closer contact with each other and with the scientific life of Britain, has its home in the premises of the Society for Visiting Scientists. The Society's financial resources were hitherto derived mainly from an annual grant of £4,000 from the British Council. The recent reduction in the Government's grant to the British Council as a whole has forced the Council to halve its annual grant to the Society. To enable the Society to function efficiently, at least £6,000 per annum is required; it is therefore necessary to raise an annual sum of £4,000. It is hoped that much of this sum will be contributed by corporations and individuals through deeds of covenant, though other subscriptions will, of course, be welcomed. Inquiries should be sent to the Honorary Treasurer, Society for Visiting Scientists, 5 Old Burlington Street, London, W.1.

### Flamsteed's Observatory

Treasury approval has been given to a scheme, proposed initially by the Astronomer Royal, under which the historic buildings of the Royal Observatory at Greenwich will be taken over, as they are vacated by the removal of the Observatory to Herstmonceux, by the National Maritime Museum. These include, the original building, designed by Sir Christopher Wren, and built in 1675, containing the Octagon Room (the observatory of the first Astronomer Royal, the Rev. John Flamsteed), and the various additions made during the eighteenth century. The historic instruments, which have played so large a part in the progress of fundamental astronomy, will remain at Greenwich. They include Halley's transit instrument—the first transit instrument to be used in England; the zenith sector, with which Bradley discovered the aberration of light and the nutation of the earth's axis; and the Airy transit circle, installed in 1851, which by international agreement defines the zero of longitude. It is the intention of the director of the National Maritime Museum to move a portion of the exhibits relating to navigation from the main museum to the Observatory, which will become an Annexe of Astronomy and Navigation. This is peculiarly appropriate, as the Royal Observatory at Greenwich was established by Charles II in the interests of navigation. The Wren building, which suffered damage during the War, has been repaired by the Ministry of Works and restored as nearly as possible to its original appearance. It is expected that the Octagon Room will be opened to the public about the beginning of May. The Shepherd 24-hr. electric clock, outside the main gate, which is an object of interest to visitors, will remain in position. The custom of dropping the time-ball at 13.00 hr. each day has been resumed: the time-ball was installed in 1833 and provided the first public time-signal in Great Britain.

### Agriculture in the United States

During the years 1945–50 Mr. A. N. Duckham, then agricultural attaché to the British Embassy in Washington, travelled all over the United States, gaining an insight into the methods of farming in each of the forty-eight States he visited. An interesting account of his experiences is given in an illustrated booklet entitled "American Agriculture: its Background and its Lessons" (pp. 78+4 pl.; London: H.M.S.O., 1952; 2*s*. 6*d*. net). The chief objects of this report are to provide the necessary technical and commercial background for a proper understanding of farming methods in the United States, and to point out features of their agriculture which may hold positive (or negative) lessons of potential value to the British farmer. The subject is dealt with from four main aspects—geographical and social background; rural organization and agricultural services; production techniques; and farm organization and labour economy—while maps and statistics giving crop acreages and yields, number of livestock and machines, etc., are included in an appendix. Throughout the report it is abundantly clear how differences in soils and climate, natural resources, land-tenure systems and social background have influenced the development of agriculture in the two countries of Great Britain and the United States, and that in general no direct comparison can be made between their farming practices. Nevertheless, Mr. Duckham appears to regard the human element as the chief cause for present-day differences, the British farmer taking a special pride in good husbandry, whereas his American counterpart attaches more weight to efficient organization and labour economy. Each, he maintains, has something to learn from the other, and, if this were achieved, rural standards on both sides of the Atlantic would be raised.

### Rabbit Problem in Gotland Island

In Bulletin No. 9 of the Royal School of Forestry. Stockholm (Stockholm: Kungl. Skogshögskolan, 1952; 5 kr.), G. Notini and S. Forselius discuss the methods which have been undertaken to exterminate the wild rabbits on Gotland Island. The wild rabbit was introduced into Sweden with the object of providing a new game animal of commercial value. Vigorous stock was selected and care was taken to ensure the proper environmental conditions, based on European accumulated experience in parts where the stock had become more or less stabilized, excess numbers being kept down by small predatory animals and also disease. As has occurred in other parts of the world where mammals, birds and plants have been introduced outside their own habitat, the rabbits in Gotland increased rapidly in numbers. None of their ordinary checks was present, the only one being the occasional severe winters experienced in the island. The ordinary methods of man—shooting, poisoning, snaring, etc.—but not poison, have proved ineffective; poison is regarded as too dangerous. The rabbit problem has therefore been transferred from the Game Department to the domain of rural economics. The rabbit to-day in Gotland constitutes such a menace to sylviculture and agriculture that it is ranked with the small rodents. Work is now being undertaken on the introduction of the virus disease *Myxomatosis cuniculi* into the Gotland rabbit population. These trials are on similar lines to those already in operation in Australia, where considerable success has already been reported (see *Nature*, 170, 7; 1952), and it will be interesting to see how the results in the two different hemispheres will eventually compare.

### Problems in the Calculation of Interplanetary Orbits

In a paper on "Interplanetary Orbits" (*J. Brit. Interplanetary Soc.*, 11, No. 5, September 1952), J. G. Porter points out two fundamental errors in dealing with interplanetary travel (the discussion being limited almost entirely to the earth–moon system) which should be noted by all serious students of astronautics. First, although computers use seven-figure tables, probably only five figures are trustworthy, because the co-ordinates of the sun and planets are doubtful beyond five decimal places in astronomical units, and in consequence of this considerable errors in miles or kilometres are inevitable in many of the calculations. The second possible source of error arises from the fact that the movements of the bodies in our solar system may not be amenable to accurate treatment by the old classical mechanics. Porter gives a number of instances where important factors have been more or less ignored in the computations. For example, some have asserted that it would be economical to send a space ship to the neutral point between the earth and the moon, this point being about 24,000 miles from the moon, and then to allow it to fall relatively slowly towards the moon. But, as Porter points out, the attraction of the sun is nearly double that of the earth or the moon at the neutral point, and this would control the ship, which would then describe an orbit about the sun. Even if the supposed possibilities regarding the neutral point are completely excluded from consideration, difficulties of a serious nature would arise in other ways.

If it is decided to travel to the moon in an elliptical orbit, the speed of approach to the moon will be so high that a large amount of fuel must be used in braking (in the paper some figures are given on this matter) and, instead of travelling in an elliptical orbit for nearly five days to reach the moon, it would be as efficient to travel in a parabolic orbit which would require a little more than two days. Another difficulty arises if a ship is perturbed by some other body because, though there may be a small increase in the acceleration, nevertheless when this has ceased the velocity increase remains and the effect on the distances can be very great. All this demands that the initial conditions of velocity, distance, and angle of projection of the ship should be accurately determined; but even with the greatest accuracy, occasions will arise when pre-computed orbits will require modification. How such modifications could be computed during flight may present serious problems to future interplanetary navigators.

## Temperature of the Chromosphere

A PAPER by Shotaro Miyamoto on the "Kinetic Theory of the Chromosphere" (*Pub. Astro. Soc. Japan*, 3, No. 2 (1951), and also *Contrib. Inst. Astrophys., Kyoto Univ.*, No. 17) examines all the available data regarding the temperature of about 30,000° C. of the corona, and points out the difficulties of accepting this high temperature. Redman derived it from the contour observation of the chromosphere emission lines at the eclipse of October 1, 1940 (his results appearing in *Mon. Not. Roy. Astro. Soc.*, 102, 140; 1942); but Miyamoto gives a number of reasons for disagreeing with these results. He does not, however, attempt to complete the low-temperature hypothesis, but refers to the paper by Woolley and Allen on "Ultra-Violet Emission from the Chromosphere" (*Mon. Not. Roy. Astro. Soc.*, 110, 358; 1950), which appeared after he had written his paper. Miyamoto claims that they are in general agreement with his low-temperature hypothesis, and, while admitting the anomalous excitation of the chromosphere as an observational fact, he does not accept this as necessarily implying a high kinetic temperature.

## *Journal of the Madras Institute of Technology*

THE Madras Institute of Technology, which is situated at Chromepet, fourteen miles from Madras, was founded in July 1949, and now the first number of its *Journal* has appeared (1, No. 1; August 1952. Rs. 4, 8*s*. or 1 dollar per issue; Rs. 8, 16*s*. or 2 dollars a year), edited by the professor of applied mathematics in the Institute, Dr. A. Narasinga Rao. The Institute was started with a gift of Rs. 500,000 from Sri C. Rajam, a grant of Rs. 500,000 from the Madras State Government and a number of smaller gifts from various organizations and persons. It deals with education and research (pure, applied and sponsored) in the physical sciences, engineering and technology, and until now it appears to have concentrated mainly on the educational side—and rightly so; but the time is fast approaching when the research activities will play an equally important, if not the major, part in the life of the Institute, and it is therefore fitting that the *Journal* should be started, wherein the fruits of new knowledge can be published. The Institute offers courses extending over three years, during the first year of which the students follow for the most part a general course in the basic sciences (mathematics, physics and chemistry) and basic engineering subjects. After that they specialize in one of the four faculties, which are as follows (numbers of second- and third-year students in each faculty being shown in brackets): aeronautical engineering (10, 24), automobile engineering (24, 23), electronics (28, 18), and instrument technology (8, 7). After a short description and faculty notes on the activities of the Institute, the main part of the first number of the *Journal* is devoted to articles as follows: "Aeronautical Science To-day", by Dr. W. Repenthin, head of the Faculty of Engineering of the Institute; "Numerical Calculations in Electrical Engineering and Electronics: Part 1, Calculation of Determinants", by Prof. R. Filipowsky, head of the Electronics Faculty of the Institute; "Oxidation of Hydrocarbons", by Dr. S. V. Anantakrishnan, visiting professor of chemistry in the Institute; "Note on a Method of Transient Analysis", by K. K. Clarke, of the Electrical Engineering Department, University of Ceylon; "On the Kalidasa Effect", by Dr. A. Narasinga Rao; "Introduction to the Giorgi System of Units", by Dr. R. Wallauschek, head of the Faculty of Instrument Technology in the Institute; "Patent: its Law and Practice", by Prof. V. Subramanian, visiting professor of the Institute; and "On a Method of measuring very Small Time Intervals", by A. Suszkin, laboratory research engineer in the Institute. A number of short notes completes the issue.

## *Fusarium* Contamination of Grain

THE prevalence and taxonomy of *Fusarium* species in cereal seed in Canada is considered in detail in a recent paper by W. L. Gordon, of the Dominion Laboratory of Plant Pathology, Winnipeg (*Canad. J. Bot.*, 30, No. 2, 209; 1952). In all, of about four thousand seed samples of wheat, barley and oats which have been examined (a hundred kernels per sample), the statistics show considerably heavier infections in Eastern than in Western samples. A total of sixteen species and varieties of *Fusarium*, classified in nine sections of the genus, was isolated. (The classification used is that of Wollenweber and Reinking, but some sections have been extensively revised in conformity with the views of Snyder and

Hansen.) Detailed diagnoses, line illustrations of conidia and chlamydospores, and some good photographs in colour of monoconidial cultures of the wild type of each species, variety or form are given.

### Chromatography of Phycocyanin

E. C. Wassink and H. W. J. Rageth have reported on a paper chromatographic analysis of the blue solution obtained by the acid hydrolysis of the photosynthetically active chromoprotein, phycocyanin, of the blue-green algæ *Oscillatoria* (*Proc. Koninkl. Nederlandse Akad. van Wetensch.*, Ser. C., LV, 4, 462; 1952). The analysis yielded sixteen amino-compounds of which thirteen were known amino-acids and three were unknown substances, one of these last being present in relatively large amount. Arginine was absent; but otherwise the assay of the *Oscillatoria* phycocyanin did not reveal important differences from the bulk proteins of the green algæ *Chlorella vulgaris* (with chloroplast proteins) or from horse hæmoglobin.

### Blundell's School Science Society

The seventh issue of the Blundell's School Science Society magazine again shows the remarkably fine work being done at boarding schools in Britain in the training of young scientists. One article, for example, describes some studies of the biology of ivy-leaved duckweed (*Lemna trisulca*) by a senior boy, M. J. Corrigan. Among the questions he investigated were methods of encouraging growth, the effect of temperature and the role of auxin on growth, the growth of the plant under different wave-lengths and intensities of light, as well as the reasons which cause *Lemna trisulca* to sink to the bottom of a canal in winter and to cause its fronds to float just below the water-surface at other times. Corrigan's article is supported by two others by boys who, like him, have been awarded school prizes for their original work. The magazine also describes the many meetings held by the Science Society during 1951–52 and the records compiled by individual members and sub-committees of the Society in and around Tiverton. In addition there is an admirable account by two boys of a recent visit to an old but recently resuscitated iron-works at Dunsford.

### Fourteenth International Congress of Zoology, Copenhagen

The Fourteenth International Congress of Zoology will be held in Copenhagen during August 5–12. It has been decided to have a fairly large number of sections, so that comparatively specialized fields can be discussed, and a provisional list of sections (with the name of each organizer) has been arranged as follows: nomenclature (Dr. H. Lemche), invertebrate palæozoology (Prof. Chr. Poulsen), vertebrate palæozoology (Dr. E. Nielsen), quaternary zoology (Dr. M. Degerbøl), zoogeography (Prof. R. Spärck), speciation (Dr. F. Salomonsen), genetics of populations (Dr. H. Lemche), cytology (Dr. H. Holter), sub-microscopical structure of animals (Prof. H. V. Brøndsted), animal regeneration (Prof. H. V. Brøndsted), morphogenesis (Prof. H. V. Brøndsted), animal psychology and ethology (Dr. H. Poulsen), comparative physiology (Prof. P. Brandt Rehberg), parasitology (Prof. M. Christiansen), nematology (Dr. P. Bovien), terrestrial ecology (Dr. Ellinor Bro Larsen), marine ecology (Dr. G. Thorson), entomology (Dr. S. L. Tuxen), vertebrate systematics (Dr. M. Degerbøl) and invertebrate systematics (Dr. P. L. Kramp). Four general meetings have been planned at which lectures lasting about an hour will be given on topics of general interest, followed by discussion. At the section meetings a specialist will be invited to give a lecture lasting about forty minutes, which will cover a central problem of the section concerned; added to this, members may read short papers, not more than twenty minutes in duration, and also give brief demonstrations of animals, slides, films, etc. The official languages of the Congress will be English, French and German. All who wish to contribute to the proceedings or reserve hotel accommodation should communicate with the secretariat before April 15; the last date for membership registration is June 1. All communications should be addressed to the secretariat of the Congress at Krystalgade 27, Copenhagen *K*.

Immediately before the Congress a colloquium, organized by Mr. Francis Hemming, will be held by the International Commission on Zoological Nomenclature, officially representing the International Union of Biological Sciences. During the Congress a colloquium will be held on "Zoogeographical Problems of the Deep-Sea Fauna", organized by Prof. R. Spärck.

### Rumford Bicentenary Celebrations in the United States

The bicentenary of the birth of Benjamin Thompson, Count Rumford, on March 26, 1753, will be celebrated in the United States at Boston, during March 26–28, by the American Academy of Arts and Sciences. The social functions in the celebrations will be a dinner on March 26, at which Sanborn C. Brown, of the Massachusetts Institute of Technology, will give an account of his researches into the life of Rumford, and on March 27 a ceremony will be held at which Rumford Medals of the Academy will be presented to Profs. E. Fermi, W. E. Lamb, jun., and L. Onsager. In addition, during the morning and afternoon of March 27 and the morning of March 28, respectively, the following three symposia will be held, at which the speakers will be as shown: recent developments in thermodynamics (Prof. P. W. Bridgman, Harvard; Sir Alfred Egerton, London; Prof. L. Onsager, Yale; and Prof. F. E. Simon, Oxford); recent developments in atomic spectroscopy (Dr. M. Deutsch, Massachusetts Institute; Prof. W. E. Lamb, jun., Stanford; Dr. E. M. Purcell, Harvard; and Prof. I. I. Rabi, Columbia); and recent developments in nuclear physics (Prof. E. Fermi, Chicago; Prof. J. R. Oppenheimer, Institute for Advanced Research, Princeton; Prof. M. Siegbahn, Nobel Institute, Stockholm; and Prof. V. F. Weisskopf, Massachusetts Institute).

### The Night Sky in March

New moon occurs on March 15d. 11h. 05m., U.T., and full moon on March 30d. 12h. 55m. The following conjunctions with the moon take place: March 4d. 23h., Saturn 8° N.; March 17d. 20h., Venus 2° N.; March 17d. 20h., Mars 5° S.; March 19d. 06h., Jupiter 6° S. In addition to these conjunctions with the moon, Venus is in conjunction with Mars on March 17d. 23h., Venus being 7° N. Mercury sets at 19h. 20m. at the beginning of the month, but draws closer to the sun and is in inferior conjunction on March 18, after which it becomes a morning star, being, however, too close to the sun for observation during the remainder of the month. Venus, an evening star, sets at 21h. 55m., 21h. 45m. and

20h. 50m. at the beginning, middle and end of the month, respectively, and is conspicuous in the western sky for some time after sunset. The visible portion of the illuminated disk varies between 0·332 and 0·070 and the stellar magnitude averages about – 4·2, the greatest brilliancy (magnitude – 4·3) being attained on March 8. Mars is visible in the early part of the night, and sets at 20h. 55m. approximately throughout the month. About the middle of the month it is a little north of ο Piscium, and later it moves into the constellation of Aries. Jupiter sets at 23h. 35m., 23h. 20m. and 22h. 15m. on March 1, 15 and 31, respectively, and lies a little south of δ Arietis during the greater part of the month. Saturn rises at 21h. 50m., 20h. 50m. and 19h. 35m. at the beginning, middle and end of the month, respectively, its stellar magnitude being 0·6, and lies a little north-east of Spica. Occultations of stars brighter than magnitude 6 are as follows, observations being made at Greenwich: March 19d. 21h. 15·9m., 16 Taur. (*D*); March 19d. 21h. 23·5m., 17 Taur. (*D*); March 19d. 21h. 34·6m., *q* Taur. (*D*); March 19d. 21h. 42·9m., 20 Taur. (*D*); March 19d. 22h. 03·1m., 21 Taur. (*D*); March 19d. 22h. 34·0m., η Taur. (*D*); March 22d. 23h. 50·6m., ε Gemi. (*D*); March 23d. 0h. 48·0m., ε Gemi. (*R*); March 26d. 0h. 53·4m., π Canc. (*D*). *R* and *D* refer to reappearance and disappearance, respectively. Vernal equinox occurs on March 20d. 22h.

## Announcements

MR. DONALD W. HUDSON, chairman of the National Pharmaceutical Union and a member of the Council of the Pharmaceutical Society, has been appointed an Officier de l'Ordre de la Santé Publique in recognition of his services as chairman of the Franco-British Pharmaceutical Commission.

MR. H. TREFOR JONES, deputy provincial director, Yorks and Lancs Province of the National Agricultural Advisory Service, has been appointed provincial director of the Province in succession to the late Mr. D. H. Findlay.

MR. J. RANNIE, welding engineer to John Brown and Co., Ltd., of Clydebank, has been awarded the William J. Larke Medal for 1952 of the Institute of Welding for his paper "Shipyard Changes with special reference to Steelwork Construction in Oil Tankers".

DR. C. M. WHITTAKER, an honorary fellow of the Textile Institute and former director of Courtaulds, Ltd., will deliver the Mather Lecture for 1953 of the Institute, following the annual general meeting at the University of Bristol on April 29. Dr. Whittaker will speak on "Common Sense on Colour in Textiles".

THE Institute of Metals has awarded the 1952 W. H. A. Robertson Medal and a premium of fifty guineas to Mr. J. F. Waight, an engineer of the West Midlands Gas Board, for his paper on "Gas Equipment for the Thermal Treatment of Non-Ferrous Metals and Alloys" (*J. Inst. Metals*, 80, 269; 1952). This Medal, which was given by W. H. A. Robertson and Co., Ltd., is awarded annually for the encouragement of the writing and publication in the Institute's *Journal* of papers on engineering aspects of non-ferrous metallurgy.

TRINITY COLLEGE, Cambridge, is offering as in former years a number of research studentships and Dominion and Colonial exhibitions, which will be tenable from next October. The research studentships, which will not exceed £375 a year for a maximum of three years, are open to graduates of universities other than Cambridge (non-graduates of exceptional ability will be considered) who are not more than twenty-six years of age (although time spent in national service may be deducted) and who have not already spent more than two years on advanced study or research. The exhibitions are for students from the British Dominions and Colonies who intend to read for an honours degree, and are worth £40 a year. Applications, to be sent through the head of the candidate's university, must reach the Senior Tutor, Trinity College, Cambridge, not later than May 1.

THE Massachusetts Institute of Technology is offering a number of graduate and advanced research fellowships for study and research in the field of electronics. Graduate student fellowships are for work leading to advanced degrees in physics or electrical engineering and are worth 1,500–2,400 dollars a year; advanced research fellowships, which are worth upwards of 3,000 dollars a year, are for those possessing a Ph.D. degree or its equivalent who wish to pursue advanced studies and research in the field of electronics at the Institute. Applications for these two classes of fellowships should be made to the Director, Research Laboratory of Electronics, Massachusetts Institute of Technology, Cambridge, Mass., at least four months prior to the intended date of entrance. A limited number of positions are also available for students to work as research assistants in the Research Laboratory of Electronics while at the same time pursuing a graduate programme of studies on a part-time basis; further information regarding this scheme can be obtained from the Director of the Laboratory.

A FULL-DAY conference will be held by the Northern Branch of Aslib on March 12 in the Council Chamber of the Town Hall, Stoke on Trent, under the chairmanship of Colonel G. A. Wade, chairman and managing director of the Wade Group of Potteries. Four lectures will be given as follows: the Iron Library, by W. B. Ingram (Britannia Iron and Steel Works, Ltd., Bedford); the British Ceramic Research Association Information Department, by A. E. Dodd (British Ceramic Research Association); historic pottery, by G. I. V. Bemrose (curator, Stoke on Trent Public Museum); and Aslib, what it is and what it does, by Leslie Wilson (director of Aslib). The fee for the conference is 3*s*. 6*d*. Visits have been arranged to various firms and institutions on March 13. Further information can be obtained from Dr. J. C. Withers, "Penmere", 11 Highfield Park, Heaton Mersey, Stockport.

A REPORT of the proceedings of the British Commonwealth Scientific Conference, held in Australia, February–March 1952 (see *Nature*, 169, 856; 1952), has now been published. Besides the opening address of the Prime Minister of Australia and Sir Ben Lockspeiser's reply, and the preliminary statement by the chairman, Dr. I. Clunies Ross, it includes the recommendations and resolutions of the Conference and the text of a statement on the national organization of research adopted by the Conference in full session. Appended are a list of committees and their composition and a summary of action taken on resolutions of the British Commonwealth Scientific Official Conference, 1946.

# PROTECTION FROM THE EFFECTS OF RADIATION

RADIATION protection was the subject for discussion at a joint meeting of the Industrial Radiology Group of the Institute of Physics and the Hospital Physicists Association, which was held at the Royal Institution, London, during January 16–17. From the papers given by the various speakers one could piece together the past history of this subject and the present quickening interest in it.

Dr. L. H. S. Clark described the service which had been established nearly twenty years ago at the Lambeth Hospital to ensure adequate protection of the staff of the radiological departments. Film badges of fast dental film were found satisfactory as means for measuring the doses of X-rays received by the individual in the course of his work. This was no isolated instance of the growing awareness of the need for protection against the damaging effects of ionizing radiation. Tribute was paid to the splendid work of the British X-ray and Radium Protection Committee which, from its inception under the chairmanship of the late Sir Humphry Rolleston and often without financial support, did heroic pioneer work.

Although many individual hospitals or groups of hospitals were taking steps to protect their staff, this was not universally so, and in 1942, as a result of the efforts of the late Dr. A. E. Barclay, it was deemed necessary to have an external monitoring service for those institutions in the Emergency Medical Service where no internal service was maintained. Mr. E. E. Smith described how the National Physical Laboratory was asked to undertake this office and how it solved the problem. Although the degree of blackening of film is dependent on the quality of the radiation applied, nevertheless it was chosen at that time because the available ionization chambers were fragile and liable to misuse. Moreover, with a service conducted by correspondence, the methods had to be as simple as possible. From small beginnings with the receipt of a few hundred films a month, the service supplied by the National Physical Laboratory has steadily progressed. Workers in factories and research laboratories were soon added to the list of customers, and an inspection service was set up to advise those bodies whose workers consistently recorded high doses. Now, about five thousand films a month are processed by five technicians, and happily the proportion of recorded doses above tolerance is steadily diminishing.

These early theoretical and practical aspects were by no means confined to Great Britain. An International Protection Commission had met on several occasions and reported its recommendations; it still continues to do so, the last meeting being in 1950. Dr. J. F. Loutit recalled some medical and biological evidence of the damaging actions of ionizing radiations which the Commission has taken into account in formulating its latest recommendations on permissible doses. It has rightly been chiefly swayed by the medical evidence where man rather than the experimental animal has suffered and even died from excessive exposure. Mr. W. Binks, himself a prominent member of the Commission, also stressed the delayed action of these effects, but appealed for a balanced approach to the problem. Respect, but not fear, on one hand, or foolhardiness, on the other, is to be encouraged, and then this hazard like others can be controlled. He quoted the figures of permissible doses of the various types of radiation so far considered. As regards penetrating radiation, he issued a note of warning that many of the published tables of transmission through lead and concrete are out of date in that narrow beams only are considered. Nowadays broad beams are more frequently in operation, and the transmissions here are vastly greater. Mr. Binks appealed for still more effort in investigating the fundamental biological action of radiation and the early incorporation of new knowledge into codes of practice. He hoped that these wishes would be implemented by a new national protection organization established jointly by the Medical Research Council and Ministry of Health.

The most modern methods of measurement of dose by means of films were reviewed by Dr. G. Spiegler. It is necessary to measure, on one hand, the hard gamma-ray radiation of radioactive isotopes and, on the other, the relatively soft emissions of diagnostic X-ray machines or the scattered rays from radioactive sources. Thus the monitoring film contains an exposed portion to record the combined soft and hard radiation and a portion or portions protected by aluminium, brass, lead, cadmium or other appropriate filter to measure the harder components. By contrast, with very hard rays of energy greater than 2 MeV., there is a reversal of the usual picture and less blackening of the unfiltered area.

Whereas X-ray film is still the main standby for the measurement of dose, ionization chambers also play their part. Dr. E. Dyson described some of those in use at the Atomic Energy Research Establishment, Harwell. Large ion-chambers are used for area monitoring; but by themselves they would be inadequate because of the variation in scattering under altering conditions. The personal dosemeter is a necessary addition. For specific purposes this can be either a condenser-type chamber which is charged and after use read by various electrometers, or a quartz-fibre electrometer which the wearer can himself read and assess the rate of accumulation of dose. With radiation of 100 keV. and more, the variation of the reading with hardness of the rays is of the order of ± 10 per cent. These electrometers are somewhat sensitive to hard beta-rays.

As modern research and development makes available X-rays of greater and greater energy and radioactive sources of greater activity, industry is finding increasing use for them, particularly in engineering for testing purposes. Dr. C. Sykes noted that, while each source is obtained for a specific purpose, the applications multiply. The increasing time and scope of use of these sources make the originally devised protective arrangements inadequate. If the job is brought to the source, protection should not be difficult; but when the source is taken to the job, it is not simple to give adequate protection without disturbing the normal routine of the workshop. This increasing use, particularly of radioactive isotopes, by firms with no previous experience of the subject and therefore no competent medical officer or physicist, exposes the need for a set of rules clear even for factory managements.

Dr. H. Harris (Babcock and Wilcox, Ltd.) and Dr. J. S. Blair (Stewart and Lloyds, Ltd.) carried the discussion further from the point of view of industry.

In their experience the literature on protection is not readily available; but a competent engineer can solve his problems by common sense and by insisting on a rigid discipline among the operating staff.

The legal responsibility for the health and welfare of workers in factories, but not in research laboratories, lies with the Ministry of Labour. Mr. K. Goodall (H.M. inspectorate of factories) described how this Ministry watches for new hazards and advises on old ones. In the case of sealed sources of radioactive isotopes, the position is at present satisfactory in that the Ministry is informed from Harwell or Amersham of the delivery of all such consignments to new customers. Present records show surprisingly few accidents, and Dr. Ethel Browning's hæmatological data contain few abnormalities. With the existing policy of persuasion, results are as satisfactory as would be expected if regulations were in force; the greatest danger, said Mr. Goodall, still remains not the closed sources of radioactivity but the open sources met with in the luminizing industry.

In industry, according to the evidence presented, the care or discipline exercised has resulted in the workers receiving doses well below tolerance (an average of about 10 mr./week in one case). By contrast, in the Ordnance Inspectorate of the Royal Navy, as it appeared from Commander P. Chandler's remarks at the meeting, policy is determined by the delivery of the goods and not by the hazard to the staff. This attitude may be necessary in the Armed Forces in time of war, but was alarming to the medical section of the audience.

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# ROYAL ASTRONOMICAL SOCIETY

## PRESENTATION OF GOLD MEDAL

At the meeting of the Royal Astronomical Society on February 8, 1952, at Burlington House, London, the Gold Medal of the Society was presented to Dr. John Jackson by Prof. H. Dingle, the president of the Society, who gave an address which has since been published in full (*Mon. Not. Roy. Astro. Soc.*, 112, 3; 1952).

Not very long after Dr. Jackson had finished his career at Cambridge he went, in 1914, as chief assistant to the Royal Observatory, Greenwich, where about twenty years of work on double stars with the 28-in. refractor awaited analysis, and this task was undertaken by Jackson in collaboration with Furner. There were also available F. G. W. Struve's results, published in 1837, which included 3,112 close pairs, and many more were added by the late Otto Struve, who continued his father's work. Jackson showed that 649 of F. G. W. Struve's stars had changed their configuration since his day; of these, 449 showed true orbital motion, 161 were optical doubles the components of which differed in proper motion, and in 39 the nature of the motion was uncertain. Among Otto Struve's stars he found that 135 were binaries, 15 optical doubles and 5 had doubtful motion. The results of the analysis were published in a number of papers in *Monthly Notices of the Royal Astronomical Society* from 1920 onwards, and the hypothetical parallaxes deduced agreed well with the trigonometric and spectroscopic parallaxes which were then available. The next step was the determination of the cross-components of the velocities of the stars from their known proper motions, from which the apex and speed of the solar motion were determined, and these showed good agreement with those found by other methods. The absolute magnitudes of the stars were also determined from their apparent magnitudes, and this provided further evidence for the separation of the stars of the later spectral type into giants and dwarfs, which had been investigated by Hertzsprung and Russell some years previously and gave strong support to Russell's theory of stellar evolution.

During 1924–30 Jackson carried out valuable work on time measurement. Two Shortt free-pendulum clocks, the running of which was in charge of W. Bowyer, acting under Jackson's direction, were installed at the Royal Observatory in 1924 and 1926, and four papers on their behaviour up to the end of 1930 appeared in the *Monthly Notices*. An analysis of the errors showed that these could be reduced to three terms, one due to nutation causing non-uniformity of sidereal time, another arising from temperature fluctuations, and the third—the 'secular term'—the origin of which was not immediately obvious but which was later attributed to a gradual increase in the length of the invar rod of the free pendulum. Other possible causes, however, were conceivable, and subsequent observations cast doubts on the supposition that the gradual growth of the invar rod was the main cause of the secular term. The conclusion was that the most that could be hoped from these clocks in detecting fluctuations in the earth's rotation was that they might determine whether erratic changes of 1·0″ a year in the moon's longitude could be due to irregularities in the earth's rotation period. One very valuable result of the whole investigation was the discovery of the nutation effect, showing the necessity for distinguishing between apparent and mean sidereal time.

In 1930 Jackson published an analysis of observations made with the Greenwich Cookson zenith telescope; this indicated that the value of the constant of nutation was 9·2066″ ± 0·0055″, which was smaller than the value used in the ephemerides. The latter, based on Newcomb's determination from a very long series of observations, agreed very well with a more recent determination by Przybyllok, and a discordance between this and the theoretical value, considerably larger than the probable error, requires some explanation. Jackson regarded it as "one of the outstanding discordances of the constants of the solar system"; but, as Prof. Dingle remarked in his address, it is unlikely that the last word has yet been said concerning the theoretical value.

In 1925 Jackson began to collaborate with Knox-Shaw and Robinson, of the Radcliffe Observatory, Oxford, on the reduction of Hornsby's meridian observations. The observations selected for reduction were those made between 1774 and 1798, and included about 43,000 observations of stars, 5,200 of the sun, 4,600 of planets, and 1,200 of the moon. From the results it was possible to apply systematic corrections to Boss's "Catalogue" and also to Newcomb's tables of the sun's longitude, and to other elements of the sun's apparent orbit about the earth—the equinox, the obliquity, the eccentricity and the longitude of perigee. The main publication appeared in 1932 and was followed with a paper in the *Monthly Notices* on the observations of Mercury; these observations were specially important in checking the motion of the planet's perihelion.

In 1933 Dr. Jackson succeeded Sir Harold Spencer Jones as His Majesty's Astronomer at the Cape of Good Hope, and until his retirement in 1950 his work there followed the main lines laid down by his predecessor. The programme consisted of three parts: the parallax work, the determination of positions and proper motions of stars in the Cape astrographical zones, and the compilation of a "Photographic Zone Catalogue" for the region $-30^\circ$ to $-90^\circ$ in declination. Spencer Jones's programme, inaugurated in 1926, was the measurement of the parallaxes of all possible stars of proper motion exceeding $40''$ a century south of declination $-10^\circ$. Although a number of determinations had been made when Jackson assumed office, the greater part of the programme remained to be executed, and results were published from time to time in the *Monthly Notices* and in three successive volumes of the *Cape Annals*, which were edited by Jackson. In his annual report for 1949 Jackson announced that 1,623 parallaxes had been determined since the work started and that it was then almost completed. The results of the second part of the programme were published in 1936 under the titles "Proper Motions of Stars in the Zone Catalogue of 20,843 Stars, 1900, Zones $-40^\circ$ to $-52^\circ$, derived from the Photographs taken at the Royal Observatory, Cape of Good Hope", and in 1939 in "Catalogue of 20,554 Faint Stars in the Cape Astrographic Zone $-40^\circ$ to $-52^\circ$, for the Equinox of 1900·0, giving Positions, Precessions, Proper Motions and Photographic Magnitudes, derived from Photographs taken at the Royal Observatory, Cape of Good Hope". Many important statistical results were derived from this study of more than forty thousand southern stars, and the information obtained has an important significance for the future. Good progress has also been made on the third part of the programme, the compilation of a "Photographic Zone Catalogue" for the region $-30^\circ$ to $-60^\circ$ in declination, with the wide-angle cameras, in which programme magnitudes and colours have also been included.

Prof. Dingle referred also in his address to a number of other tasks which Dr. Jackson has undertaken at the Cape; but it is sufficient in this résumé to quote Prof. Dingle's words that "The Gold Medal of our Society is bestowed for outstanding excellence of astronomical work, and for nothing else".

# BRITISH DEPENDENCIES IN THE CARIBBEAN AND NORTH ATLANTIC

PROF. W. M. MACMILLAN'S "Warning from the West Indies" was published in 1936: the 'warning' of the book's title, he wrote later, was "originally an appeal, and looked to the future". How far his warnings and those of others have been heeded may be judged by a recently issued Colonial Office publication* which surveys the history of the British territories in the Caribbean and North Atlantic during the past thirteen years. It is the fourth in a series of official reports designed to take a longer view of trends and developments than is possible in the various annual Colonial reports. The previous reports have covered the post-war period in the Far East (Cmd. 7709, 1949), East and Central Africa (Cmd. 7987, 1950), and the British islands in the southern hemisphere (Cmd. 8230, 1951). The present report extends its range backwards to 1939 and even earlier, and it does so wisely, for the situation to-day in these areas is so dependent on the circumstances of the inter-war and war years that it is impossible to understand it without reference to this background.

This point is clearly made in the first chapter of the report, "The Seeds of the Present", which summarizes the position in the period preceding the appointment of the West Indies Royal Commission of 1938–39 and the results of that Commission, and reviews the events of the war-years that followed. The Commission decided that the region was in urgent need of social services which it could not afford from its own resources or from any unassisted development of these resources that was likely in the near future. Considerations such as these in the Colonial Empire generally lay behind the establishment of the Colonial Development and Welfare Fund in 1940: in the West Indies a Development and Welfare Organization was set up with the late Sir Frank Stockdale as its first comptroller and, despite war-time shortages, much re-organization and rehabilitation were carried through. Although, as the report puts it, "the impact of the war was manifold and serious", the end of the War left the West Indies with their basic economy largely intact and with good prospects for the planning of the future.

The chapters that follow and the useful statistical appendixes present a synoptic view of the situation to-day. The survey of political and constitutional development indicates the diversity of political structure and the complexity of local government, as well as the variety of ways in which advance is being made in the different territories from representative to responsible government. It also explains both the difficulties and the prospects of federation, towards which there is a distinct movement in most of the islands and about which a further conference is to be held in London in April.

The economic outlook just before the Second World War was, to quote the Royal Commission, "not at all reassuring", on account of the depression in the main primary-producing occupations of the region and because of the problems resulting from the high natural rate of increase of population. To-day the report states that "the uncertainty of the inter-war years has gone", partly through the development of new markets and of systems of guaranteed prices, and partly because of action taken under the Development and Welfare Acts to strengthen the region's economy, particularly its agriculture. At the same time, some of the economic problems have been intensified: developments in preventive medicine, in particular, by increasing the rate of growth of population, are already increasing the demand for education and for employment. The necessity for "the more intensive use of the land with increased production of food" is as great to-day as when the Royal Commission expressed this need, and it is satisfactory to learn that since 1939 there has emerged a new approach to the question of the most efficient use of the land, for foodstuffs as well as for export crops such as sugar, cocoa and bananas. There has been progress, too, in animal husbandry, forestry, the processing and other industries, and mining (British Guiana is the world's second largest producer of bauxite, which is also now being mined in Jamaica with the financial assistance of the Economic Co-operation Administration of the United

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* Colonial Office. "British Dependencies in the Caribbean and North Atlantic, 1939–1952." (Cmd. 8575.) Pp. xi+98. (London: H.M.S.O., 1952.) 3s. 6d. net.

States). Despite these and other developments, unemployment and under-employment remain serious problems, though good progress has been made in the fields of labour supervision and industrial relations.

The general emphasis of the Royal Commission's recommendations was on welfare rather than on development, and it is not surprising to find much more advance in the social services than in economic productivity. The links between the two have been discussed in Britain in recent years, and for the Caribbean were considered by Prof. T. S. Simey (one of the war-time advisers to the Comptroller for Development and Welfare) in his "Welfare and Planning in the West Indies" (1946). Although the report notes that "in recent years it has been increasingly recognised that the maintenance of improved social services calls for intensive and sustained efforts to promote economic development", it very rightly emphasizes the considerable progress made in education, medical services, and social welfare generally.

In the modern world no area can be understood in isolation from its neighbours, least of all these British islands for which, as the report states, "a co-operative policy has been a firm feature of the conduct of affairs". International relations with the United Nations, the United States, Guatemala and Venezuela are discussed, and special attention is given to the significance of the Four-Power Caribbean Commission, which is to concentrate in future less on overall research (much of which has been done) than on those activities that have direct bearing on immediate economic development—agriculture, forestry, fisheries, industrial development and housing, in that order. Reference is also made to the considerable numbers of West Indians working and studying overseas, and to their importance in the two-way process of West Indians knowing the world and being known to the world.

The Colonial Office has produced in this report a very readable, well-balanced and most valuable account of these territories and their peoples. A realistic assessment has been made of the prospects of political, economic and social development, and some at least of the probable limitations on such progress are stressed. The main interest in the period under review has lain not in the discovery of new problems but in the progress made in dealing with them, and in the increasing recognition of the importance of joint action as a means of meeting the economic and other problems of the region. "Increased productivity, as a basis for improved or even maintained standards of living, remains the fundamental need," the report concludes, "and this must be the main objective of Governments and peoples alike in the years to come." Up to a point, this survey has covered the area's problems in a comprehensive and understanding manner: yet nowhere is there any real or sustained analysis of the problems posed by the rapid growth of population in nearly all these dependencies. To-day they have some 3,200,000 people; within a generation it seems there may be five or even six million. If this is so, is not increase of population the major problem of these British territories? Are the individual governments and the Colonial Office really alive to the urgency of this aspect of the future of the Caribbean territories? They probably are, but this report will scarcely give the informed reader that impression.

R. W. STEEL

# HUMIDITY OF THE UPPER TROPOSPHERE AND LOWER STRATOSPHERE

THE troposphere is the lower part of the atmosphere, and the stratosphere the upper part. Temperature in the troposphere on the whole falls with height at the rate of about 3° F. per 1,000 ft.; but in the lower part of the stratosphere it changes little with height. The troposphere and stratosphere are separated by the tropopause, a shallow layer within which the vertical temperature gradient changes rapidly. Over southern England the mean height of the tropopause is about 37,000 ft. in summer and 35,000 ft. in winter, but large variations, sometimes exceeding 10,000 ft., occur on either side of the mean. The tropopause is low over depressions and high over anticyclones.

Within the troposphere there is much mixing of air by convection currents, and this convectional stirring produces the large fall of temperature with height. The temperature distribution in the lower stratosphere is believed to be determined by radiative equilibrium in which water vapour, as the most important constituent of the atmosphere absorbing and emitting long-wave radiation, plays a predominant part. Knowledge of the water vapour content of the upper troposphere and lower stratosphere is therefore important for study of the radiative exchange of heat in the atmosphere. It is also important in connexion with both large-scale and small-scale atmospheric circulations because, provided there is no condensation of water vapour, the ratio of mass of water vapour to mass of air (the humidity mixing ratio) remains constant as the air moves. Another application is to the formation of condensation trails which are important in military aviation.

The temperature at tropopause-level is very low, rarely exceeding − 50° F. (− 45·6° C.) and being often below − 80° F. (− 62·2° C.). This makes humidity measurements difficult, because instruments such as hair hygrometers are extremely sluggish at such low temperatures. The problem of measuring humidity at this level was solved in 1942–43 with the invention by Prof. G. M. B. Dobson and Dr. A. W. Brewer of a frost-point hygrometer operating on the same principle as Regnault's dew-point hygrometer. The instrument can be carried in an aircraft; with it the first observations of humidity in the lower stratosphere have been made, and a detailed analysis of the observations taken with the instrument in the course of 130 flights between 1943 and 1950 over southern England has been published in Geophysical Memoirs No. 88 of the Meteorological Office*.

The most striking feature is the extreme dryness of the lower stratosphere. This was quite unexpected. The mean relative humidity with respect to ice at the tropopause is 41·5 per cent, but at a height of about 6,000 ft. above (more precisely at 50 mb. lower pressure) the mean is only 5 per cent. The frost point in the lower stratosphere is rarely outside the range − 80° F. to − 120° F. (− 62·2° C. to − 84·4° C.). The corresponding saturation vapour pressures are $7 \cdot 8 \times 10^{-3}$ mb. and $2 \cdot 6 \times 10^{-4}$ mb.

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* Air Ministry: Meteorological Office. Geophysical Memoirs No. 88: Humidity of the Upper Troposphere and Lower Stratosphere over Southern England. (M.O. 530c.) By J. K. Bannon, R. Frith and H. C. Shellard. Pp. 36. (London: H.M.S.O., 1952.) 2s. 6d. net.

At the tropopause there is generally an increase in the magnitude of the rate of fall (lapse-rate) of frost point with height; but this increase usually holds over a shallow layer only, and higher up the lapse-rate returns to the value it had in the upper troposphere. The increase in lapse-rate of frost point at the tropopause is most marked when there is an increase of air temperature with height there. Such an arrangement is characteristic of the tropopause above depressions and is believed to occur because the tropopause moves downwards over a depression. The subsidence of the air of the lower stratosphere necessarily tends to produce an inversion of temperature and a reduction of frost point. When the tropopause is marked in the vertical temperature curve by a reduced lapse-rate and not an inversion, the lapse-rate of frost point shows no tendency to increase there. This is characteristic of anticyclones and occurs because above them the tropopause is lifted up.

The humidity observations are analysed also for variation with season and air mass and the changes which occur on passing through a frontal surface.

The height attainable by the aircraft used for making the observations was not sufficient to enable them to climb into the stratosphere when the tropopause was above about 41,000 ft., and the results have some bias towards low tropopause. It is to be hoped that measurements of humidity to greater heights in the stratosphere will become possible in the future on a routine basis. The Americans Barrett and Herndon have flown an automatic frost-point hygrometer to 100,000 ft. below a very large plastic balloon; but their apparatus (Compendium of Meteorology, American Meteorological Society, p. 1220; 1951) weighed 46 lb. Routine flights with balloon-carried apparatus must await the development of a lighter instrument.

## SOCIAL SECURITY AND UNEMPLOYMENT IN LANCASHIRE

UNDER the title "Social Security and Unemployment in Lancashire", Political and Economic Planning has issued a useful broadsheet (No. 349; December 1, 1952) analysing the effects of unemployment on the working of the more comprehensive social security measures now in existence. The information was sought particularly from the cotton towns, and, although the survey is too limited to throw light on the adequacy of benefit and assistance payments, it confirmed the conclusion reached in an earlier broadsheet that actual patterns of expenditure by poorer families differ widely from that accepted as the basis of social security payments. Families appear to draw extensively on savings, and, failing these, economize on food and fuel to maintain certain types of expenditure, including even entertainment, as long as possible. The survey has shown that relatively few of the unemployed in Lancashire have applied for national assistance. This is partly due to ignorance or misunderstanding about the regulations, especially those concerning house ownership and the amount of savings which are to be disregarded in assessing need. Something less than half of those who would qualify for assistance seem ready to ask for it.

While on the whole the machinery of the scheme appears to have been put into motion quickly and smoothly, and regulations too have been administered in the spirit of the new Acts, the survey has shown that many people do not qualify for benefit, or qualify only for less than the standard amount. Most of the former are married women, and P E P makes the point that, when married women have to stay at home from time to time for such reasons as looking after their children or an invalid dependant, there is a strong case for relaxing the contribution conditions so as to enable more married women to draw benefit, either by crediting them with insurance contributions or by permitting them to continue contributions as if they were still in employment. Workers with secondary, part-time occupations are also in an anomalous position, and P E P suggests that the Ministry of National Insurance should review the regulations concerning subsidiary earnings in the light of recent experiences in Lancashire.

The evidence collected in Lancashire must obviously be interpreted with great caution for other areas; and P E P directs attention to the difficulty in making precise judgments about the working of the social services in Lancashire, because of the gaps in information which exist and the different methods by which the various official statistics are collected and presented. If for good reasons unemployment and national insurance statistics cannot be made comparable, it suggests that sample inquiries in circumstances such as those in Lancashire during recent months would provide evidence of material value to administrators and others concerned with the social services as well as to research workers.

## BREEDING BEHAVIOUR OF THE SWIFT

THE breeding biology of the swift (*Apus apus*) has been studied by David and Elizabeth Lack (*British Birds*, **44**, No. 6; June 1952). The first observations were made in 1946 on birds nesting in holes in thatched roofs in villages near Oxford; attempts were made later to induce the birds to breed in nest boxes. For many years swifts had nested in the ventilators in the tower in the Museum of Oxford and, in 1948, platforms were erected inside the tower and ventilators were replaced by nest boxes to which glass backs were fitted. The observers could now sit in semi-darkness a few inches from the birds, watching against the light from their entrance holes without causing them any disturbance. The paper describes the behaviour recorded.

Most adult swifts show little fear in their boxes, presumably owing to lack of natural enemies at the nest. There is, however, great individual variation. Some were extremely tame from the start and were not at all disturbed when, in weighing experiments, the eggs or young under them were removed and later replaced. Others at first left the box if a hand were inserted, but became tame through repeated handling. Some fiercely attacked an inserted hand with their claws, and displayed if noises were heard outside the box or objects seen near the glass.

The observations showed that each year about twenty pairs laid eggs, and several non-breeding pairs, possibly in their first year, occupied other boxes. The adults arrived in spring and departed in summer over about three weeks, the two members of each pair usually arriving and departing separately. Each pair normally rested in their boxes throughout the summer.

Adults were seen to visit the boxes at any hour of the day but especially around 7.30 a.m. and 6 p.m., sometimes sheltering in the boxes in rain. In fine weather single individuals or small parties might fly up to and brush against the boxes and were treated as strangers by the pairs. When another swift entered the box it was often treated with incipient threat display. If it were the bird's own mate, the display quickly gave place to mutual preening; if it were a stranger, a fight sometimes followed. Little preliminary display took place before coitus, which occurred in the boxes.

Nest building was observed to start on the day that the pair was formed and continued until the end of incubation, the material being stuck down with saliva. Non-breeders were observed to build throughout the summer. If a clutch of eggs were lost for any reason a repeat clutch sometimes followed. Part or the whole of the clutch was sometimes ejected, the ejected eggs being sometimes fertile. The reason for ejection is still obscure.

Parent birds took an equal share in incubation, the time of each sitting varying from 2 to 345 minutes; the eggs were sometimes left uncovered during the day for periods of up to 6¼ hours. Although considerable investigation was undertaken, the influence of weather on the incubation rhythm was found to be obscure. The parents brood the young by day almost continuously in the first week and for about half the time in the second week, but very little thereafter.

Feeding habits showed that the parent brings a mass of insects stuck together with saliva, this being normally passed in a single food ball to one nestling; with very small nestlings the food ball was divided. The parent swifts readily adopted a strange nestling added to or in place of their own. The parents moved some of the fæces but many others were left in the boxes, the older nestlings sometimes defæcating from the hole.

In a description of the fledging habits, Mr. and Mrs. Lack record that at Oxford most young swifts left the nests between the third week of July and the third week of August, the latest being on September 7. The young left equally in good and bad weather and departed in a steady stream, most of them leaving over a period of three to four weeks.

The young swift left the nest fully able to take care of itself and was assumed to migrate on the day that it left the nest. Nearly all the departures were in the morning, and no fledgling returned to its box. It was also reported that, in 1951 at least, most of the parent swifts stayed for several days after the departure of their young.

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# MAGNETIC MEASUREMENTS IN DEEP-SEA INVESTIGATIONS

## Construction of Non-magnetic Containers

FOR its biological investigations the ship *Galathea* of the Danish Deep-Sea Expedition round the world during 1950–52 was equipped with a longer wire and a more powerful winch than previous deep-sea expeditions. Due to this and the fact that the construction of magnetometers of high precision has been specially developed in Denmark through the work of the late D. la Cour, it was thought natural to take up on the *Galathea* expedition also the problem of measuring the variation in the oceans with depth below sea-level of the magnetic field of the earth. The problem of the origin of terrestrial magnetism being still an open question, such measurements may elucidate this problem, which has become of special interest through the recent investigations of Blackett, Bullard and Elsasser. In this and the following note is described the work with this object.

To contain the magnetometers and protect them against the pressure of the water, which at the greatest measured ocean depths was about 1,000 atm., special water-tight containers had to be constructed of a non-magnetic and sufficiently strong material. None of the existing alloys known to us fulfilled both requirements except the aluminium alloy 'Hiduminium *RR*77'. Unfortunately, this alloy cannot be cast but only forged, a procedure which could not be used due to the limited economic resources and time at our disposal. However, Messrs. Paul Bergsøe and Son produced a new alloy satisfying all our requirements. This alloy is a completely iron-free β-manganese bronze with a high content of aluminium. Its characteristics are: magnetic permeability, less than 1·01; elastic limit, 28 kgm. per mm.$^2$; 0·01 per cent limit, 29 kgm. per mm.$^2$; 0·2 per cent limit, 38 kgm. per mm.$^2$; tensile strength, 70–80 kgm. per mm.$^2$ at an elongation of 10–20 per cent; Young's modulus, $E$ = 6,100 kgm. per mm.$^2$; density, 8·1. (A detailed account of this alloy is to be published shortly in Great Britain.) Messrs. Burmeister and Wain constructed two containers of this material, which for mechanical reasons were made in the form of spheres. The first container, shown in Fig. 1, is a single sphere, internal diameter 50 cm., wall thickness 10 cm., weight 1,100 kgm. The second container, shown in Fig. 2, consists of two single spheres like the former, connected by a tube 100 cm. long. Its total height is 270 cm. and total weight 1,700 kgm.

From experience with diesel engines, the containers were made water-tight without any packings, simply by direct contact between the polished surfaces of the single half-spheres, which were made as plane as technically possible.

The double sphere has been lowered four times to a maximum water depth of 6,900 m. It was found to be completely water-tight on all four occasions. The single sphere has been lowered twenty-nine times to various depths down to a maximum of 10,000 m. in the Philippine Trench. At the beginning some water leaked into the single sphere. This was found to be due partly to casting stresses, which gradually disappeared, and partly to the surfaces of its two halves being not perfectly plane, thus needing extra grinding and checking by means of a normal plane. In this way we reduced the leakage to the insignificant amount of 40 cm.$^3$ at a depth of 5,000 m. Lack of time did not allow us to make further experiments to remove this residual water.

Finally, the elastic properties of the containers were tested. For this purpose the horizontal internal diameter of 500 mm. was measured before and after the descent of the single sphere to 10,000 m. in the Philippine Trench. A reduction of diameter of at most 0·04 mm. was found. The corresponding figure for the double sphere at a depth of 6,900 m. was 0·01 mm. Also the elastic reduction of the spheres while lowered was measured. At a depth of 6,900 m. we found that for the double sphere the vertical internal diameter of 500 mm. had been reduced by

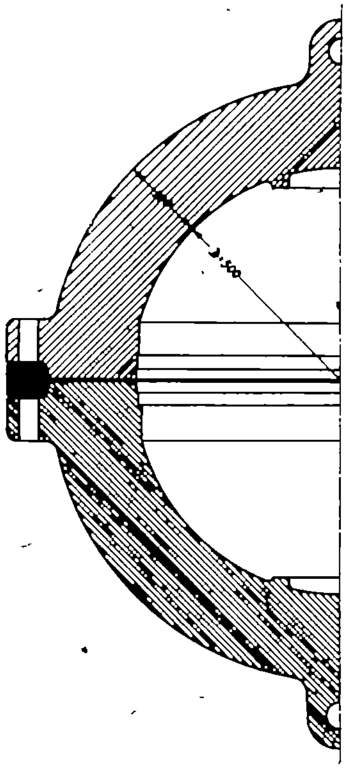

Fig. 1

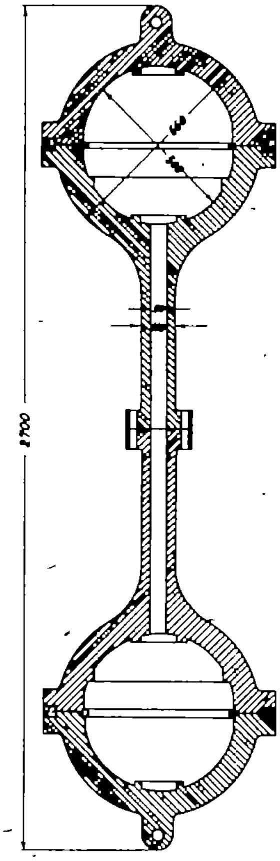

Fig. 2

at most 1·2 mm., that is, by an amount not exceeding 0·24 per cent.

Thus our results show that it is possible to construct containers allowing ordinary magnetic and other physical instruments to be lowered to even the greatest ocean depths. Apart from magnetic work, these spheres may also be used for gravimetric, seismic, cosmic ray and other work. We shall be very pleased to put our spheres at the disposal of others for such investigations.

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## Magnetic Investigations on the *Galathea* Expedition

Three self-recording, relative magnetometers have been constructed: (*a*) and (*b*) measuring the horizontal component $H$, and (*c*) measuring the vertical component $Z$. The principle of (*a*) and (*c*) is that the deflexion of a magnetic needle of the la Cour monad type from a vertical and a horizontal position, respectively, is measured optically on a moving photographic film. The principle of (*b*) is that the earth's field induces an alternating current in a coil rotating about a vertical axis. This current is recorded on a magnetic recorder after having been amplified by an electronic amplifier, the amplification of which is inversely proportional to the frequency with which the coil rotates. Instruments (*a*) and (*c*) are housed successively in the single sphere, (*b*) in a double sphere, described in the preceding communication. The lower sphere of the double sphere contains the coil driven by an axle through the tube, with a motor in the upper sphere, which contains also the batteries for the motor, the amplifier and its batteries, and the recorder. To obtain sufficiently high measuring accuracy in all three instruments, most of the field to be measured is compensated by suitable magnets, so that only a small fraction is actually measured. Furthermore, in (*a*) and (*b*) these compensating magnets have the form of compass needles to give the direction of the magnetic meridian.

Within a total time of about 270 hr. which could be spent on magnetic work at sea during the expedition, our instruments were lowered twenty times to various depths of water down to 5,000 m. The first part of our programme was to make trial experiments with the instruments and adjust them to the working conditions at sea, to work out the method of observation such as manœuvring the ship, checking the tables of Vestine *et al.*[1] which form the basis for the adjustment of the instruments, investigating the perturbing effect of the ocean bottom, and so on. The second part of the programme was to use the results of the first part to take measurements at a depth of water of 5,000–6,000 m. in the central part of the Pacific Ocean, which offers great areas with flat bottom. However, due to lack of funds to meet the rising prices, the working time of the expedition had to be cut down. Thus lack of time prevented us from carrying out the second part of our programme.

The main problem in reaching the desired measuring accuracy, namely, about 10 γ, was found to be the fact that due to the weight of the spheres the wire unwound itself, thus rotating the spheres about the vertical with speeds too fast for the instruments. (To investigate both the rotation and oscillations of the spheres a special instrument was constructed recording the motion of the spheres.) This problem was solved by means of a special ball-bearing swivel inserted between the sphere and the wire, a 3-m. long aluminium rudder on the sphere, and finally by manœuvring the ship in such a way that at each depth at which magnetic measurements were taken the sphere moved horizontally at about 1 knot, which speed was found to be sufficient for the rudder to keep the spheres in a definite azimuth.

The following results were obtained. A method has been worked out whereby in any event an average value for $H$ with an accuracy of about 5 γ can be measured within an hour down to at least 3,000–4,000 m. Furthermore, at a given depth at which magnetic measurements were taken the observed variation of the field with the position of the sphere showed that a rugged ocean bottom gave considerable perturbations as long as the instruments were not at least 2,000–3,000 m. above the bottom. Finally, we found that at most stations the tables of Vestine *et al.*[1] agreed surprisingly well with the field we observed. However, at a few of our stations in the Pacific we observed anomalies where the field deviated by about 500 γ in $H$ and about 1,000 γ in $Z$ from the values given in the tables.

Although on the stations given by the plan of the expedition it was not possible to eliminate with certainty the perturbing effect of the bottom, all our measurements indicate that both $H$ and $Z$ increase numerically with increasing depths below sea-level. These findings are in agreement with what has recently been found in mines by Runcorn *et al.*[2]. Lack of time prevented us from obtaining on this expedition a physically reliable measurement of the vertical gradient of the field independent of the perturbing effects of the bottom, but we hope to be able to utilize our experiences and results on future deep-sea expeditions, and we ask anybody planning such expeditions to get into touch with us to consider the possible continuation of this work.

A detailed account of the present work will be published in the *Journal of Geophysical Research*.

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# A NEW METHOD FOR THE PAPER CHROMATOGRAPHY OF OLIGOSACCHARIDES

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ALTHOUGH the application of paper chromatography to the separation and identification of bioses and higher saccharides was reported in 1948 by Partridge[1], and has since been used with advantage in numerous studies, the effectiveness of the method is still limited considerably by the low $R_F$ values of these substances. In theory, the absolute distances separating components can be suitably increased by prolonging the irrigation time to several days; but, unless excessive care is taken, such a procedure often results in irregularities of the solvent front, and in any event is frequently too lengthy to be of use. Alternatively, the rate of movement of the oligosaccharides down the paper can be increased, as described by Hough, Jones and Wadman[2], and by Jeanes, Wise and Dimler[3]. The former workers ran the chromatograms at 37°, a procedure which is not altogether suitable for general use. Jeanes *et al.* increased the water content of the solvent and also introduced the multi-development technique; for example, with a solvent containing equal parts of fusel oil, pyridine and water, two to four developments, each of 22 hr., gave discrete spots of amylosaccharides ranging from maltose to the decaose. We now report a new method, based on a different principle, by which considerable increases in $R_F$ values (about eight-fold for disaccharides) may be effected; it involves the conversion of the oligosaccharides, on the chromatogram, into the corresponding N-benzyl glycosylamines, thus reducing their preference for the cellulose–water phase. Conditions suitable for the resolution of dextrins containing up to about ten sugar units have been determined; but there is no reason why, when the necessity arises, this range should not be extended by further modifications of the type described by Jones[2], Jeanes[3] and their co-workers.

After studies of the various factors involved, the following method was selected as being most suitable for general purposes: a spot of the sugar solution (2 μl.) is allowed to dry on the paper (Whatman No. 1), a spot (3 μl.) of a 10 per cent solution (w/v) of benzylamine in methanol is superimposed, and the paper is heated at 85° for 5 min., before being irrigated in the usual way with the upper phase of an *n*-butanol–ethanol–water–ammonia (40 : 10 : 49 : 1) mixture. After being dried, the paper is sprayed with a 0·25 per cent solution of ninhydrin in ethanol. The spots begin to appear within an hour, are fully developed after about 12 hr., and begin to fade after three days. The excess of benzylamine forms a band at the solvent front.

It is important that the sugar and benzylamine spots should be applied in the order given above; for best results only one spot of the sugar solution should be applied, otherwise succeeding spots tend to concentrate the sugar in a ring and the benzylamine is then less effective. Moderate amounts of impurities, such as mineral matter, organic acids, etc., do not interfere with the condensation. In view of the excessive amounts of benzylamine used, the initial spots of different test mixtures should not be closer than 3 cm. Although the N-benzyl glycosylamines stain with aniline hydrogen phthalate almost as well as the corresponding free sugars, the ninhydrin spray is more sensitive, and, moreover, does not detect the free sugar (c. 20 per cent) which remains after the reaction with benzylamine. About 5 μgm. of maltose or panose can be detected comfortably in an 18-hr. run; there does not appear to be any tendency for a major constituent in a sugar mixture to mask a minor one, provided that their $R_F$ values differ sufficiently to permit the formation of discrete spots. It is desirable that the initial sugar solution should be free from impurities which, after development with an ammoniacal solvent, will stain with ninhydrin (for example, amino-acids, high concentrations of carboxylic acids); but if such impurities cannot be avoided, then their behaviour on a chromatogram must be known. A distinction between amino-acids and fairly strong spots of N-benzyl glycosylamines can be obtained by heating the sprayed paper for 2–3 min. at 85° after drying; under these conditions the glycosylamine derivatives, in contrast to the amino-acids, stain brown before turning to purple. Such heating causes no marked reduction in the time taken for N-benzyl glycosylamine spots to reach their maximum intensity. As evidence that the sugars do, in fact, move as N-benzyl glycosylamines, the spot obtained in the case of glucose has been shown to correspond to that of authentic N-benzyl glucosylamine[4] run in the same solvent ($R_F$ c. 0·7).

Typical mixtures which can be resolved by the general method in 18 hr. are: (*a*) maltose and *iso*maltose; (*b*) *iso*maltotriose and panose; (*c*) maltopentaose and maltohexaose (see also Fig. 1). The method is satisfactory for galactose, mannose, rhamnose and xylose (and presumably for oligosaccharides derived therefrom), but not for fructose. The N-benzyl glycosylamines of arabinose and ribose appear to be rather unstable under the conditions of the general method, but suitable modifications doubtless could be devised to meet these cases, if required.

For mixtures of disaccharides which give benzylamine derivatives with almost identical $R_F$ values, it is usually better to employ an irrigating solvent containing less water than in the general method; for example, a distinction between *iso*maltose and gentiobiose can be observed readily in 28 hr. using the organic phase of a butanol–ethanol–water–ammonia (45 : 5 : 49 : 1) mixture (see Fig. 2).

With mixtures containing the higher oligosaccharides, improved results are obtained if the general method is modified in two ways: (*a*) by using a solvent of higher water content, namely, a mixture of butanol, ethanol, water and ammonia (40 : 12 : 20 : 1), and (*b*) by using a more efficient method of equilibration (see below). Under these conditions, the benzylamine derivatives of the higher homologues of maltose and laminaribiose have, respectively, the following approximate $R_F$ values: tetraose, 0·36, 0·45; hexaose, 0·19, 0·32; octaose, 0·07, 0·21. Since laminarioctaose moves 8 cm. from the starting line in a 19-hr. run, it is clear that the method is capable of dealing with even higher saccharides, particularly if the running time is extended, or the water content of the solvent is increased still further. Within the range of saccharides examined, there seems to be little or no decrease in staining power, per reducing group, with increasing chain-length.

Thorough equilibration of the tank before the commencement of the run has a markedly beneficial effect on the $R_F$ values of the slower-moving oligosaccharides. The usual method of equilibration, involving the use of trays of the solvent mixture in the bottom of the tank, takes at least 24 hr. and, during this time, glycosylamines are sometimes produced by interaction between ammonia vapour from the solvent and the N-benzyl glycosylamine spots. Since ammonia is essential in order to prevent hydrolysis of the N-benzyl glycosylamines, the following rapid method of equilibration was used. A blank sheet of filter paper was dipped into the irrigating solvent and suspended from a second trough in the tank. The solvent was introduced immediately into this trough, and the tank was sealed for 45 min., before the solvent was introduced through an orifice into the trough supporting the actual chromatogram. The degree of equilibration thus attained was better than that effected in 24 hr. in the usual way. Although this simple technique was designed primarily for use with the higher oligosaccharides, we find it beneficial also in the general method.

Fig. 1. Chromatogram run for 18 hr. according to the general method. Besides glucose, spots are apparent corresponding to the oligosaccharides containing up to six glucose units in the 1 : 4-α series, and up to five in the 1 : 6-α and 1 : 3-β series

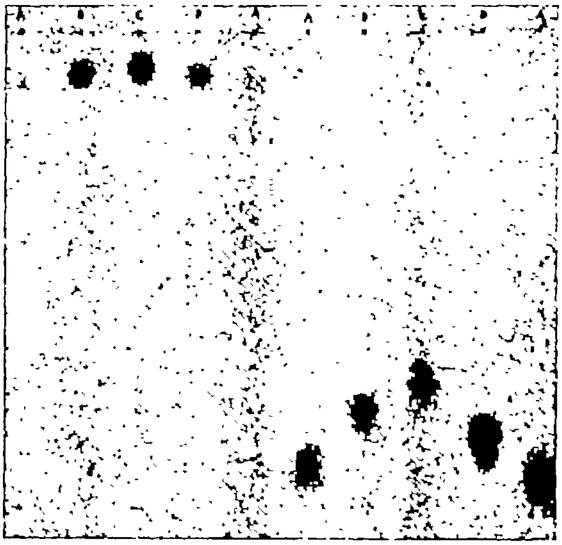
Fig. 2. *A*, maltose; *B*, *iso*maltose; *C*, gentiobiose; *D*, lactose. *Right:* Sugars treated with benzylamine and chromatogram sprayed with ninhydrin. *Left:* Identical sugar solutions run in the same solvent in the normal way and chromatogram sprayed with aniline hydrogen phthalate

Following earlier theoretical considerations[5], Bate-Smith and Westall[6] deduced that $\Delta \log \left(\frac{1}{R_F} - 1\right)$ should be constant within a homologous series; they obtained good experimental confirmation with various phenolic compounds. Jeanes *et al.*[7] demonstrated later that the relationship, and also its approximation for low values of $R_F$, namely, $\Delta \log 1/R_F$, were true for a series of amylosaccharides. The benzylamine method enables these relationships to be tested over a wide range of $R_F$ values. Preliminary studies with partially hydrolysed amylose and laminarin have shown good agreement, glucose excepted, with the relationship of Bate-Smith and Westall[6]; but, rather unexpectedly, with partially hydrolysed dextran, Jeanes's approximation holds better. A fuller examination of these and other homologous series of oligosaccharides, covering all types of glucosidic linkages, would enable a possible structure(s) for any oligosaccharide containing mixed glucosidic linkages to be assigned more accurately than in the past from the position of its spot relative to suitable markers. One advantage which would be gained thereby is that, if a trisaccharide of this type were detected in the hydrolysis products of a polysaccharide, then the two different linkages of the triose would be proved to be adjacent in the polysaccharide itself.

In partial hydrolysates of the dextran synthesized by *Betacoccus arabinosaceous* (Birmingham strain) we have observed, *inter alia*, spots corresponding to a 1 : 3-biose and (more faintly) to a triose ; the position of the latter spot indicated that the triose contained a 1 : 6- and a 1 : 3-link. These observations suggested that the linkages at the branch points of this particular dextran molecule were of the 1 : 3-type, and not of the 1 : 4-type, as has been believed hitherto[7]. A full chemical analysis has confirmed that this is so[8].

Again, a partial hydrolysate of the polyglucosan of *Aspergillus niger* (strain 152), which was known already to contain 1 : 4- and 1 : 3-links in almost equal amounts[9], showed only one triose spot, the position of which indicated that it contained one of each of these linkages. Thus, it was highly probable that, in the polyglucosan, the 1 : 4- and 1 : 3-glucosidic bonds were arranged alternately; confirmatory evidence of this has now been obtained by other methods[10].

The above observations are reported in the belief that they represent a real advance in the chromatography of oligosaccharides ; and, to the extent that paper chromatography is a useful preliminary to the isolation of crystalline reference compounds, that they will aid the determination of polysaccharide structures.

We are indebted to Prof. M. Stacey for his interest and advice, and to Dr. E. T. Dewar who kindly supplied the laminarin employed. [Sept. 29.

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# PATTERN DISCRIMINATION AND THE VISUAL CORTEX

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DURING recent years attempts have been made to explain the organization of the cerebral cortex in terms of electronic computing machines. Comparisons have been made with two-way switches, regenerative storage systems and cathode ray tube scanning-systems ; yet none of these analogies has met with general acceptance, nor have they led to testable hypotheses.

We have made an attempt to examine some of the problems associated with pattern discrimination and the organization of the visual cortex by means of two approaches, each of which is fundamentally statistical. On one hand, some of the elements of the visual cortex have been described in a statistical manner (D. A. S.) while, on the other hand, the organization of a machine operating on a probability basis has been explored (A. M. U.). It is suggested that a valuable analogy exists between the two methods of study. Some relations between them are beginning to emerge, and already there has been a surprising measure of agreement between hypotheses suggested by the theory of the machine and the experimental observations of cortical structure.

There is reason to believe that many of the complexities of the cerebral cortex are due to an organization that is fundamentally of a statistical nature and the parameters of which can only be described in terms of probabilities. One of the obstacles to the formulation of adequate hypotheses for many branches of biology has been the language and mathematics which have been used in attempts to frame these hypotheses ; consequently, some of the concepts that we introduce will be strange to biologists. Nevertheless, we feel that the effort to master this approach will be amply repaid.

First of all, the finer branches of the axons running from the thalamus to the primary sensory areas of the cerebral cortex end in an apparently random manner among the surrounding cells and their dendrites. Quantitative study of the lengths of the dendritic processes and their branches shows that there is no simple law relating these lengths to the position of the cell or the size of the perikaryon.

With this background, one of us (A. M. U.), working in the field of computer design, has proposed definitions of the word 'pattern' in terms of set theory, and of 'measure of pattern difference'. These definitions have led to the design of an efficient machine with random connexions between its units and the inputs, and with the ability to measure differences between a representation and a constantly changing statistical description of past representations.

By a 'representation' is meant a set of physical quantities internal to a machine, which are determined by an external physical configuration and may be called attributes of it ; each attribute will have a measure, which may be continuous or discrete. By a 'pattern' is meant a subset of such measures. A machine for comparing a present representation with a past ensemble of representations, member by member, requires a storage capacity that must grow with the ensemble, and each comparison leads only to a binary statement of identity or difference. If, on the other hand, a statistical method of describing the ensemble of representations is used, whereby the ensemble is specified by the relative frequencies with which the different sets of attributes have occurred in the past (or the probabilities that the members of the 'given' ensemble possess certain sets of attributes), and if the comparison is made only with this system, then a constant storage capacity is all that is required. For example, if there are $n$ input quantities (attributes) and each has $s$ possible discrete measures, the number of different possible representations can be shown to be $(1 + s)^n$ ; this is the fixed number of descriptive probabilities that must be stored, regardless of the number and type of past representations.

The simplest possible machine of this nature must employ the simplest possible measure for which $s$ is unity. In this case, either a proposition of the form 'the configuration $A$ possesses the property $j$' is made, or no proposition is made at all. This measure will be called unitary, in contrast with binary measure in which an additional proposition of the form 'the configuration $A$ does not possess the property $j$' is made. The input, therefore, must possess two states; if it is active, a proposition is made, and if it is inactive, no proposition is made.

An example of the kind of mechanism that could provide an input of this unitary nature would be a threshold-operated detector which could be in one of only two states. The detector would be in an active state if, say, a chemical concentration or a packet of radiant energy exceeded a certain value; otherwise the detector would be inactive. There must be no varying degree of activity in any one input channel to the machine. In consequence, for detectors of a different nature, it would be necessary to interpose a coding system between them and a machine of the type which has been described.

Using this unitary measure, a complete non-redundant statistical description of an ensemble of representations consists of the joint probabilities of occurrence of all possible sets of attributes. It is therefore necessary to have units capable of counting and storing these probabilities; and the units must be connected to the inputs in all possible ways. This can be achieved precisely by random connexions between the input points and the units of the machine; it can be shown that if the chance of any unit being connected to any particular input is ½, each unit will be replicated about the same number of times. Other laws describing the probabilities of connexions will lead to other population distributions.

In order to define a measure of pattern difference between a present representation and a past ensemble in respect of a set of attributes, the following axiom is laid down: if the set can be separated into two subsets with *a priori* independence, the pattern difference in respect of the total set is the sum of the pattern differences in respect of the two subsets. From this it can be shown that the only possible measure of pattern difference is the negative logarithm of the *a priori* probability of the set; if the set does not occur in the present representation, there is no measure of pattern difference. Probabilities must therefore be computed in the units on a negative logarithmic scale.

For a past ensemble occurring as a sequence in time, each unit must have two properties: it must possess some quantity which grows approximately logarithmically with time, and the act of counting must consist in the destruction of some of this quantity. Different mathematical laws of growth and destruction lead precisely to different weighting functions of past events. The act of counting must occur only if all the connected inputs are in the active state caused by occurrence of the corresponding attributes.

The machine can be extended to measure a difference in respect of a pattern, even if some of its attributes have not occurred; it can be shown that the measure must be the negative logarithm of the conditional probability of the set of attributes.

Conditional probabilities can be computed in the following manner. Consider attributes $j$, $k$ and $l$; there will be units storing $-\log p(jkl)$ and $-\log p(jk)$, the negative logarithms of the probabilities, in the past, of the sets $(jkl)$ and $(jk)$. If $(jk)$ occurs, then the conditional probability of the set $(jkl)$ is $p(jkl)/p(jk)$; so that on a negative logarithmic scale the $(jkl)$ unit should contain $-\log p(jkl) - (-\log p(jk))$. This can be achieved if the momentary decrease in the $(jk)$ unit, from $-\log p(jk)$ to zero, is communicated to the $(jkl)$ unit. This effect has been called supercontrol; it leads to precise laws defining the connective function between units; these laws are different from those required between inputs and units for counting purposes. An electromechanical model of the basic unit has been built embodying the principles described and which possesses all the necessary properties of counting, storing and interconnexion.

Returning to the problem of random connexions, the simple statement that the probability of connexion is ½ cannot lead to a knowledge of the position of units in relation to a set of inputs; this will be determined by the manner in which the probability of connexion depends on the position of the input relative to the unit. It can be said that there is a connective probability field surrounding a unit; from the form of this field it is possible to calculate the distribution of units which are directly connected to inputs for the purpose of computing unconditional probabilities. Supercontrol employing interconnexions between units leads to the concept of an indirect connective probability field. For the two forms of control to be effective, the direct and indirect fields must be of approximately the same form; it can be shown that this is met if they fall off exponentially with distance from the unit.

It is possible to define the probability of connexion between an incoming axon and cortical dendrites according to our limited knowledge of the physiology of the connective process and the morphology of the cell. It has been shown experimentally (D. A. S.) that this direct connective probability field does, in fact, fall off exponentially with distance from the perikaryon. This is equally true of the basal dendrites of the pyramidal cells.

To calculate the actual numbers of connected units a second factor is required, the packing density of the perikarya; this has also been determined. It has therefore been possible to predict the population distribution of cells connected to different numbers of afferent fibres.

Finally, we wish to stress the fundamental importance of the decisions: (*a*) to base the theory on the statistical description of an ensemble; (*b*) to adopt a continuous measure of pattern difference; and (*c*) to employ a unitary measure of attributes. The binary measure of pattern difference leads to binary machines employing the gating principle; such a pattern machine can handle two-valued logic, but it can compare only single items, not ensembles. The result of the comparison is of the form '$A$ differs from $B$' or '$A$ does not differ from $B$'. The continuous measure leads to statistical machines employing the analogue principle; such pattern machines can compare two ensembles, or a single item with an ensemble. The result of the comparison is continuous and has the form 'Item $A$ differs from ensemble $C$ by more than does item $B$'.

A full account of the mathematical concepts involved and a detailed description of the application of the theory to specific problems will appear elsewhere.

We wish to thank Prof. J. Z. Young for his encouragement and valuable criticism of this work. Acknowledgment is made by one of us (A. M. U.) to the Chief Scientist of the Ministry of Supply for permission to publish this paper. [Nov. 20.

# LETTERS TO THE EDITORS

*The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications*

## Investigation of the Cœlacanth

It was my privilege to carry out detailed investigations on the first Cœlacanth, and to have discovered what appears to be the area where those fishes still live.

The recent Comoran Cœlacanth, while mutilated more than was at first realized, nevertheless retains most of the soft parts, including the abdominal viscera. This extends enormously the scope of the investigational work that may be carried out on the specimen. There will be still more that can be done only on parts, exudates, and secretions from an untreated fresh specimen, which it is hoped to seek before very long.

It is in keeping with the importance and scope of the investigations on all parts of this fish that they should be assigned to leading experts in the field in which they fall. I have advised the South African Council for Scientific and Industrial Research, and have requested the Council's approval of and co-operation in this matter.

Application to be included in this scheme should be sent either to the South African Council for Scientific and Industrial Research, P.O. Box 395, Pretoria, or to me personally at Rhodes University, Grahamstown. While every possible facility will be granted to selected visiting specialists, it should be noted that there is no possibility of financial aid from this end.

The ownership of the next specimen or specimens is of less importance than their proper preservation for scientific purposes. As certain organs and body fluids require special treatment and preservation, it is intended to compile a set of special instructions to be issued to those in areas where it is possible that a fresh Cœlacanth may be obtained. It will be appreciated if those interested will kindly furnish detailed special instructions composed in language as simple as possible, giving full directions and not only the names, but also the actual composition of any materials to be employed.

Since there is a hope that more Cœlacanths may be found at the Comoro Islands, it is desirable that all such materials should be available there.

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Feb. 8.

## Plastic Properties of Coking Coals

The processes which take place when a coking coal is turned into coke by heating in the absence of air are very complex and only partly understood, though they have been studied for many years[1,2]. We have made a renewed approach to the problem, and have evolved for guidance an elementary theory applicable in the temperature-range within which coking coals show plastic properties. Supporting experimental evidence is described below.

It is widely accepted[1] that a coking coal at temperatures of the order of 300° C. and higher shows plastic properties, the word 'plastic' being used here in a general sense; and there is evidence that it behaves as a liquid having a normal viscosity–temperature relationship[3]. At temperatures approaching 400° C., this liquid is subject to thermal decomposition and changes into a gas and an infusible solid. We assume this change to take place according to the laws governing first-order chemical reactions, so that if at time $T = 0$ there exists a mass $m_0$ of coal in the liquid state, at a later time $T = \tau$ there will remain a mass:

$$m_\tau = m_0 \exp - k\tau,$$

where $k$ is the velocity constant of the decomposition reaction at the temperature of the decomposition; and at any later time $T = \tau + t$, there will be:

$$m_{\tau+t} = m_0 \exp - k(\tau+t) = m_\tau \exp - kt. \qquad (1)$$

The time $T = 0$ can never be experimentally realized, as some decomposition must take place in the period of heating to the required temperature, which for reasons of fundamental and experimental limitation cannot be made infinitely short. The time $T = \tau$ is taken to be the time when the predetermined temperature has been reached.

As the solid product of decomposition accumulates, the viscosity of the liquid/solid mixture will rise. We assume a relationship of the form:

$$\bar{\eta} = \eta(1 + \lambda c),$$

where $\lambda$ is a constant later shown to be equal to, or not far from, unity, $\eta$ is the viscosity of the mixture before the concentration of solid matter is increased by $c$, after which it becomes $\bar{\eta}$. (A fixed value of $\lambda$ cannot be assumed, *a priori*, to apply over a long period of time, but it can be shown that it approaches constancy over periods which are not infinitesimal. Idealized extreme cases of solid suspensions and analogous systems have been studied by G. I. Taylor[4] and A. Einstein[5].) It follows that

$$\eta_{\tau+t} = \eta_\tau \left(1 + \lambda \frac{m_\tau - m_{\tau+t}}{m_{\tau+t}}\right); \qquad (2)$$

and substituting from equation (1), we have:

$$\eta_{\tau+t} = \eta_\tau (1 + \lambda \exp kt - \lambda),$$

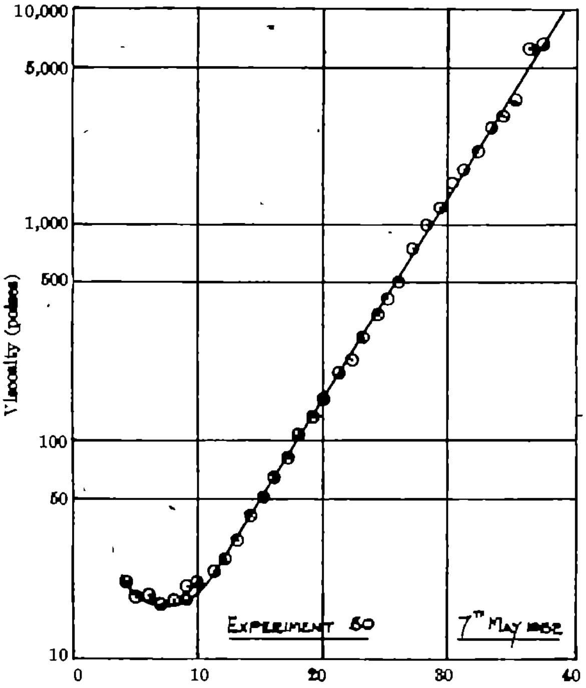
so that:

$$\frac{d}{dt}(\log \eta_{\tau+t}) = \frac{\lambda k \exp kt}{1 + \lambda \exp kt - \lambda} = \frac{\lambda k}{(1-\lambda)\exp(-kt) + \lambda}. \qquad (3)$$

This equation makes the following statements concerning the slope of the graph of $\log \eta$ against $t$: (i) for $t \to 0$, the slope tends to $\lambda k$; (ii) for $t \to \infty$, the slope tends to $k$. Thus, as $t$ increases, the slope changes from $\lambda k$ to $k$.

The predictions of the theory were checked by measuring the viscosity of four different coals at various temperatures using an apparatus developed by Gieseler[6] and other workers[7]. A stirrer is embedded in compressed powdered coal in a crucible. A torque is applied to the stirrer which makes it rotate when the coal softens on heating. The viscosity of the coal is inversely proportional to the rate of revolution of the stirrer. In the past, the apparatus has been used for observing the viscosity changes with rising temperature, but there is no difficulty in adapting it to work at constant temperature.

The graph shows the result of a typical experiment. A linear relationship between $\log \eta$ and $t$ is clearly shown. The precision of the experiment is such that a slight curvature would not be detected. Exact linearity would imply $\lambda = 1$ (see equation 3), so that the slopes give the reaction velocity directly. The graphs obtained permit the statement that $\lambda$ is a



Results of a typical experiment on 'Manvers coal' at 414 ± ½° C.; the slope is 0·094 min.$^{-1}$

constant in the range $0{\cdot}8 < \lambda < 1{\cdot}2$. The value of $\lambda$ does not affect the calculation below.

Experiments have been carried out at a number of temperatures, for each coal, so that the values of $\lambda k$ can be used to find the activation energy of the carbonization process, using Arrhenius's equation:

$$\log k = \frac{-E}{RT} + \text{constant},$$

where $E$ is the activation energy, $R$ the gas constant, and $T$ the absolute temperature. Graphs of log $k$ against $1/T$ gave straight lines for each of the coals examined.

The table gives details of the four coals used, together with the activation energies found. It is interesting to note that although these coals differ widely in their coking properties, assessed by conventional criteria, all the activation energies are near 50 kcal./mole, which has been quoted as the energy required to break the carbon–carbon bond in the thermal decomposition of mineral oils[9].

DETAILS OF COALS USED

| Coal | | Volatile matter† (dry ash-free) % | Agglutinating value‡ | Temperature-range over which $E$ is determined (° C.) | Activation energy (kcal./mole) |
|---|---|---|---|---|---|
| Name | Type* | | | | |
| "Maritime" | 301 | 24·6 | 26 : 1 | 419–448 | 52·7±2·8 |
| "Manvers" | 502 | 37·6 | 23 : 1 | 406–427 | 48·2±2·4 |
| "Blackwell" (blend)§ | 602/401 | 38·0 | 20 : 1 | 402–422 | 54·2±2·2 |
| "Grassmoor" | 702 | 40·0 | 17 : 1 | 405–426 | 47·3±1·2 |

* Coal Survey Classification, according to: Survey Paper No. 58, "Rapid Survey of Coal Reserves" (Fuel Research Division, D.S.I.R., H.M.S.O., 1946).

† According to B.S.1016.

‡ According to B.S.705.

§ Of which 25 per cent has 31·8 per cent dry ash-free volatile matter content and 75 per cent has 41·0 per cent dry ash-free volatile matter content.

The values we have obtained agree well with those of van Krevelen and co-workers[10], who used a very different method on a series of broadly similar coals.

This work is being continued at this Establishment, along the lines indicated, and is published by permission of the Director-General, Scientific Department, National Coal Board. A fuller treatment will be published elsewhere.

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Sept. 15.

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## Selenium Hexafluoride: Dielectric Strength and some Chemical Properties

THE physical and chemical properties of selenium hexafluoride have received little investigation[1,2]. We have prepared selenium hexafluoride by reaction of the elements at 300° C. in a copper tube, and found that, provided steps are taken to return selenium tetrafluoride (boiling point, 106° C.) to the reaction zone, a yield of more than 90 per cent selenium hexafluoride is readily obtained. The gas was condensed in a trap cooled to − 160° C. and afterwards sublimed into an aspirator. The greater part of the small amount of selenium tetrafluoride collected remained in the trap after the selenium hexafluoride had sublimed. The product was scrubbed with 10 per cent sodium hydroxide solution, condensed in liquid air, and transferred to an evacuated steel cylinder cooled in 'Drikold'.

The vapour density of a sample of the purified gas, dried by sublimation *in vacuo* from a trap cooled to − 80° C., was determined by direct weighing and the molecular weight found to be 192·6 ± 1 (theoretical value, 192·96).

Hokhberg and Sandberg[3] have reported the dielectric strength of selenium hexafluoride to be nearly twice that of sulphur hexafluoride, giving the ratio 4·63 : 2·49 : 1 for the relative dielectric strengths of selenium hexafluoride, sulphur hexafluoride and air. Their measurements were carried out using two Rogovsky electrodes of 32 mm. diameter spaced at 2–8 mm. The maximum value of pressure × gap was 220 mm. mercury × cm., and the results were extrapolated to a value of 1 cm. at 1 atmosphere pressure. They make no mention of the method of preparation or of the purity of the gases tested.

The breakdown potential between two half-inch diameter brass spheres has been measured in selenium hexafluoride prepared as above, in sulphur hexafluoride containing not more than 41 p.p.m. of

RELATIVE BREAKDOWN VOLTAGES IN SELENIUM HEXAFLUORIDE, SULPHUR HEXAFLUORIDE AND AIR

| Pressure × gap mm. Hg. × cm. | Relative breakdown voltage | | |
|---|---|---|---|
| | $SeF_6$ | $SF_6$ | Air |
| 50 | 1·80 | 1·75 | 1 |
| 100 | 2·10 | 2·00 | 1 |
| 150 | 2·40 | 2·20 | 1 |
| 200 | 2·50 | 2·30 | 1 |
| 250 | 2·65 | 2·40 | 1 |
| 300 | 2·70 | 2·40 | 1 |
| 350 | 2·75 | 2·40 | 1 |

disulphur decafluoride and 12 p.p.m. of sulphur tetrafluoride, and in dry air. The relative breakdown voltages obtained using gaps of 0·05–8·6 mm. and pressures of ½, 1, 1½ and 2 atmospheres are shown in the accompanying table. Extrapolation of the results to a gap of 1 cm. at 1 atmosphere pressure indicates that the relative dielectric strengths of selenium hexafluoride to air and of sulphur hexafluoride to air are not greater than 2·9 : 1 and 2·4 : 1 respectively.

We have found selenium hexafluoride to be slightly soluble in alcohol and acetone, insoluble in 5 per cent aqueous sodium hydroxide solution, but soluble in 10 per cent alcoholic sodium hydroxide solution. It reacts slowly with mercury, forming mercurous fluoride, and reacts readily with a solution of sodium iodide in acetone:

$$SeF_6 + 6NaI \rightarrow Se + 6NaF + 3I_2.$$

No change in volume occurs after heating selenium hexafluoride to 500° C. for 10 min. in 'Pyrex' glass. At 700° C., reaction with the glass occurs.

We wish to acknowledge our indebtedness to Mr. G. H. F. Seiflow and Mr. J. Adams, who carried out the electrical measurements.

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Sept. 17.

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## Thermal Degradation of Polystyrene

THE degradation of polymers may be elucidated by various approaches; one of the more accessible routes is a study of the volatile degradation products.

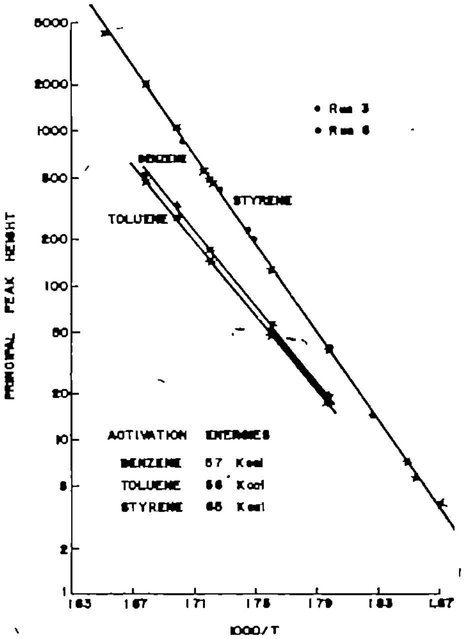
Grassie and Melville[1] measured the pressure of volatilized monomer (having determined the identity of the gas by other means) from heated polymethyl methacrylate in a continuously pumped system with a constriction limiting the pumping speed to a constant value. The measured pressure was directly proportional to the rate of production of monomer. This method has been modified by using a mass spectrometer instead of a Pirani gauge. The advantages of the mass spectrometer as the pressure gauge are: (*a*) it can analyse the gas produced; (*b*) it can measure each product independently; (*c*) it has great sensitivity.

Twenty-five milligrams of thermally polymerized styrene prepared by Dr. F. R. Mayo of this laboratory was deposited as a film over 150 cm.$^2$ of quartz by evaporation of the benzene solvent. This would leave a layer $1 \cdot 6 \times 10^{-4}$ cm. thick if uniformly distributed. The quartz tube (20 cm. long, 4 cm. diameter) containing the sample was sealed directly to the sample inlet tube of a General Electric analytical mass spectrometer. The sample inlet tube was the constriction limiting the flow through the ion source. It had a calculated conductance of approximately 0·012 litre sec.$^{-1}$ for styrene. The conductance of the pumping system beyond the ion source was of the order of 1,000 times greater. The maximum pressure in the spectrometer tube when rate measurements were made was $2 \times 10^{-7}$ mm.; hence the pressure of monomer in the sample tube was about $2 \times 10^{-4}$ mm.

The sample was given a preliminary degassing to remove solvent by pumping while heating at 80° C. for 4 hr. and at 30° overnight. The spectrometer, with the sample at 30°, had a very high background, with benzene predominating. The temperature of the sample was then increased at such a rate that the pressure in the spectrometer tube did not exceed $1 \times 10^{-6}$ mm. At the end of five hours the sample was at 110°, and benzene, methyl*cyclo*hexane, toluene, ethyl benzene and acetic acid comprised 95 per cent of the material evaporating from the sample. Within nine hours a temperature of 145° was reached, and acetic acid predominated in the volatilized materials. After sixteen hours at 145°, the rate of production of volatile materials dropped, permitting the sample to be heated to 210° before large amounts of acetic acid limited the rate of heating. A temperature of 220° was reached in three additional hours. Small amounts of styrene were then observed, along with other materials, the acetic acid having decreased. The temperature was increased by small steps which brought out more acetic acid at the beginning of the next three or four increments; benzene and toluene were also produced. A temperature of 310° was finally reached. At this temperature the polymer was decomposing, chiefly to styrene, benzene and toluene, but the rates of evolution decreased with time at any one temperature. The sample was then left at 230° for about seventy hours; at the end of this period there was no measurable evolution of gas. All the results noted up to this point were ascribed to adsorbed or dissolved impurities, or odd configurations present in small amounts. The total amount of material volatilized is estimated as less than 1 per cent of the sample. The persistence of the solvent, benzene, under conditions where 'molecular distillation' would remove it in an extremely short time, indicates another rate-limiting process. This indicated a phenomenon to be considered in other investigations of this kind. The presence of acetic acid and methyl*cyclo*hexane is unexplained. The early evolution of styrene (at 220°) may have been due to desorption of unreacted monomer or scission of loosely bound monomer.

Subsequent heating of the sample from 230° to the temperature-range 260°–330° C. at intervals extending over a period of ten days showed the rates of evolution of styrene, benzene and toluene to be functions of temperature only. This is believed to be decomposition of the polymer. A plot of principal peak heights for these three materials against the reciprocal of the temperature is reproduced herewith.

From the graph, the activation energies for the production of the various substances have been derived. It is seen that benzene and toluene have



the same activation energies (57 and 56 kcal.), within experimental error, and may be produced by similar mechanisms. The styrene has a distinctly greater activation energy (65 kcal.) and must be accounted for in another way.

The rate of production of styrene may be calculated if the signal height for a given rate of flow can be established[2]. This was determined, and it was found that a rate of 1·0 × $10^{-4}$ μlit./sec. gave a peak height of 960 units. Hence at 330°, 7·0 × $10^{-3}$ per cent of the sample will decompose per minute to styrene. Extrapolations of Madorsky's results[3] for higher temperatures would indicate a maximum rate of 4·0 × $10^{-2}$ per cent per min. at 330°. It should be pointed out that the results described here were obtained with less than 1 per cent of the total sample degraded, and the results were obtained in the temperature-range 260°–330°. Madorsky, working in the range 335°–365°, degraded a large fraction of the sample; hence, our results are not expected to be comparable. His value of 58 kcal. for the initial activation energy was deduced from measurements of loss of weight of the sample, as was the value of 44·7 found by Jellinek[4]. In the cases cited, the weights of volatilized materials were summed, instead of measuring the rate of volatilization of each substance.

In addition to styrene, benzene and toluene, small amounts of other substances were observed, the dimer of styrene being next in abundance. Higher temperatures would be required to get reliable values for the activation energies of these other materials. The very high molecular weight materials reported by Madorsky were not observed under these conditions of degradation and measurement.

The simpler case of polymethylmethacrylate was studied in the temperature-range 170°–210°, and an activation energy of 29·5 ± 1·0 kcal. was found for the production of the monomer, essentially in agreement with 31·0 kcal. found by Grassie and Melville[1]. The problem of removing solvent and other impurities were more acute in the case of methylmethacrylate; however, when they were removed, the monomer alone was produced.

The investigation is being extended to other systems, and detailed results and interpretations will be described elsewhere.

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Oct. 27.

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## Interaction of Manganous Ions with Enolase

MANY enzymes require the presence of metal ions for activity[1]. Kinetic studies on such systems indicate the existence of an equilibrium between the enzyme protein, the activating metal ion and a complex between metal ion and enzyme. By assuming the complex to be the only species catalytically active, a hypothetical dissociation constant can be determined from activity measurements. Considerations of this kind have led Smith[2] to formulate a theory of peptidase action according to which the metal ion acts as a binding group bringing enzyme and substrate together. Already in 1942, the same type of mechanism was suggested by Warburg and Christian[3] for the activation of enolase by magnesium, manganous and zinc ions. Since, however, no direct measurements of the interaction of activating metal ions with well-characterized enzyme preparations have been published, the present study was undertaken.

Enolase was purified by the method of Warburg and Christian[3]. These authors only investigated the activation by magnesium ions in detail, but the present work was extended to include the other activating ions. Fig. 1 shows the activity[3] of the enzyme as a function of the concentration of manganous ions measured in a 0·04-*M* phosphate buffer, *p*H 6·8. Employing the conventions of Warburg and Christian[3], the hypothetical dissociation constant of the enolase–manganous ion complex was calculated to be 2·5 × $10^{-5}$ mole/l. under the conditions used.

The interaction of manganous ions with enolase was also studied by the equilibrium dialysis technique[4]. Fig. 2 gives the average number of manganous ions bound per molecule of enzyme in 0·025 *M* phosphate buffer, at *p*H 6·8 and + 4°, as a function of the concentration of free manganous ions. The experimental points are too few to permit a detailed mathematical analysis, but they indicate that, in the range of concentration studied, the manganous ions

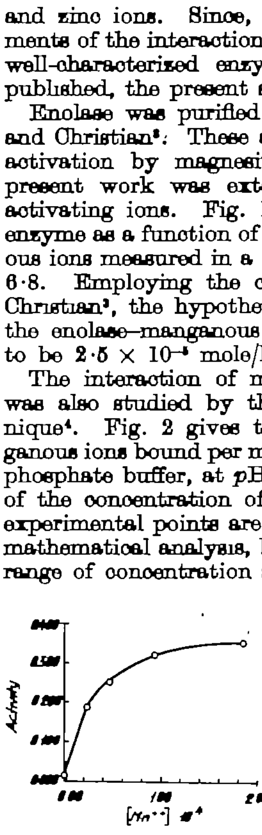

Fig. 1

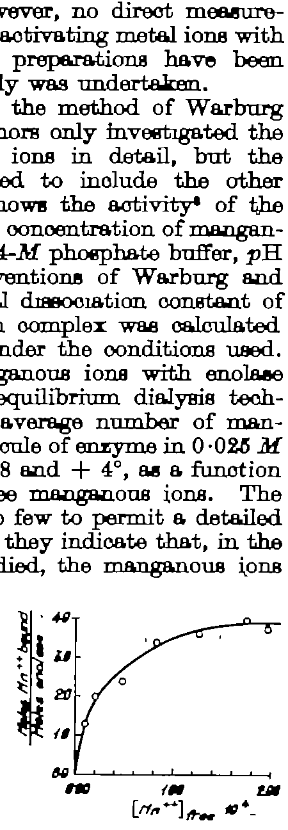

Fig. 2

Fig. 1. Influence of the concentration of manganous ions on the activity (arbitrary units) of enolase in 0·04 *M* phosphate buffer, *p*H 6·8

Fig. 2. Effect of the concentration of free manganous ions on the number bound by enolase in 0·025 *M* phosphate buffer, *p*H 6·8, at + 4°

interact with four groups of the enolase molecule, the overall dissociation constant being about $2 \times 10^{-4}$ mole/l., a value of the same order of magnitude as that calculated from the activity measurements.

If it is assumed that the four binding groups are identical and do not interact, the logarithm of the first association constant can be calculated and is 5·3. Thus, the interaction of manganous ions with enolase is stronger than that demonstrated with any amino-acid or simple peptide[4–7]. It is of interest to note that the enolase molecule contains eight sulphur atoms[3], since Cohn *et al.*[8] have recently suggested that cystine may furnish the complex-forming group in metal-activated enzymes.

The work described in the present communication is being extended and a detailed report will be published elsewhere.

I wish to thank Prof. Arne Tiselius for his interest in this investigation.

*Note added in proof*. Experiments on the activation of enolase by zinc ions, carried out since the above communication was submitted for publication, demonstrated a fall in activity at high metal ion concentrations. This led to a re-investigation of the activation by manganous ions, which showed that the data are more correctly interpreted by assuming two types of interaction between manganous ions and enolase, one giving an active complex and the other resulting in inhibition. If this inhibitory effect is taken into account, the hypothetical dissociation constant of the active complex is found to be $4 \cdot 4 \times 10^{-5}$ mole/l. (as compared with $2 \cdot 5 \times 10^{-4}$ mole/l. above), while that of the inactive complex is $2 \times 10^{-3}$ mole/l.

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Uppsala.
Sept. 3.

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## A Biophysical Test for Aldohexoses

I HAVE observed that some sugars inhibit the flocculation of bottom-fermentation brewer's yeast in tap water, whereas others do not.

| Sugars which inhibit flocculation | Sugars not inhibiting flocculation |
|---|---|
| Glucose | Fructose |
| Mannose | Galactose |
| Maltose | Lactose |
| Sucrose (after interaction for some time) | Xylose |
| | Arabinose |
| | Dextran, etc. |

The flocculation is thus inhibited by aldohexoses. This fact can be used for a quick test for glucose in the presence of fructose. About 30 mgm. of freeze-dried brewer's yeast were suspended in 5 ml. of tap water. When held at rest, the yeast flocculates, and is precipitated within one minute. On addition of an equal volume of the solution under examination, the presence of the above aldohexoses is indicated by the fact that the yeast suspension remains stable for a longer time (some hours). The influence is distinct up to a sugar concentration of 0·1 per cent.

The pH of the solution should be kept in the range 4–7, and the temperature above 25° C. As a condition for flocculation is the presence of calcium or magnesium salts in the medium, anions giving undissociated salts with these metals, such as oxalate, fluoride, phosphate and carbonate, should be avoided.

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Aug. 23.

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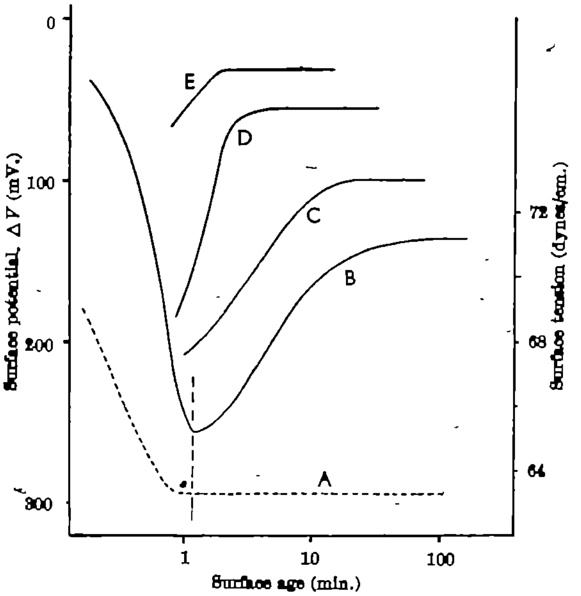
## Dynamic Potentials of Freshly Formed Liquid Surfaces

As a basis for the study of the adsorption of a surface-active solute to a fresh liquid surface, it is necessary to establish with accuracy the changes in the physical properties of the surface which occur immediately after its formation, and throughout the adsorption process. Two important properties, which undergo considerable change as adsorption proceeds, are the surface tension and the surface potential. We have recently observed that the surface potential of aqueous solutions of many long-chain compounds, at the instant when adsorption is complete, differs widely from the ultimate equilibrium value. The changes in potential following establishment of concentration equilibrium between surface and bulk solution are comparable in magnitude with those occurring during adsorption, and erroneous deductions may result from the assumption that dynamic surface tensions and potentials change in a similar manner with age of surface.

Measurements of the rate of change of surface tension in aqueous solutions of straight and branched-chain alcohols[1] have shown that the surface tension of such solutions is determined primarily by surface concentration of solute, and is little influenced by molecular orientation in the surface. Changes in dynamic surface tension therefore provide a satisfactory means of following the development of an adsorbed film; when concentration equilibrium is established, no further appreciable change in tension occurs.

Curves *A* and *B* in the graph compare the change in surface tension and potential respectively for a 0·00045 per cent aqueous solution of decyl alcohol at 15°. Whereas tension is constant after one minute, the potential shows a considerable rise after adsorption is complete. In interpreting these effects, we consider that adsorbing molecules of solute arrive at the surface in a disorientated state, and that the continual arrival of solute molecules maintains this disorientation throughout the adsorption process. Unlike tension, the surface potential is influenced greatly by surface orientation as well as by surface concentration; the potential of the surface when adsorption is complete is therefore characteristic of the disorientated film. The general use of the well-known expression $\Delta V = 4\pi n\mu$ in surface potential studies implies that the decrease in the air–water contact potential ($\Delta V$) is brought about by the solute only. However, it seems probable that the potential changes which follow adsorption are greater than can be attributed entirely to variations in the effective dipole moment $\mu$; it is therefore considered that water as well as solute molecules are disorientated by adsorption to fresh surfaces.

When the disturbing effect of adsorption is no longer operative, the film can become rearranged to



a stable configuration. An important observation in these experiments is that the time required for the orientation process is in all cases of a different order from that required for the initial adsorption. Curves *C*, *D* and *E* (and the accompanying table) show that the effect persists down to the shortest chain-lengths, and illustrate the increase in time of orientation with length of carbon chain.

| Curve | Alcohol | Concentration (%) | Adsorption time | Orientation time |
|---|---|---|---|---|
| *B* | *n*-Decyl | 0·00045 | 70 sec. | 30 min. |
| *C* | *n*-Hexyl | 0·020 | 0·065 sec. | 15 ,, |
| *D* | *n*-Butyl | 0·154 | < 0·005 ,, | 3 ,, |
| *E* | Ethyl | 0·385 | < 0·005 ,, | 1–2 ,, |

The term 'surface potential' has therefore no meaning without reference to the age and condition of the surface. For any given surface excess, there are clearly two limiting values, the 'disorientation' and 'orientation' potentials characteristic of the two limiting surface conditions; the measured potential may lie on or between these limits, depending on the particular solute used and its concentration.

The following example illustrates the significance of these observations. A new technique for the measurement of dynamic surface tensions has been described by Posner and Alexander[2], in which the authors measured the changes in potential along jets of *iso*-amyl and *sec*-octyl alcohol solutions and translated these potential values into dynamic tensions using calibration curves derived from equilibrium values of these two quantities measured under static conditions in a trough. The dynamic tensions so deduced showed considerable divergence from the values determined by Addison[3] from jet dimensions. Since the latter values have been employed in certain theoretical studies of the adsorption process[4], it is important to investigate this divergence. The results in the accompanying graph indicate that solute becoming adsorbed to the surface of a jet must be in a state of disorientation; it has been found that, when the potential values of Posner and Alexander are translated into dynamic tensions using the appropriate tension – disorientation potential calibration curves, the results obtained by the two techniques are in almost ideal agreement.

A full account of this work is being submitted for publication in the *Journal of the Chemical Society*.

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## Identification of Radiosensitive Volume with Nucleic Acid Volume

On the basis of inactivation data for nearly two dozen plant, animal and bacterial viruses, Lea[1] pointed out that the radiosensitive or target diameter was within a factor of 2 of the physical diameter of nearly all the viruses studied, the agreement becoming poorer with increase in diameter. From this agreement Lea concluded that the small viruses must be composed almost exclusively of radiosensitive material which he identified with nucleoprotein. The very large viruses were stated to be more like ordinary cells in that they seemed to have an appreciable amount of relatively insensitive 'cytoplasmic' material. Other workers (for example, refs. 2 and 3) have given experimental reasons for believing that the nucleoprotein material is the radiosensitive portion of a cell.

The first purpose of this communication is to point out that Lea's interpretation of his results may be incorrect. The source of the error is the fact that a difference of a factor of 2 in diameter means a difference of a factor of 8 in volume. On this reasoning it is improbable, except for the very smallest viruses, that the entire virus can be considered to be radiosensitive. The question then arises as to what might be identified with the target, if, indeed, any single structure can be so identified.

My second purpose is to show that a more straightforward use of the radiation data gives quantitative support to the idea that the radiosensitive portion of a virus is its nucleic acid (not its nucleoprotein).

Both radiation data and nucleic acid data have been found for ten viruses. Radiation data for the four plant viruses and two of the three animal viruses in this group have been given in ref. 1 along with the size of virus. Radiation data for the three bacterial viruses are given in ref. 2. The inactivation data for influenza are given in ref. 4. Nucleic acid data for the bacterial viruses are given in refs. 5, 6 and 7; for the remaining viruses in ref. 8. Virus densities are given in ref. 10, except for tobacco necrosis, tobacco ringspot, and vaccinia viruses; the latter were assumed to have densities of 1·3 gm./ml. The nucleic acid density was taken[9] as 1·63 gm./ml. The results of the calculations of radiosensitive volumes and nucleic acid volumes are given in the accompanying table.

It is evident that there is a good agreement between target volume and nucleic acid volume except for the largest two viruses (influenza and vaccinia); these are well known to have complex internal structures which could easily make inapplic-

| Virus | Target volume $(10^6\ m\mu^3)$ | Nucleic acid volume $(10^6\ m\mu^3)$ |
|---|---|---|
| Tobacco mosaic | 2·4 | 2·5 |
| Tobacco necrosis | 1·3 | 1·2 |
| Tobacco ringspot | 1·9 | 1·2 |
| Tomato bushy stunt | 2·0 | 1·8 |
| Coliphage *T2* | 56 | 86 |
| Coliphage *T6* | 56 | 86 |
| Coliphage *T7* | 27 | 26 |
| Influenza | 55 | 21 |
| Shope papilloma | 2·1 | 4·2 |
| Vaccinia | 13 | 194 |

able the single-target, single-hit theory used in the calculations. It should be emphasized that the uncertainties in the data are sufficiently large for the agreement between target volume and nucleic acid volume to be well within probable error. Similarly, of course, it cannot be excluded that the volumes could be different by, perhaps, a factor of 2.

It was not possible to use the data on nucleic acid contents of four other bacterial viruses given in ref. 9, because some of the resultant nucleic acid volumes are greater than the entire volumes of the viruses.

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## Luminosity generated by Shock Waves

Luminous phenomena accompanying shock waves have been observed under extreme conditions by Michel-Lévy, Muraour and Vassy[1] through head-on collision of shocks generated by explosives, and by Perry and Kantrowitz[2] at the point of convergence of a cylindrical shock wave. A related phenomenon is observed in the gas discharges of Fowler, Goldstein and Clotfelter[3], although the creation of the shocks in this type of work is of an electrical nature and does not immediately allow a hydrodynamic interpretation.

It was noticed some time ago that the University of Michigan shock tube exhibits luminosity in gases such as air, nitrogen and argon. This shock tube[4] has a rectangular cross-section of 2 in. × 7 in., a compression chamber 7 ft. long and an expansion chamber of 18 ft. Shocks are produced in the expansion chamber by rupturing a diaphragm between it and the compression chamber, which generally contains hydrogen at a pressure of several atmospheres. Preliminary results of our investigation were reported at the Salt Lake City meeting of the American Physical Society in June 1952. At that time experiments were also reported by Kantrowitz which, although different substances were used, seem to show very similar results. In what follows, further experimental investigations are reported.

Luminosity is observed when the shock is reflected normally from a plate at the end of the tube. In order to localize this phenomenon within the space-time events taking place in the shock tube, wave-speed camera exposures were taken of the region near the reflecting plate. This established with complete certainty the fact that the luminosity is confined at first to the region between the reflecting plate and the reflected shock, until the latter meets the interface or cold front which divides the gases initially in front of and behind the burst diaphragm. From then on, the luminous region is limited by the end plate and by the expansion wave generated at the meeting of the reflected shock and the interface. The wave-speed camera pictures show a roughly triangular region, the entire duration of time of the phenomenon being between 1,500 and 3,000 microsec., depending upon the strength of shock and the nature of the gas.

Spectroscopic investigation has been carried out with a two-prism glass spectrograph, which has a dispersion of 12 A./mm. at 4000 A. and of 140 A./mm. at 9000 A. Preliminary exposures with nitrogen and argon showed merely the *D* lines of sodium and the *g* line ($^1S - {}^1P$) of calcium. According to hydrodynamical reasoning, stronger shocks with correspondingly higher temperatures can be obtained, for given pressures in front of and behind the diaphragm, when using heavy monatomic gases. Therefore krypton and xenon (we are indebted to the Linde Air Products Co., Tonawanda, N.Y., for a generous gift of rare gases) have recently been used. The following table shows the theoretical temperatures attained with three atmospheres of hydrogen in the compression chamber and the indicated pressures of xenon in the expansion chamber after reflexion of the shock from the end plate.

| Xenon pressure | Temperature |
|---|---|
| 32·4 mm. mercury | 6,000° K. |
| 17·8 " " | 9,000 |
| 5·7 " " | 18,000 |

The actual temperatures are, because of viscosity and radiation losses, somewhat lower. The last pressure and temperature just about represent the working limit of the present shock tube.

It is now possible to make a comparison of the intensity of the *g* line of the neutral Ca with that of the *H* and *K* lines of Ca II as the temperature increases. While for weaker shocks the *g* line alone is present, for stronger shocks the *H* and *K* lines increase in strength, with the *g* line even diminishing its intensity. This behaviour conforms to the theory of stellar atmospheres put forward by Saha, Fowler and Milne[5]. It is thus established that the luminosity of the gases behind shocks is purely a temperature phenomenon. Especially at lower shock-strengths, metallic lines are of greater prominence than the lines of the carrier gases, similar to the conditions in stellar atmospheres. Thus several hundred lines of sodium, calcium, barium, iron, aluminium, as well as bands of calcium, are observed which are due to room dust and to the walls of the tube. Further, by introducing the acetyl acetonate of copper the spectral lines of this metal were observed.

As to the lines of the carrier gas, it is obvious that xenon offers the most favourable conditions not only because of the higher temperatures attainable but also because of its comparatively low excitation potential. Indeed, at calculated temperatures above 12,000° K., xenon lines are first observed. With a single flash produced by a shock of calculated temperature 18,000° K., about fifty xenon lines below 9000 A. have been identified. These are all the lines obtainable with a xenon-filled Geissler tube after an exposure of about 2–5 min. Comparison of the xenon lines produced in these two ways appears to indicate a broadening and, in some cases, a shift—effects which were announced by Kantrowitz. In view of the results of Michel-Lévy, Muraour and Vassy and also of Schulz[6], there seems little doubt that, as the strength of the shocks increases, continuous spectra will play a more and more important part.

It is intended to apply quantitatively the theories of Saha, Fowler and Milne with the purpose of determining the degree of ionization and the electron pressure at various shock strengths. The investigation of the shapes of spectral lines under these novel conditions of rapid pressure and temperature changes should complement the information gained from astrophysical and electrical discharge studies. Like the *Schlieren* and shadowgraph methods, observation of luminous phenomena will give information on the flow of a supersonic gas stream around a model. As the incoming flow is deflected or reflected by a model, the luminosity distribution will furnish a measure of the local temperature.

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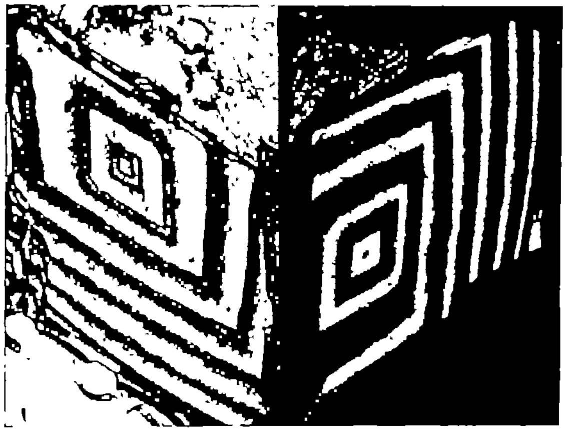
## Transmission-like Reflexion Fringes in Birefringent Crystals

IT has long been known that the suppression of the first beam in multiple-beam reflexion interference fringes produces a transmission-like pattern. This was established in 1907 by Lummer[1], and was recently applied by Bruce[2], who cut out the first beam by a knife edge. In high-magnification studies, this obscuration of the lens may lead to diffraction anomalies (Tolansky[3]).

In the special case of thin birefringent crystals, transmission-like systems can be obtained in reflexion by a simple optical device. If a birefringent tabular crystal is grown on a silvered optical flat and the upper surface is then silvered, we have a birefringent medium between silvered surfaces capable of producing familiar multiple-beam localized Fizeau fringes, and in reflexion such a system gives dark fringes on a bright background. Fig. 1 gives an example using the crystal stearic acid. Owing to birefringence the fringes are double, the components being mutually perpendicularly plane polarized. However, if illuminated with plane-polarized light and the reflected system is viewed through an analyser, it is clear that, without any change of the numerical aperture, the first reflected beam can easily be cut out, since this is the only beam in the interference system which does not go through the crystal, and hence its plane of polarization differs from that of the complete multiple-beam system. Fig. 2 shows the appearance of the pattern obtained by thus suppressing the first beam. Here the two components are polarized in the same plane. It is clear that this simple technique permits not only the total suppression of the first beam but also its partial suppression if wished. Hence it is possible to study systematically the continuous change in the appearance of the fringe pattern as the contribution of the first beam is successively varied.



Magnification × 200

Detailed analysis of the system will be published elsewhere.

I wish to thank Prof. S. Tolansky for his interest and Miss P. M. Reynolds for valuable discussion. This work is being done during the tenure of an I.C.I. Fellowship while on study leave from the University of Delhi.

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## Relationship between Relative Viscosity and Volume Concentration of Stable Suspensions of Spherical Particles

MANY relationships have been suggested for the relative viscosity, $\eta_r$, of a suspension of rigid, smooth spheres in a liquid in terms of the volumetric concentration $c$. Einstein[1] obtained the equation:

$$\eta_r = 1 + 2\cdot 5c,$$

for a suspension of spherical particles at infinite dilution and devoid of such influences as agglomeration, solvation, accumulation of electric charge and so forth. Other equations and empirical relationships have also been derived by different workers.

In recent work we have found it convenient to plot the value $1 - \frac{1}{\eta_r}$ against the volumetric concentration $c$ for stable suspensions of spheres, and have obtained a straight line. The results of other workers were treated in this way, the data used including those obtained from rising sphere, rotating cylinder and capillary tube viscometers. In most cases a straight line has been obtained up to concentrations of at least 20 per cent (the highest concentration used in some of the investigations), although the data given for the suspensions of glass spheres used by Vand[2], and by Eirich, Bunzl and Margaretha[3], gave lines which curve towards the concentration axis and which closely resemble curves we have obtained for unstable suspensions.

The equation to the straight line may be written

$$1 - \frac{1}{\eta_r} = kc,$$

that is, $\eta_r = \frac{1}{1 - kc}$ or $\eta_r = 1 + kc + k^2c^2 + k^3c^3 \ldots$,

where $k$ is a constant. At extremely low concentrations the expression reduces to

$$\eta_r = 1 + kc,$$

which, if $k = 2{\cdot}5$, is identical with Einstein's equation.

The accompanying table shows the values of $k$ obtained from curves for the data of various workers.

| Worker | Type of viscometer | Size ratio of suspended spheres | $k$ | Range of volumetric concentration over which equation applies (per cent) |
|---|---|---|---|---|
| Eirich, Bunzl and Margaretha (ref. 3) | Capillary | * | 2·41 | 0–15+ |
| Broughton and Windebank (ref. 4) | Rotating cylinder | 2·0 : 1 | 2·57 | 0–15+ |
| Whitmore (ref. 5) | Rising sphere | 1·8 : 1 | 2·41 | 0–20+ |
| | | 1·2 : 1 | 2·77 | 0–20+ |
| Iveson (ref. 6) | Rotating cylinder | 1·4 : 1 | 2·56 | 0–20 |
| Nandi (ref. 7) | Capillary | 1·4 : 1 | 2·42 | 0–35 |
| Higginbotham (ref. 8) | Capillary | 1·2 : 1 | 2·38 | 0–25 |
| Williams (ref. 9) | Capillary | 5·0 : 1 | 2·34 | 25–35 |
| Present work | Capillary | 1·6 : 1 | 2·45 | 0–30 |

* Killed yeast, size ratio not exactly known. All other results refer to perfect spheres.

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## A Theoretical Approach to the Problem of determining the Relationship between the Constants of Circuits and their Intrinsic Safety

There is an urgent need for a comprehensive theoretical correlation between the constants of a complex circuit and its intrinsic safety in the presence of inflammable gases. This has not yet been attempted owing to the lack of knowledge of the fundamental mechanism of spark ignition. I believe, however, that even in the present state of knowledge it is possible to derive a circuit theory which would permit the approximate correlation between intrinsic safety and circuit constants however complex the circuit may be.

The available evidence suggests that the principal factors controlling ignition are the nature, composition, ambient temperature, pressure and turbulence of the inflammable gas; the material, configuration and manner of separation of the electrodes; the energy dissipated in the discharge and its duration; and the volume of gas influenced by the discharge. What, in fact, appears to matter is that the temperature of a sufficient volume of an inflammable gas be raised above some critical level. Thus, for a particular inflammable gas under specified conditions and for a specified electrode system, a certain minimum amount of energy must, it seems, be imparted to the gas. This energy is the difference between that supplied by the discharge and that removed to surrounding space.

The expression for energy expended in a discharge through an opening current-carrying switch is, in operational notation,

$$U = \int_0^T [Z_p (I - i)\, i \, . \, 1]\, dt,$$

where $I$ is the initial current through the switch before it starts opening at time 0; $i$ is switch current at any time $t$ between 0 and $T$; $T$ is duration of discharge; $Z_p$ is impedance across the open switch when all sources of voltage are short-circuited.

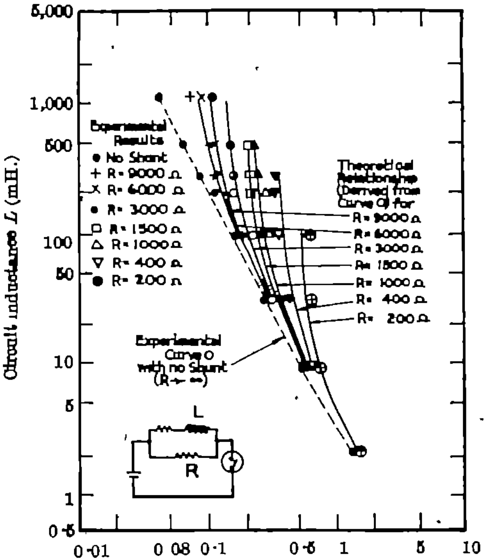

Fig. 1. Comparison between experimental results obtained by the Safety in Mines Research Establishment and the theoretical relationship derived from the curve O for the effect of shunt resistance on minimum igniting current

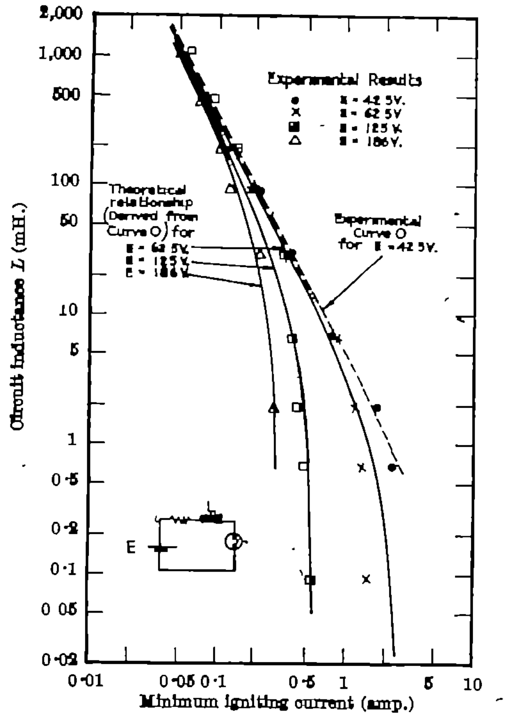

Fig. 2. Comparison between experimental results obtained by the Safety in Mines Research Establishment and the theoretical relationship derived from curve 0 for the effect of battery voltage on minimum igniting current

This energy $U$ can be computed for any linear circuit, whatever its voltage and impedance, so long as the duration of the discharge and the manner in which current $i$ varies are known. Non-linear circuits, such as iron-cored inductors, rectifiers and non-linear resistors, can also be treated similarly.

The above theoretical considerations were checked for non-capacitative circuits against results of tests with an 8·3 per cent methane–air mixture published by the Safety in Mines Research Establishment[1]. In the absence of information regarding current and voltage patterns or the duration of discharges obtained in the tests, the following assumptions were made: (1) constant rate of current decrement; (2) constant duration of discharge (of magnitude derived from a few test results) for each electrode system and rate of separation; (3) constant fraction of energy of a discharge employed in igniting the gas for each electrode system and rate of separation.

On this basis and adopting the concept of constant minimum igniting energy for a particular gas, electrode system and time of discharge, minimum igniting currents were computed for the effects of circuit inductance, shunt resistance and circuit voltage.

The computed results for the effects of shunt resistance and circuit voltage were compared with corresponding test results in Figs. 1 and 2 respectively. It can be seen that, even with the scant test information available at present regarding characteristics of discharges obtained, it was possible to predict the approximate point of ignition of the majority of circuits tested on the basis of information derived from a small fraction of the circuits.

Additionally, the test results for the effect of inductance in a series inductive-resistive circuit were shown to be predictable from a single test result. Finally, the effect of the rate of electrode separation reported by the Safety in Mines Research Establishment was shown to be consistent with the proposed theory.

A close agreement has thus been demonstrated between the calculated and the existing test results. New experimental work will be required to determine whether refinements of the theory are necessary to take account of additional factors, such as the recovery transient, the arc voltage or the ionization voltage; or whether, for example, a closer approximation to actual conditions is obtained if the voltage of the discharge is taken as constant or linearly rising and the discharge current is re-calculated from the above basic equation. It is proposed to publish a full report of this work elsewhere.

Thanks are due to the Director-General of the Scientific Department of the National Coal Board for permission to publish this account, and to Mr. D. R. Scott for his assistance in mathematical calculations.

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## Conversion of Solid into Ascites Tumours

Previous studies by different authors[1-6] have shown the possibility of the conversion of solid into ascites tumours. Further observations have revealed information which promises to elucidate the nature of this conversion. In all, forty-two different mouse tumours have been tested so far.

The following procedure was used throughout. Solid tumours of various origin (Table 1) and, in most cases, homologous to one of a number of inbred mouse strains (*C3H*, *C57* black, *C57* leaden, *dba*, *Ak*, Strong *A*) were minced mechanically and 0·2–0·5 gm. of the fresh tumour pulp was injected intraperitoneally into mice belonging to the strain of origin or suitable *F*1 hybrids. The tumour was then maintained by successive intraperitoneal transfers for at least ten, but in most cases up to thirty to forty, transfer generations. While carrying out successive transfers, inoculations of peritoneal exudate in 0·4-ml. amounts were made whenever an exudate was present in appreciable amounts. If no exudate was available, solid-tumour mince was again used.

Table 1 lists the different tumour lines used with respect to their capacity for growing as typical ascites tumours. In agreement with previous definitions[3,4],

Table 1. Tumours Grouped According to Type

| Tumour type | Total number | Transformation into ascites tumour | | |
|---|---|---|---|---|
| | | Successful immediately | Successful gradually | Unsuccessful |
| Spontaneous mammary adenocarcinoma | 17 | 0 | 0 | 17 |
| Transplanted mammary adenocarcinoma | 6 | 0 | 4 | 2 |
| Transplanted sarcoma originally induced | 4 | 0 | 2 | 2 |
| Transplanted sarcoma originally spontaneous | 4 | 1 | 0 | 3 |
| Transplanted lymphoma | 5 | 5 | 0 | 0 |
| Transplanted melanoma | 2 | 0 | 0 | 2 |
| Transplanted hepatoma | 2 | 0 | 0 | 2 |
| Transplanted neuroblastoma | 1 | 0 | 0 | 1 |
| Transplanted chondrosarcoma | 1 | 0 | 0 | 1 |
| Total | 42 | 6 | 6 | 30 |

the term 'ascites tumour' is used for denoting the condition when intraperitoneally injected tumour cells primarily start multiplying in the peritoneal fluid, induce accumulation of ascites and eventually reach there a high concentration. The final stage represents a nearly pure culture of free tumour cells.

The tumours used fall into three different categories as regards their ability to grow as ascites tumours. Some of them give rise to typical ascites tumours immediately after their first intraperitoneal inoculation. All five lymphomas tested and one out of eight transplanted sarcomas fall into this group. Other tumours showed a more gradual transformation and resulted in typical ascites tumours after a number of exudate-transfer generations only. These two categories were already recognized when our previous experiments were reported[3]. The number of transfer generations was, however, too small to permit definite conclusions as to the third category, which included tumours that gave negative results and grew only in the form of solid neoplasms. On the basis of examination of a larger number of tumours and a more prolonged observation period, it can now be stated that, under the conditions used, a number of tumours did not lend themselves to transformation into ascites tumours. This is at variance with the opinion of Goldie *et al.*[6], that cells from any mouse tumour strain inoculated into the peritoneal cavity can induce the accumulation of fluid and multiply therein as free cells.

The question arises as to the factors concerned in determining whether the tumour cells injected can proliferate freely in the peritoneal fluid and provoke ascites production. If the tumours used are classified according to the median survival time of animal groups receiving intraperitoneal inoculations of 0·2–0·5 gm. of minced solid tumour (Table 2), it will be seen that transformation into ascites tumour occurs only with the rapidly growing tumours, although even here not invariably. Moreover, the tumours belonging to these rapidly growing categories were all highly anaplastic and had previously passed through a long series of transfer generations before being used for the present experiments. It would appear that a rapid growth-rate and/or high degree of anaplasticity of the tumour tested are necessary, but in itself not sufficient conditions for the final attainment of the ascites tumour condition.

The capacity to induce the production of ascites and to grow in this ascites are thus shown to be the attributes of certain tumour cells only. In all five lymphomas tested, and in one of the sarcomas, such an ability seems to be inherent in a large proportion of the cell population, thus making transformation into ascites tumour instantaneous. On the other hand, in the tumours that show transformation of the gradual type, this property may perhaps be associated with a small number of cells only. These cells, possibly arising by mutation, would then be selected during the successive exudate-transfer generations, where the particular cells that can survive in the fluid will always be the transmitters of the tumour. Alternatively, the transformation may be viewed as an adaptive change, in which case there would be a given chance for each cell in the original population to survive and proliferate in the fluid exudate. If the former concept is true, then an ascites tumour, when once established, should retain its capacity for growing in the ascites form immediately and at any time, even if kept routinely by subcutaneous solid transfers. The following experiment shows that this is the case for one of the tumours used.

Table 2. TUMOURS GROUPED ACCORDING TO THE MEDIAN SURVIVAL TIMES OF INTRAPERITONEALLY INOCULATED ANIMALS

| Median survival time in days | Total number of tumours tested | Transformation into ascites tumour | |
|---|---|---|---|
| | | Successful | Unsuccessful |
| 6–10 | 7 | 5 | 2 |
| 11–15 | 6 | 5 | 1 |
| 16–25 | 5 | 2 | 3 |
| 26–35 | 6 | 0 | 6 |
| Over 35 | 18 | 0 | 18 |
| Total | 42 | 12 | 30 |

Table 3. COMPARISON BETWEEN THE EFFECT OF INTRAPERITONEAL INJECTIONS OF SOLID KREBS 2 TUMOURS OF THE ORIGINAL SOLID STRAIN (*SS* STRAIN) AND THE STRAIN DEVELOPED BY SUBCUTANEOUS INJECTION OF THE KREBS 2 ASCITES TUMOUR AND KEPT AS SOLID TUMOUR FOR TWELVE TRANSFER GENERATIONS (*AS* STRAIN)

| | No. of animals inoculated | No. of animals developing only solid tumours | No. of animals forming ascites | Average percentage of tumour cells in ascites |
|---|---|---|---|---|
| *SS* strain | 9 | 8 | 1 | None detected |
| *AS* strain | 10 | 0 | 10 | 78 |

The Krebs 2 tumour (belonging to the category showing gradual transformation into ascites tumour[4,5]) has been kept in the ascites form for more than twenty intraperitoneal transfer generations. When 0·2 ml. of ascites was injected subcutaneously into *C3H* mice, solid tumours developed at the place of inoculation. Subcutaneous transfers of the solid tumours were then made by the trocar technique through twelve transfer generations. At the end of this serial transfer the tumours belonging to this line (*AS* strain, Table 3) were broken up, and 0·5 gm. solid-tumour mince was inoculated intraperitoneally to ten *C3H* mice. These inoculations provoked typical ascites tumours immediately in all animals injected, the frequency of the tumour cells in the ascitic fluids ranging from 67 to 92 per cent. This behaviour was in marked contrast to that of the original solid tumour[4] (*SS* strain, Table 3), which, on its first intraperitoneal transfer in comparable amounts, gave rise exclusively to the solid type of growth. This observation indicates a difference between the original cell population of the solid tumour and that of the solid-tumour line developed from the ascites in its relationship to growth as ascites tumours. In the line developed from ascites, this capacity was retained through twelve subcutaneous transfers, during which the cells grew in the form of solid tumours. This favours the possibility that one or several 'mutants' possessing this capacity were selected during the original procedure of transformation into ascites tumour, rather than the assumption that the transformation represents an adaptation to the fluid environment, in which case a reverse change might be expected to occur during the subcutaneous transfer generations. Experiments are now in progress for further elucidation of the question.

These investigations have been made possible by grants from the Wallenberg Foundation, Kooperativa Kvinnogillesförbundet and the Swedish Cancer Society.

GEORGE KLEIN

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Stockholm. Oct. 24.

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## An Action Potential from the Motor Nerves of the Jellyfish *Aurellia aurita* Lamarck.

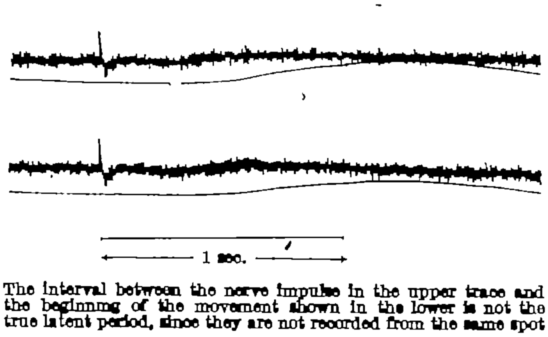
So long ago as 1878, E. A. Schafer demonstrated in *Aurellia* a network of bipolar and tripolar nerve cells the processes of which run in all directions, frequently coming close together at points which have been interpreted as synapses[1,2]. Using Holmes's method of silver staining, I have been able to confirm this histological picture; moreover, the fibres are similar to those of the through-conducting system in the mesenteries of *Metridium*[3]. These fibres can be seen clearly in living *Aurellia* under phase-contrast or oblique illumination.

It has long been known[4] that a bridge of tissue between two pieces of *Aurellia* will conduct a stimulus in either direction, resulting in a contraction in each piece. The ability to see the fibres has made it possible to show that this transmission can occur in either direction even when only a single fibre crosses the bridge. Such conduction does not occur when no nerve fibre can be observed under phase-contrast illumination.

Physiological work has shown[3] that there is a through-conducting system in Cœlenterates which behaves in the same way as the nerves of higher animals. The existence of an all-or-nothing response and a refractory period is characteristic of nerve fibres. The above experiment with *Aurellia* shows that the observed nerves are carrying the excitation. Formerly, there was no rigorous proof of this. It is to be expected, therefore, that one or more impulses with action potentials are propagated through at least some of the fibres at each contraction wave. Direct recording from a living nerve shows that this is actually so.

The fibres of the motor nerve net can be picked up individually with a single electrode of thin platinum wire mounted on a micro-manipulator. With a condenser-coupled amplifier of long time-constant, such a preparation gives one action potential at each spontaneous beat of the bell (see traces reproduced herewith). A majority of fibres tested do not show this action potential; but one cannot distinguish between fibres that have been damaged by the manipulation and those that may be inactive.

A single electrical stimulus applied to the subumbrella surface gives rise to a contraction of the muscle, and the spread of the contraction to every part of the bell is consistent with the histological arrangement of a network of nerves. In these and other experiments I can find no evidence of polarization, interneural facilitation, or decremental conduction in this motor system of *Aurellia* except occasionally in narrow bridges where it may be due to damage. Direct recording of the impulse in a single nerve fibre shows that the excitation, which can travel in all directions, consists at each beat of a single impulse at any point. This fact gives rise to important conclusions which will be discussed in a later paper.



The interval between the nerve impulse in the upper trace and the beginning of the movement shown in the lower is not the true latent period, since they are not recorded from the same spot

There is evidence, especially in other Scyphomedusæ, that an excitation can be transmitted across the subumbrella without giving rise to movement *en route*, and presumably this must go through some diffuse system other than the motor fibres. There is not sufficient evidence to extend these conclusions concerning *Aurellia* to groups other than Semæostome Scyphozoa.

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Sept. 4.

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## Competitive Suppression of Prototrophs

IN a recent publication[1], Jinks has compounded the erroneous impression, first given by Grigg[2], that competitive suppression is a neglected source of error in studies of prototrophs or reversions of nutritional requirement in micro-organisms. Køhmark and Westergaard[3] have shown that Grigg's criticism is inapplicable to their case; but since Jinks's publication is subsequent to this, and expresses the belief that "it is not easy to see a simple way of avoiding [the] effects" of competitive suppression, a brief recollection of the facts published elsewhere on the matter seems called for. Competitive suppression is certainly a real phenomenon and has been studied experimentally in some detail[4-6]. The findings relevant to the present issue are that: (1) the addition of prototrophs to the culture of organisms from which prototrophs it contains are being screened measures the extent of competitive suppression; (2) when competitive suppression is not acting, dilution of the culture results in a corresponding decrease in the number of prototrophs, and added prototrophs are recovered.

In Nelson's[7] studies of recombination in *E. coli*, the recovery of added prototrophs showed that competitive suppression was inoperative in a majority of crosses. In that cross in which the parents seemed to prevent the formation of colonies by the prototrophs formed, added prototrophs were not recovered. In these cases, however, suppression was exhibited only in concentrations far beyond those usually employed. Newcombe and Nyholm[8], for example, used smaller concentrations, in the range where limited testing showed ten-fold dilutions to give ten-fold decreases in numbers of prototrophs plated (Newcombe, personal communication). Similar consistent relationships between dilution and number of mutants were found in the work of Newcombe and Hawirko[9] on streptomycin resistance in *E. coli*. Moreover, in their publication they presented evidence for the recovery of added mutants in a background of parents more concentrated than that used in their determination of mutation-rates.

Similarly, studies on the reversion of biochemical mutants of *Neurospora crassa* have been performed under conditions where competitive suppression is absent. Giles[10], whose report on this point was presumably not available to Grigg, has shown by the addition of prototrophs that the parental conidia did not prevent their expression. The results of Grigg's experiments appear to be a function of starvation conditions, as Kølmark and Westergaard have claimed. McElroy (personal communication) finds that, even when sorbose is used, competitive suppression does not operate when the agar plates are as thick as those used in his previous experiments[11].

It is no doubt correct to demand that the reliability of the screening method employed be established in each case. In spite of what has been said above, one may still ask whether mutants of recent origin differ in no way from those somewhat older or whether, as Nelson suggests, the reaction-rate constant of bacterial recombination should be used instead of the empirical frequencies of prototrophs. But it is wrong to imply that laboratory workers in this field do not appreciate and have not studied the rôle of competitive suppression.

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Dec. 3.

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## The Mitochondrial Membrane

THE mitochondrial membrane has been a subject of controversy. Two distinct problems have arisen: whether a morphological membrane exists, and, if so, whether it is semi-permeable.

As Hogeboom and Schneider[1] point out, a number of workers, starting with Claude and Fullam[2], have interpreted structures seen in electron micrographs as mitochondrial membranes. Mühlethaler, Müller and Zollinger[3] observed such a membrane and estimated its thickness to be 200 A. Harman[4], however, doubted the existence of a membrane and considered that "it is acceptable on all available evidence to regard mitochondria as tightly coiled or compact gels".

The illustrations reproduced here show mitochondria from red beet tissue prepared in two different solutions, 30 per cent sucrose and 0·45 per cent potassium chloride, by the usual methods of centrifuging. Drops of the mitochondrial suspension were placed on electron microscope specimen screens and fixed; after drying, the soluble materials were removed by diffusion into water through the collodion membrane. The preparations were shadowed with uranium. The particles prepared in 30 per cent sucrose appeared as compact spheres 0·7–1·0 μ in diameter (Fig. 1). The particles prepared in 0·45 per cent potassium chloride appeared as large diffuse disks, 1–2 μ in diameter (Fig. 2). The same extracts under a phase-contrast microscope showed, in sucrose, compact spheres, and in potassium chloride, larger spheres with uneven patches, closely resembling the animal mitochondria prepared in potassium chloride by Zollinger[5]. The appearance of our preparations suggested uptake of water by the particles prepared in the solution of low osmotic pressure. Fig. 2 would be consistent with collapse of these particles from a sphere to a disk on drying. The disks show distinct folds or crinkles; from the length of the shadows the thickness of the membrane is of the order of 270 A. The appearance of the particles in water as swollen spheres which disintegrate after a time is evidence against the possibility that the membrane could have been formed while the particles were drying, and we conclude that these mitochondria have morphological membranes.

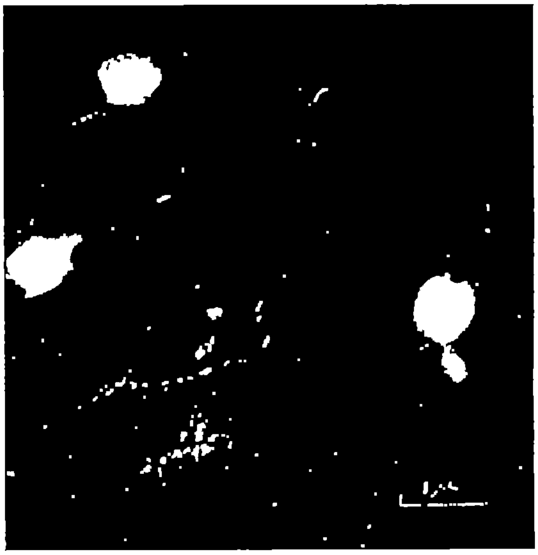

Fig. 1. Electron micrograph of beet mitochondria prepared in 30 per cent sucrose solution, fixed with formalin and shadowed with uranium; ratio of shadow length to particle height, 4 to 1

Fig. 2 shows a distinct membrane on a plant mitochondrion, thereby establishing beyond all doubt the suggestion made originally by Bucholz[6] and the inter-

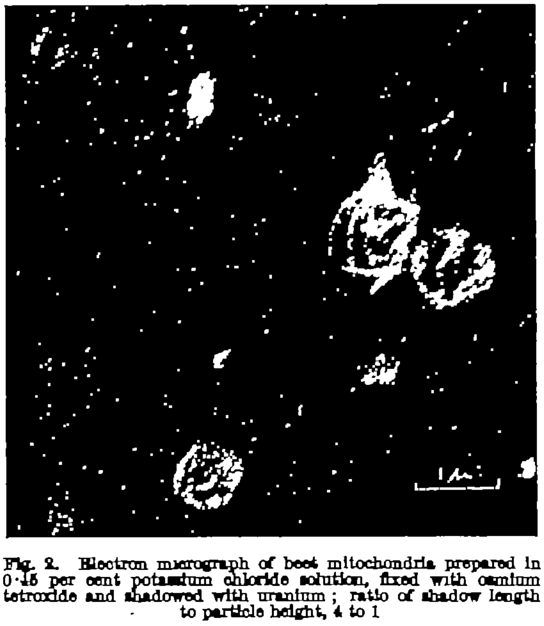

Fig. 2. Electron micrograph of beet mitochondria prepared in 0·45 per cent potassium chloride solution, fixed with osmium tetroxide and shadowed with uranium; ratio of shadow length to particle height, 4 to 1

pretation of the pictures published by Stafford[7] and Anderson[8]. Whether the membrane has semi-permeable properties and is responsible for the osmotic properties of the particle must still be investigated.

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Oct. 15.

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## Fixation of Bacterial Products by Erythrocytes *in vivo* and by Leucocytes

IT is known that, under suitable conditions *in vitro*, certain substances of bacterial origin may become fixed on to the surfaces of erythrocytes of various mammalian species, rendering the cells susceptible to agglutination by the specific antibacterial serum (see refs. 1, 2). The term 'hæmosensitin' has been suggested for substances which sensitize erythrocytes in this way[3]. This phenomenon has found important practical application in serological technique; but little work has been reported on the mechanism of the fixation process, or on its possible significance in relation either to bacterial disease, to hypersensitivity, or to normal cellular physiology. In this connexion, we have considered it of interest to investigate whether hæmosensitization can take place *in vivo*, and also whether mammalian cell types other than erythrocytes can fix the hæmosensitins.

A polysaccharide preparation ($S_t$) made from tuberculin by Lamensans, Grabar and Bretey[4] was used as a source of hæmosensitin in these investigations. Antiserum was obtained from rabbits after repeated injections of phenol-killed tubercle bacilli. All sera were heated at 56° C. for 30 min. and afterwards absorbed with an excess of guinea pig erythrocytes before use.

In connexion with the possibility of hæmosensitization existing *in vivo*, it is worth mentioning that *in vitro* the reaction is known to take place much more rapidly at 37° C. than at room temperature, and that it is negligible at 0–4° C. The following experiment was designed to show whether, in fact, the reaction can take place in the animal body. A number of guinea pigs (average weight, 300 gm.) were injected intravenously with different quantities of the polysaccharide ranging from 1 to 20 mgm. dissolved in 2 ml. saline. The controls received saline alone. After three hours, blood was taken from the heart into a sodium citrate solution, washed six times in saline, and the erythrocytes exposed to dilutions of the antiserum and of normal rabbit serum. The antiserum was found to agglutinate the erythrocytes taken from animals which had received 10 and 20 mgm. of polysaccharide, but not those from animals which had received 5 mgm. or less. Erythrocytes taken three days later from the animals which had received 20 mgm. were still sensitive to agglutination, although a higher concentration of antiserum was necessary to produce it. At six days the sensitivity had disappeared. There was no agglutination of the control cells in antiserum or of any of the cells in normal serum. This result demonstrates that hæmosensitization can take place in the blood stream of the living animal in spite of the presence of undiluted plasma, which is known to have a certain inhibitory effect on the reaction *in vitro*.

Leucocytes were used for demonstrating whether other types of cells could also fix hæmosensitins. In a typical experiment, a citrated suspension of guinea pig leucocytes was obtained from a peritoneal exudate after injection 16 hr. previously of 50 ml. Locke's solution. 68 per cent of the cells were polymorphonuclear. The exudate was divided into two portions, to one of which was added polysaccharide to a final concentration of 1 mgm./ml. Both portions were then incubated for 1 hr. at 37° C. and then washed; after resuspension, each was further divided into two parts, which were added respectively to suspensions of normal erythrocytes and of erythrocytes themselves sensitized with the polysaccharide. The resulting suspensions, which were made in normal guinea pig serum, consisted of approximately equal numbers of erythrocytes and white cells. Antiserum was added to a sample of each mixture to a final concentration of 1 per cent, and normal rabbit serum to a second sample. Microscopic examination after 3 hr. at room temperature showed that, in the tube containing leucocytes treated with polysaccharide, sensitized red cells and antiserum, 65 per cent of the leucocytes, comprising both polymorphonuclear and mononuclear cells, were in direct contact with erythrocytes. In the tube containing antiserum and sensitized erythrocytes but in which the leucocytes had not been treated with hæmosensitin, only 9 per cent of the latter were in contact with erythrocytes. In each of the other six tubes in the series, this figure was less than 15 per cent.

Similar experiments have been carried out with suspensions of lymphocytes obtained from lymph glands. For example, in one experiment, 55 per cent of the polysaccharide-treated lymphocytes were found to be incorporated in the clumps of sensitized erythrocytes in the presence of antiserum, whereas in the corresponding tube containing untreated lymphocytes the erythrocyte clumps were virtually free of lymphocytes, only 1 per cent of which were in contact with erythrocytes. Thus, when both leucocytes and erythrocytes are treated with hæmosensitin and are afterwards exposed together to the antibacterial serum, a specific adherence of leucocytes to erythrocytes occurs. This indicates that material of the same antigenic specificity has become fixed on to the surfaces of both types of cell.

Two main conclusions may be drawn from these studies. In the first place, it has been shown that hæmosensitization can take place *in vivo* when a high enough concentration of hæmosensitin is reached in the immediate environment of the cells. Secondly, the ability to fix these substances is not limited to erythrocytes, but is shared by leucocytes, and it seems probable that many other types of cell in the body may be capable of this activity.

This work was carried out in Paris during the tenure of an exchange scholarship of the Medical Research Council and the Centre National de la Recherche Scientifique.

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Sept. 29.

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## Cost of German Medical and Scientific Periodicals

Dr. W. Bonser and Miss Margaret P. Russell have discussed the prices of German medical and scientific periodicals in *Nature* of September 13, 1952, p. 446.

The prices of the periodicals published by the Springer Verlag are fixed in such a way that the number of subscriptions wholly, or at least approximately, covers the costs of production. It is only through subsequent orders that a profit is made. This method automatically leads to a reduction in price when the number of subscribers increases. Thus in July 1952, we announced reduced prices for 1953 for the following periodicals: *Zeitschrift für Physik*, *Zeitschrift fur analytische Chemie*, *Biochemische Zeitschrift* (by DM 10 per volume), and *Archiv für experimentelle Pathologie und Pharmakologie* (by DM 8 per volume), that is, some DM 30 less per annum for each of the four periodicals.

A comparison with the cost of periodicals from other countries, particularly from Anglo-Saxon countries, is misleading, for conditions there are quite different.

(1) The number of subscribers is much larger than that to German periodicals. For example, the number of subscribers to the *Zeitschrift für Krebsforschung* is 400, and to *Cancer* 4,000. Our experience is that a reduction in price would not essentially change this proportion. We publish many special periodicals demanding numerous illustrations of high standard, and appealing to only a few hundred subscribers.

(2) Especially in the United States and Great Britain, the periodicals often receive financial support either from scientific societies or universities, or from the Government or from the author himself. For example, in the *Physical Review* and *Journal of Chemical Physics*, the author or his institute has to contribute 15 dollars per page. For the *Journal of Neuropathology* the author is not reimbursed for his expenses nor does he receive free separate prints, but is asked to answer for part of the costs of production.

With reference to particular points made by Dr. Bonser and Miss Russell, we wish to make the following comments:

(1) *Annual cost.* Since 1933, foreign libraries have received price lists every year showing the maximum cost for the coming year.

(2) With the exception of one Swiss journal erroneously mentioned, the list supplied to us by Dr. Bonser and Miss Russell in which Springer periodicals are compared with periodicals of other German publishing houses contains only periodicals which are published—or at least printed—in the Eastern Zone of Germany, where the costs of production are at most one-half as high, not considering the difference in currency exchange.

(3) The tables of the detailed list which Dr. Bonser and Miss Russell were kind enough to let us have can scarcely be considered as a basis, in so far as (*a*) a comparison is made not of the prices per sheet but of the total prices without regard to number of pages and get-up (number and quality of illustrations); (*b*) devaluation of sterling is mentioned but not allowed for in the tables; (*c*) it was due to measures (now abandoned) taken by the German Government to promote export that, during 1935–45, selling prices abroad were 25 per cent lower than on the home market.

Springer periodicals are published at the expense and risk of the publishing house alone. Costs of production of West German publishing houses had risen in 1949 to two and a half times the pre-war level and are now three times as high. The prices per sheet of Springer periodicals, on the other hand, average only twice as high as before the War.

SPRINGER VERLAG

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We wish to make the following reply to some of the points in the above letter from the Springer Verlag. It quotes from the fuller version of our paper, necessarily condensed in *Nature*, but now widely circulated.

The primary fact that the cost of German, and especially of Springer's, periodicals is far in excess of that of other countries still holds. The reduction in their sales which is likely to result must prove detrimental, scientifically as well as financially, to German progress.

The Springer Verlag points out that its periodicals are completely its own financial venture. We have already suggested, in our fuller paper, that a solution to the problem might be a change-over of responsibility to the German societies concerned, as has been done for certain publications in Great Britain and the United States.

We should like to reply to the following comments on details.

(2) The Swiss journal (*Annales Pædiatrici*) was not "erroneously mentioned" but was intentionally included, since it is the continuation of the German journal *Jahrbuch für Kinderheilkunde*, both of which have the same publisher now in Basle but formerly (until the end of 1938) in Berlin.

(3*a*) We actually did compare two journals from the point of view mentioned, namely, the *British Journal of Experimental Pathology* and the *Archiv für experimentelle Pathologie*, to the great disadvantage of the Springer periodical; (3*b*) it was pointed out that devaluation of sterling amounted to 45 per cent for American and only 26 per cent for German periodicals—the figures presented in our table are the resultant prices paid by us.

We feel that our table of comparisons still stands as a summary of facts, and we still hope that some means of reducing the cost of these essential contributions to knowledge, so as to be comparable with those of other German firms, may be possible.

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# FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

## Monday, March 2

SOCIETY OF CHEMICAL INDUSTRY, LONDON SECTION (joint meeting with the INSTITUTE OF PETROLEUM, at the Institution of Electrical Engineers, Savoy Place, Victoria Embankment, London, W.C.2), at 10 a.m.—Symposium on "Production and Utilization of Petroleum Raw Materials in the U.K. Chemical Industry".

BRITISH SOCIETY FOR THE HISTORY OF SCIENCE, PHILOSOPHY OF SCIENCE GROUP (in the Joint Staff Common Room, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Annual General Meeting.

SOCIETY OF ENGINEERS (at the Geological Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Mr. C. L. Boucher and Mr. D. Bagley: "Developments in the Recovery of By-Products from Coke Oven Gases".

UNIVERSITY OF LONDON (in the Anatomy Theatre, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Prof. A. Unsöld: "Some Recent Progress in Astrophysics".* (Further Lecture on March 4.)

UNIVERSITY OF LONDON (at King's College, Strand, London, W.C.2), at 5.30 p.m.—Prof. H. C. Longuet-Higgins: "Matter". (Inaugural Lecture in the Chair of Theoretical Physics.)*

## Tuesday, March 3

UNIVERSITY OF LONDON (in the Anatomy Theatre, University College, Gower Street, London, W.C.1), at 1.15 p.m.—Mr. A. R. Jonckheere: "Recent Experiments in the Psychology of Learning".*

SOCIETY OF PUBLIC ANALYSTS AND OTHER ANALYTICAL CHEMISTS, PHYSICAL METHODS GROUP (at the Chemical Society, Burlington House, Piccadilly, London, W.1), at 6.30 p.m.—Absorptiometry Meeting.

SHEFFIELD METALLURGICAL ASSOCIATION (in the Grand Hotel, Sheffield), at 7 p.m.—Mr. D. R. O. Thomas: "Technological Education in relation to the Iron and Steel Industry".

SOCIETY OF COSMETIC CHEMISTS OF GREAT BRITAIN (at the British Colour Council, 13 Portman Square, London, W.1), at 7 p.m.—Mr. J. K. Barraclough: "Dyes".*

## Wednesday, March 4

ROYAL SOCIETY OF ARTS (at John Adam Street, Adelphi, London, W.C.2), at 2.30 p.m.—Dr. C. B. Frisby: "The Assessment of Suitability for Employment".

## Thursday, March 5

ROYAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Sir Harold Hartley, F.R.S.: "Sir Humphry Davy, Bt., P.R.S." (Wilkins Lecture).

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 5.15 p.m.—Sir Lawrence Bragg, F.R.S.: "X-Ray Optics". (Further Lectures on March 12, 19 and 26.)

BRITISH INSTITUTION OF RADIO ENGINEERS, SCOTTISH SECTION (in the Lecture Theatre, The University, Glasgow).—Dr. J. M. Reid: "Electronics in Nuclear Research".

## Friday, March 6

INSTITUTION OF MECHANICAL ENGINEERS (joint meeting with the Steam Group, at Storey's Gate, St. James's Park, London, S.W.1), at 10.30 a.m.—Series of Papers from the Parsons and Marine Engineering Turbine Research and Development Association dealing with Steam Turbine Research and Development work carried out at their Research Station.

SOCIETY OF PUBLIC ANALYSTS AND OTHER ANALYTICAL CHEMISTS (at the Chemical Society, Burlington House, Piccadilly, London, W.1), at 2.45 p.m.—Annual General Meeting; at 3.15 p.m.—Dr. J. R. Nicholls: Presidential Address.

ROYAL INSTITUTE OF PHILOSOPHY (at University Hall, 14 Gordon Square, London, W.C.1), at 5.30 p.m.—Mr. Meyrick H. Carré: "Poetry and Philosophy".

UNIVERSITY OF LONDON (at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 5.30 p.m.—Prof. G. F. Marrian, F.R.S.: "Some Aspects of the Metabolism of the Steroid Hormones".*

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 9 p.m.—Prof. R. V. Jones: "The Pressure of Radiation".

## Saturday, March 7

NUTRITION SOCIETY (at King's College of Household and Social Science, Campden Hill Road, London, W.8), at 10.15 a.m.—Symposium on "Education in Nutrition in the United Kingdom".

LONDON COUNTY COUNCIL (at the Horniman Museum, London Road, Forest Hill, London, S.E.23), at 3.30 p.m.—Dr. John Layard: "The Journey of the Dead in Malekula, New Hebrides".*

JOINT BIOLOGY COMMITTEE and the ASSOCIATION OF AGRICULTURE (at University College, Gower Street, London, W.C.1).—Conference on "Plant and Animal Breeding".

# APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

LECTURER IN AGRICULTURAL CHEMISTRY—The Secretary, Edinburgh and East of Scotland College of Agriculture, 13 George Square, Edinburgh (March 7).

SCIENTIFIC OFFICERS (Grade 3) and SCIENTIFIC OFFICERS (Grade 1) for research and development in (a) radio transmission and reception at high and ultra-high frequencies, (b) modulation methods and terminal equipment, and theory connected therewith, (c) electronic and electromechanical equipment for computing and recording, and EXPERIMENTAL OFFICERS (Grade 3) and EXPERIMENTAL OFFICERS (Grade 1) for research or development associated with (a) radio transmission and reception at high and ultra-high frequencies, (b) modulation methods and terminal equipment, (c) electronic and electro-mechanical equipment for computing and recording; at the Electronic Research Laboratory, Salisbury, Australia—The Senior Representative, Department of Supply, Canberra House, 87 Jermyn Street, London, S.W.1 (March 7).

BIOCHEMIST at the Southport General Infirmary—The Secretary, Southport and District Hospital Management Committee, Promenade Hospital, Southport (March 9).

DEMONSTRATOR or ASSISTANT LECTURER IN THE DEPARTMENT OF PHYSICS—The Secretary, Bedford College, Regent's Park, London, N.W.1 (March 9).

DEPUTY DIRECTOR OF RESEARCH—The Director of Research, British Leather Manufacturers' Research Association, Milton Park, Egham (March 9).

LECTURER IN THE DEPARTMENT OF MINING AND GEOLOGY—The Principal, Wigan and District Mining and Technical College, Wigan (March 9).

ASSISTANT LECTURER IN ENGINEERING (with qualifications in civil engineering, with special interests in structures or hydraulics)—The Registrar, The University, Manchester 13 (March 11).

HEAD OF THE DEPARTMENT OF PHYSICS, Makerere College (University College of East Africa)—The Secretary, Inter-University Council for Higher Education in the Colonies, 1 Gordon Square, London, W.C.1 (March 12).

LECTURER IN MEDICAL STATISTICS—The Registrar, The University, Manchester 13 (March 12).

CHEMICAL ENGINEERS, MECHANICAL ENGINEERS, METALLURGISTS, THEORETICAL PHYSICISTS, CHEMISTS, and PHYSICISTS (Senior Principal Research Officer, Principal Research Officer, Senior Research Officer and Research Officer grades) in the Commonwealth Scientific and Industrial Research Organization, for research in the field of development of atomic energy as a source of industrial power—The Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting No. 4157 (March 14).

RESEARCH WORKERS (2, one with zoological, the other with botanical training) to establish a unit for the study of the ecology of polluted rivers and streams—The Director, Freshwater Biological Association, The Ferry House, Far Sawrey, Ambleside, Westmorland (March 14).

ANALYST (with sound experience in the analyses of fertilizers, soils and other agricultural materials) IN THE DEPARTMENT OF CHEMISTRY—The Registrar, Wye College, Wye, Ashford, Kent (March 16).

BOTANIST (Assistant Lecturer grade) in the Marine Biology Station—The Secretary and Registrar, University College of North Wales, Bangor (March 17).

ASSISTANT LECTURER IN MATHEMATICS (with special qualifications in applied mathematics)—The Registrar, The University, Manchester 13 (March 18).

HEAD OF THE DEPARTMENT OF MECHANICAL ENGINEERING—The Registrar, College of Technology, Suffolk Street, Birmingham 1 (March 20).

HEAD OF THE DEPARTMENT OF MATHEMATICS, and a LECTURER or ASSISTANT LECTURER IN CHEMISTRY (preferably in physical inorganic chemistry), at Makerere College (University College of East Africa)—The Secretary, Inter-University Council for Higher Education in the Colonies, 1 Gordon Square, London, W.C.1 (March 21).

AGRICULTURAL OFFICER (with degree in agriculture or equivalent, with at least two years postgraduate experience) in Sarawak, for extension and investigational work in a district under fairly strenuous conditions—The Director of Recruitment, Colonial Office, Great Smith Street, London, S.W.1, quoting CDE.63/24/02.

AGRICULTURIST (with degree in agriculture or horticulture and, preferably, with knowledge of commercial date cultivation) in the Somaliland Protectorate, to take charge of experimental scheme for date cultivation with a view to its eventual expansion—The Director of Recruitment, Colonial Office, Great Smith Street, London, S.W.1, quoting CSC 63/5/01.

CHEMIST (with good honours degree in chemistry or agricultural chemistry, and postgraduate research experience, preferably in soil science) IN THE DEPARTMENT OF SCIENCE AND AGRICULTURE, Barbados, for investigational and advisory work on soils, soil survey and analysis, manurial trials, etc.—The Director of Recruitment, Colonial Office, Great Smith Street, London, S.W.1, quoting CDE 83/28/01.

CIVIL ENGINEERS in various branches of the Public Works Department in Nigeria, for general civil engineering, irrigation projects, rural and urban water supplies, road development, etc.—The Director of Recruitment, Colonial Office, Great Smith Street, London, S.W.1, quoting CDE.112/14/03.

METEOROLOGIST (with a first- or second-class honours degree in mathematics or physics) in Nigeria, for meteorological forecasting, research, climatology and administrative duties involved in the organization of the Service—The Director of Recruitment, Colonial Office, Great Smith Street, London, S.W.1, quoting CDE.57/14/01.

SCIENCE GRADUATE (preferably with some research, production, or information experience) as scientific assistant in the Information Department—The Information Officer, British Scientific Instrument Research Association, Sira, Southill, Elmstead Woods, Chislehurst, Kent.

SENIOR LECTURER IN CHEMICAL ENGINEERING—The Principal, West Ham College of Technology, Romford Road, London, E.15.

TEACHING AND RESEARCH ASSISTANTS (part-time) IN THE DEPARTMENT OF PHYSICS—Dr. A. B. McLay, Chairman of the Physics Department, Hamilton College, McMaster University, Hamilton, Ont., Canada.

ZOOLOGISTS (with good honours degree in zoology, and at least two years postgraduate experience) in the East African Tsetse and Trypanosomiasis Research and Reclamation Organization, for research into distribution and behaviour of tsetse fly and their ecological background—The Director of Recruitment, Colonial Office, Great Smith Street, London, S.W.1, quoting CDE.77/88/01.

# NATURE

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# OVERSEAS DEVELOPMENT AND MAN-POWER PROBLEMS

THE Volta River aluminium scheme[*] set forth in a White Paper issued in November 1952 is of exceptional interest, quite apart from its possible contribution to the supply to the industry of the United Kingdom of aluminium from within the 'sterling area' at competitive prices. Under the scheme the United Kingdom Government, the Gold Coast Government and the producers would develop the resources of water-power and bauxite in the Gold Coast to yield ultimately 210,000 tons of aluminium annually. An initial capital expenditure of about £100 million would be required, rising eventually to £144 million, and in the White Paper the British Government states that it believes the scheme to be soundly conceived. The magnitude of the undertaking is such, however, that it considers that the scheme should not be embarked upon without every practicable assurance that it can be carried through to a successful conclusion. The British Government proposes, therefore, with the agreement of the Gold Coast Government and the aluminium producers, to set up at once a Preparatory Commission to follow up the work already done and to examine in greater detail the chief problems which would have to be overcome. This Commission would be instructed to report with all practicable speed so that final decisions could be taken as soon as possible. The cost of this Commission, of which Commander R. G. A. Jackson will be in charge (see *Nature*, February 21, p. 330), will be shared in the first place between the Governments of the United Kingdom and of the Gold Coast.

The wider interest of the scheme is derived, however, from its bearing on Colonial development and welfare. In commending the scheme, the White Paper points out that as one result the Gold Coast would be enabled to develop further its mineral wealth and to create a new source of power of great potential benefit to its future social and economic progress; and a reason given for favouring participation in the scheme by the British Government is that it would further the Government's policy of encouraging the development of the resources of the Commonwealth as well as contributing to the raw material needs of the United Kingdom. This applies particularly to the hydro-electric aspect of the scheme. The possibility of developing hydro-electric power from the Volta River, which is the principal river of the Gold Coast, with a total length of some 1,000 miles and a drainage area of about 150,000 square miles, of which roughly 40 per cent lies within Gold Coast territory, has been considered at various times during the past three decades. Proposals for the construction of a dam at Ajena in the Akwapim Hills for generating power for the production of aluminium were considered by the Gold Coast Government in 1924; but a detailed survey started in 1938 by Mr. Duncan Rose was interrupted by the Second World War. Six years later, West African Aluminium, Ltd., was formed with Mr. Rose as chairman to carry the scheme further, while in January 1951 a joint mission of Aluminium, Ltd., of Canada and the British Aluminium Co., after further detailed study, reported that the scheme prepared by West African Aluminium, Ltd., was a sound engineering proposition and could produce aluminium at an economic cost.

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[*] Volta River Aluminium Scheme. (Cmd. 8702.) Pp. ii+22. (London: H.M. Stationery Office, 1952.) 9d. net.

Meanwhile, the Gold Coast Government, which had long recognized the possibilities of the Volta River, but which also realized that the heavy capital expenditure required would not be justified unless there were adequate industrial outlets for the large quantities of power produced, decided that the development of the Volta River basin should be viewed as a whole and in relation to the total economy of the Gold Coast, rather than merely in relation to the most important immediately visible outlet for power. In October 1949 it engaged Sir William Halcrow and Partners to undertake a survey of all aspects of the Volta River development, including not only hydro-electric power but also irrigation and drainage of lands in or near the catchment of the river, navigation on the river, transport and port facilities. The British Government itself both encouraged the examination of the practicability of aluminium production in the area by the joint mission of Aluminium, Ltd., and the British Aluminium Co. already noted, and provided in the year ended March 31, 1950, £15,000 for a scheme made under the Colonial Development and Welfare Acts for a comprehensive survey of all aspects of the scheme to determine the potential value of the river. During 1951–52 a further £19,000 was provided for a scheme for an aerial survey of part of the Volta River basin in connexion with the projected hydro-electric scheme.

Sir William Halcrow and Partners submitted a preliminary report dated July 25, 1950, and in a final report on August 15, 1951, set out a scheme for the development of the Volta basin. So far as it related to aluminium production, this report was the basis for the subsequent exploratory discussions between representatives of the United Kingdom and Gold Coast Governments, of Aluminium, Ltd., and of the British Aluminium Co. in October and November 1951 and in May 1952 in London, and in June 1952 in Accra. The discussions considered the conditions under which the two Governments and the aluminium companies might jointly participate in a scheme for aluminium production in the Gold Coast, and the scheme proposed in the White Paper is the outcome of these discussions.

The scheme now proposed envisages the construction of a dam and power-station at Ajena in the gorge through the Akwapim Hills and would create a lake with an area of some 2,000 square miles. After allowing for other users in the Gold Coast, the power available from the hydro-electric installation would suffice for an aluminium smelter, operating on bauxite drawn from reserves within the Gold Coast, and sited at Kpong, twelve miles from the dam, to produce 210,000 tons of aluminium a year. The smelter and bauxite mines would be managed by private enterprise through a smelter company financed mainly by the aluminium companies with some support from the Gold Coast Government, though the scheme contemplates that up to half the capital required to expand the capacity of the smelter from its initial 80,000 to 120,000 tons a year may be provided by the United Kingdom Government.

The United Kingdom and Gold Coast Governments would be jointly responsible for financing the hydro-electric undertaking as a whole, the ultimate cost of which is estimated at £54 million. Apart from a minimum of £8 million contributed by the Gold Coast Government, which would be solely responsible for facilities for the distribution of power to other users besides the smelter, this would be borne by the United Kingdom Government, whose maximum expenditure is visualized at £56·8 million. The Gold Coast Government would be responsible for providing the £26 million required for port, rail, road facilities and other public works. Apart from that fraction of capital for the smelter provided later by private investors, the remainder of the £144 million for the whole scheme would be provided by the Gold Coast Government or the aluminium companies.

As already indicated, the scheme contemplates extensive public works. Establishment of an aluminium industry of this magnitude would necessitate construction of a new port conveniently situated to serve its needs. Accra has already reached the limit of its capacity and is unsuitable for further development as a port. Takoradi, the only major port in the Gold Coast, has recently been extended, but Sir William Halcrow and Partners recommended that a new port to serve both the general and the aluminium needs should be constructed at Tema, about twenty miles east of Accra. After obtaining a second opinion the Gold Coast Government has already decided to construct a new port at Tema, whether or not the whole scheme is undertaken, and preliminary work is in hand.

Besides this, a considerable development of communications would be required, particularly of railways, linking the new port at Tema with both Accra and Kpong and providing for movement of the bauxite by rail. Existing roads would need improvement and new roads would have to be built. It is proposed accordingly that the Gold Coast Government should set up a Volta River Authority, which would be responsible for co-ordinating all planning and construction work arising out of the Volta River scheme, including the building of the dam and power station, the aluminium smelter and alumina works, port and railway facilities, roads and townships. On completion of the construction work, the Volta Electricity Board would be set up to assume responsibility for the management of the power undertaking and also for the installation of additional generating units, transmissions and extension to the original works.

It is this aspect of the scheme which strikes the imagination. The analogy with the Tennessee Valley Authority is unmistakable, and from the caution with which both the Gold Coast Government and that of the United Kingdom are proceeding it is clear that in the minds of all concerned the development and welfare of the people of the Gold Coast and not the exploitation of an important mineral resource are the dominant considerations. The appointment of a preparatory commission to examine in greater detail the chief problems which would have to be overcome shows that the lessons of earlier failures, such as the groundnuts scheme in East Africa and the poultry scheme in Gambia, have been learnt; and the Gold Coast Government, no doubt with the warning of Abadan in mind, is no less anxious to avoid even the appearance of an infringement of national independence.

If the scheme proves practicable and the technical problems can be surmounted, the financial proposals appear to be reasonable and flexible enough to accommodate political changes if they are made in good faith. To execute the scheme, moreover, demands not merely the supply of capital by Great Britain and a further drain on the country's limited supplies of technical experts, but also co-operation over a period of years between such experts and the peoples of the Gold Coast. Under the proposed Volta River Authority, the people of the Gold Coast should receive a training in responsible local administration which may itself materially smooth the path for the advance of the Gold Coast towards Dominion status. The very conditions essential for the technical execution of the scheme involve a spirit of co-operation and mutual understanding and a training in democratic methods calculated to engender the atmosphere and the goodwill which are the best safeguards against dangers from prejudice, misunderstanding and racial sentiment a generation or more hence.

The importance of this factor was stressed by Lord Rennell in a debate in the House of Lords on the Gold Coast last July, and it affects equally the Technical Assistance programme of the United Nations. Lord Rennell inquired specifically regarding the relationship between the new nationalist governments which are being set up and European capital and investors, on one hand, and their own European staff, on the other. It is unlikely, he pointed out, that either capital or technologists would be attracted to the Gold Coast from Britain and the United States for the Volta River scheme unless the sponsors of the scheme have confidence in the direction of constitutional development there. The Parliamentary Under-Secretary of State for the Colonies, the Earl of Munster, in replying to the debate, was able to supply evidence that Dr. K. Nkrumah and the Ministers of the young Gold Coast Government recognize the need both to maintain the goodwill of overseas investors and to retain the services of their European staff, and are dealing with some success with the difficulties caused by the anti-European feeling which brought them to power.

Nevertheless, as was emphasized in a recent broadsheet from Political and Economic Planning (see *Nature*, 170, 679; 1952), the supply and quality of the technical experts remain the critical factors, and in this respect the Volta River scheme is no exception. Such questions as the numbers of technical experts required and the conditions of service to be offered to them are among the most important which the Preparatory Commission will have to consider. Failure to handle them in a way which will attract men of the requisite calibre would jeopardize the execution of the scheme no matter how excellent its technical merits. Moreover, although the situation in regard to scientific and technical man-power for such projects may be easier than in November 1949, when Dr. W. F. P. McLintock expressed the view before the Parliamentary and Scientific Committee that Great Britain's man-power resources in this field were already strained to the utmost (cf. *Nature*, 165, 251; 1950), it must not be assumed that no special efforts will be required to find the necessary staff or that the effect on the man-power situation can be disregarded. So late as May 1952, Lord Reading expressed the view that our own man-power was still severely strained, and it would seem that a report from the sub-committee of Lord Hankey's Technical Personnel Committee which is dealing with overseas requirements is overdue.

The last report on "Colonial Research" and the survey "The Colonial Territories 1951–52" both indicated some improvement in the staff position in the Colonial Service. Apart from this, up to September 30, 1952, Great Britain had offered 65 technical experts against a total of 136 requested under the technical co-operation scheme of the Colombo Plan. It has also offered 416 of the 613 training places requested, as well as a further 300 places against which nominations have yet to be made by Colombo Plan countries. These requests are chiefly for India, Pakistan and Ceylon: the needs of Burma and Indonesia have as yet scarcely been charted.

Thus the need for technical help in southern Asia is likely to exceed supply for a long time to come. Even, therefore, if the strain on the world's scientific and technical man-power is diminished by the new method of technical assistance for backward countries adopted by the United Nations, under which collective advice is given by the developed countries, it may still be necessary for the execution of such schemes to contemplate the recruitment of experts not merely from Great Britain but also from elsewhere. The United Kingdom Government itself has suggested that, in view of the difficulty of finding suitable experts for specific projects, requests for the services of British consultant firms and technical consultants could be considered as part of the Colombo Plan. Such requests have already been received from India, Pakistan and Ceylon and are being negotiated.

However successful the fuller use of scientists or technologists as consultants may prove in meeting the situation, more also in the way of international co-operation may well be required. The Parliamentary and Scientific Committee when discussing the general problem had Anglo-American co-operation specially in mind; but there is also a considerable reservoir on the European continent which could be tapped. Switzerland, Denmark, Austria and Western Germany might well contribute appreciably to the numbers of engineers, scientists and medical men required for such schemes as the Volta River project under appropriate conditions, and there might be advantages in recruiting overseas staff from different countries, provided the essential conditions were fulfilled.

Those conditions, upon which the successful execution of even the soundest development scheme depends, are not purely technical on either side. Good faith and goodwill, vision and understanding as well as technical and scientific competence are required of the expert. Good faith and goodwill and imagination must no less be shown by the responsible government of the territory concerned. On that government rests, further, the responsibility for establishing the conditions which will both attract the capital required for development and the men to carry it out. Above all, having attracted the experts of the necessary quality, it must provide the conditions of service which will enlist their loyalty in the imaginative service not merely of one territory or people but, through that people and territory, of mankind.

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## PHYSICS OF THE EARTH

### The Earth

Its Origin, History and Physical Constitution. By Dr. Harold Jeffreys. Third edition. Pp. xiv+392+10 plates. (Cambridge: At the University Press, 1952.) 70s. net.

A COMPARISON between the third edition of Jeffreys's book, "The Earth", long awaited by geophysicists and geologists, and the second edition (1929) brings out the developments in geophysics in recent years. In some geophysical fields the ideas of twenty-five years ago have been confirmed and expanded; in others they have had to be abandoned and frequently replaced by a variety of hypotheses conflicting with each other. In this latter group belong the hypotheses on the origin of the solar system and the earth. The chapters previously devoted to these subjects have been omitted in the new edition, which begins with fundamental equations of elastic and non-elastic motions. Unfortunately, experimental research on creep and plastic flow is still in its early stages, whereas the theoretical treatment of such processes and of fracture in the earth is very complicated except with very special assumptions. A short discussion of rock types and minerals concludes the first chapter.

Chapter 2, the theory of elastic waves, forms the basis for Chapter 3, on observational seismology, which opens with a few remarks on seismographs (pp. 64–65). In the discussion of records of nearby earthquakes, Jeffreys is handicapped by the fact that the European material on which he relies to a great extent is inferior to that available in several other regions of major activity. Data from the latter show more 'disturbing features' than Jeffreys mentions and leave little doubt that our ideas concerning the outer layers of the earth, including the so-called granitic layer in the continents, are even less certain than indicated by him. This chapter also includes discussions of travel times, of body waves and of surface waves, with examples of their use in determining the structure of the earth. In the concluding pages (119–120) of Chapter 3 a few hypotheses on microseisms are mentioned with some details concerning the ideas of Deacon, Longuet-Higgins and Miche concerning the process in which energy is transmitted from ocean waves to the bottom. Chapters 1 to 3, seismology in a wide sense, cover the first third of the book.

In Chapter 4 the figure and density of the earth are discussed. Here, as in other parts of the book, much is based on Jeffreys's own research. Some of the always-changing hypotheses concerning the outer and inner core—iron or high-pressure form of olivine or other material—are treated. Chapter 5 includes a discussion of the gravity field of the earth and of isostasy. Chapter 6 begins with theoretical problems connected with static loads. Solutions for elastic and non-elastic conditions are considered, and gravity anomalies are discussed. Jeffreys concludes that stress differences of at least $1{\cdot}5 \times 10^7$ dynes/cm.$^2$ exist within the outermost 50 km. of the earth and that differences of the order of $2 \times 10^8$ may exist between depths of 50 to 600 km. without producing fracture.

Chapter 7 contains details of the theory of variations of latitude and the bodily tides of the earth and a discussion of the associated constants, and the succeeding chapter is devoted to tidal friction of the earth and other planets with some remarks on the resonance theory of the origin of the moon. Thus Chapters 4–8 (pp. 121–248) mainly cover geodetic problems.

The last third of the book begins with methods used to determine the age of the earth (Chapter 9). "There is general consistency with an age in the neighbourhood of 2000–3000 million years." The question as to whether the earth started as a hot or cool body enters here, as well as the problem of the thermal history of the earth (Chapter 10, pp. 271–302). If the earth was originally liquid and cooling, the solution of the problem as to where solidification started depends on the relationship between melting-point gradient and adiabatic gradient. Jeffreys believes that the former exceeds the latter at all depths, and that the earth's shell solidified from the bottom upwards. During solidification materials separated; some details are discussed. The problem of the heat developed in radioactive processes leads to a more detailed discussion of the radioactivity of rocks at present and in the past, and its effect on the assumed cooling of the earth. In the mantle, the depth where the temperature approaches the melting point most closely is most likely at the bottom of the 'intermediate layer' in the continents. Recent findings of a relatively large heat flow in the bottom of the Pacific remain unexplained. Jeffreys discusses here once more the composition of the core in the light of recent ideas about atomic structure, as well as Bullen's hypothesis that in the deeper parts of the earth the bulk modulus is mainly a function of pressure.

Chapter 11 is devoted to the origin of the earth's surface features and to geotectonic hypotheses such as the contraction theory (which Jeffreys supports) and convection theories. Also included are remarks on changes in the earth's rotation, elastic instability, the origin of the continents and ocean basins, and on volcanism. In Chapter 12, Jeffreys discusses various phenomena such as after-shocks, movements of the earth's axis, continental drift, surface features of the moon and growth of continents. On pp. 357–371 he gives a mathematical background for some of the problems. The book concludes with some "Notes" on recent findings, and a subject index.

Unfortunately no geophysicist can now be familiar with the progress made in all fields of geophysics nor study in detail the whole literature. Thus, in this new edition little or no space is devoted to problems concerning the earth's magnetism and to the results of Benioff or of M. Ewing and his group. Some geophysicists, geologists or geochemists will find that the discussion of one of their special problems is not quite up to date. But there can be no doubt that a study of the new edition of this classical work is essential for all those who are interested in the development and structure of the earth or in the properties of its interior. B. GUTENBERG

## TEXT-BOOK ON PLANT PROTECTION

Elements of Plant Protection

By Dr. Louis L. Pyenson. (Wiley Farm Series.) Pp. x+538. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1951.) 40*s*. net.

DR. L. L. PYENSON has produced a comprehensive elementary text-book of plant protection. All types of plant pests are dealt with—animals, both invertebrate and vertebrate, fungus and virus diseases, and weeds. In addition, there is a section dealing with equipment required for combating plant pests.

Throughout the book the author's aim has been to emphasize the general principles underlying all plant protection rather than to specify each and every control method. He has therefore divided the book into a number of sections, each dealing with a particular group of plant pests, and he has introduced each section by one or more chapters describing simply the biology of the group. These introductory chapters are perhaps unnecessarily elementary for the majority of students; but they do emphasize that there must be a sound knowledge of the biology of a given pest before a suitable method for its control can be selected. Unfortunately, some of the information they contain has been over-generalized to the point of inaccuracy; the description of the characteristics of the insect nervous system (p. 29) is an example. But the author's wide experience has enabled him to present a balanced account of plant protection and to assess all control methods strictly at their true value.

Many features of the book are excellent, especially the diagrams detailing the life-histories of a large number of plant pests and the tables setting out such diverse things as the diets of various birds, the purposes and limitations of various insecticides, pests and plant diseases associated with certain weeds, and the compatibility of common spray materials, to mention only a few.

The information on the control of insect pests is sound, and, as a result of the approach by way of general principles, biological control is given fair consideration. Control of fungus and virus diseases of plants and weed control are also well described, while the section on application equipment is excellent. Of course, a good deal of the more specialized information given applies only in the United States. Also, the colloquial names of the species mentioned in the text are American and often not current in Britain. The latter difficulty is not very serious, since the scientific name is nearly always quoted in addition to the colloquial one. Each chapter is followed by a list of questions, which are well chosen and stimulate a critical and reasoned approach to the subject. The somewhat condensed style of writing presumably results from including so much information in a book of such modest size. This conciseness, however, while making the book less readable, has not interfered with its lucidity. The book is well produced and the printing legible; but the pages present a somewhat untidy appearance due to the method of word-spacing used. P. E. BURT

## WAVE MECHANICS FOR BEGINNERS

Elements of Wave Mechanics

By Prof. N. F. Mott. Pp. ix+156. (Cambridge: At the University Press, 1952.) 21*s*. net.

ALTHOUGH the principles of wave mechanics have been well established for almost a quarter of a century, there is, at present, no unanimity of view regarding the most satisfactory way of presenting the subject to the beginner. A glance at the introductory chapters of the numerous books on wave mechanics, or quantum mechanics, published in recent years shows the extent to which authors differ in their method of introducing the new principles. Some favour an axiomatic approach and base the theory on a few precisely stated postulates the justification of which is simply that they lead to a successful theory. Others prefer a more historical approach in which the Correspondence Principle of Bohr and the analogies with geometrical and wave optics are stressed.

In this new book, which is intended to replace the older "An Outline of Wave Mechanics", Prof. N. F. Mott presents the theory as a logical development from what are now well-established experimental data. He writes: "The theory will be based on a single experimental fact, the diffraction of electron beams". There are undeniable advantages in this approach to the subject, and it is no objection to the method that the theory was, in fact, well established before these particular experiments were made. With the skill of an experienced teacher, Prof. Mott leads the student on, from the wave equations of classical physics to the fundamental Schrödinger equation, with a minimum of discomfort and a considerable sense of continuity. The well-known stumbling blocks, such as the complex character of the wave function and the linearity in the time of the time-dependent Schrödinger equation, are met and most skilfully disposed of, and, by a series of well-chosen examples, the principal features of wave mechanics are brought to light.

For a book of this size a surprisingly large field of physics is covered. Apart from the more usual topics, such matters as the excitation of an atom by a passing proton or $\alpha$-particle are dealt with; there is a section on the theory of solids, and another on molecular structure; a few words are devoted to the relativistic wave equation and the positron; and the essentials of the theory of $\alpha$- and $\beta$-decay of nuclei are made clear. A feature of the book which will commend it to both students and teachers is the inclusion of a number of well-chosen exercises.

The author says in the preface that this book was written for students of experimental physics and to serve as an introduction to more advanced books for those who intend to specialize in this subject, and to these categories of students it can be unreservedly recommended. If those who afterwards study the more advanced text-books should be surprised at the difficulties they encounter, that will be due, not to any lack of rigour in their introduction to the subject, but to the skill with which they have been led along the smoothest paths at the beginning of their journey.

H. Jones

## SECOND BERKELEY SYMPOSIUM ON STATISTICS

### Proceedings of the Second Berkeley Symposium on Mathematical Statistics and Probability

Held at the Statistical Laboratory, Department of Mathematics, University of California, July 31–August 12, 1950. Edited by Jerzy Neyman. Pp. xi+666. (Berkeley and Los Angeles: University of California Press; London: Cambridge University Press, 1951.) 11 dollars.

A collection of papers presented at an international conference is apt to be disappointing. The proceedings take so long to appear in volume form that an author with something new to say is apt to publish it elsewhere for fear of anticipation. It has also to be admitted that some contributors have nothing much to say but think that the occasion is too good to let pass without sharing the limelight. In consequence, the final records of a conference tend to become monuments of past endeavour, with the magnificent façade of a mausoleum and about as much vitality as its contents.

But there are exceptions, and the Second Berkeley Symposium is among them. There are papers in this collection which will long be consulted as major contributions to mathematical statistics. Prof. J. Neyman is to be congratulated on the standard maintained by the contributors. The First Symposium was good, but this is even better, and if Prof. Neyman can continue at this level the Berkeley Symposia will take a high place among the statistical literature of the world.

There are forty-six papers in the collection: thirteen on mathematical statistics, fourteen on probability, five on astronomy, two on biometry, three on econometrics, five on physics, two on traffic engineering and two on wave analysis. The contributors to the first symposium were all United States citizens, but this collection contains some very distinguished foreign names—Cramér, de Finetti, Paul Lévy, Lindblad and Kampé de Fériet. There is, alas, no member of the British Commonwealth among them, but perhaps Prof. Neyman will remove this serious drawback in the third symposium which he hopes to organize.

Of the group on mathematical statistics, Wald's paper on asymptotic minimax solutions of point-estimation problems and Hoeffding's on optimum non-parametric tests, though written in abstract style, are well worth the trouble of mastering, a remark one cannot always make of papers in this subject. Hotelling, writing on a generalization of the $T$-test, shows how a difficult subject can be made lucid and readable. Blackwell's paper on the "Comparison of Experiments", following work by Bohnenblust, Shapley and Sherman, will be of general interest. An experiment $\alpha$ is said to be more informative than an experiment $\beta$ if, for every possible risk function, any risk attainable with $\beta$ is also attainable with $\alpha$. On this basis one can develop a kind of logic of experiment and set up criteria for the choice of methods leading to results which are by no means intuitively obvious.

The group of papers on probability are mainly written around the theme of dynamic probabilities: Paul Lévy on Wiener's random function, Kac on some connexions between probability theory and differential and integral equations, Feller on diffusion processes in genetics (a very readable little paper), several papers on random walks and ergodic theorems, and one by Doob on "Continuous Parameter Martingales"—a title which, rightly handled, could have added much to the gaiety of the proceedings.

I am not competent to express an opinion on the merits of the papers on astronomy and physics, but the papers by Lindblad on the dynamics of stellar systems, by Struve on stellar evolution considered statistically, and by Elizabeth Scott on the distribution of the elements of spectroscopic binaries, offer some interesting new statistical problems. The group on physics (Feynman on the concept of probability in quantum mechanics, Lewis on statistical questions in meson theory, and Lenzen on the philosophical problems of the statistical interpretation of quantum mechanics) indicate the advent of a useful *rapprochement* between statistics as generally studied and the specialized statistics of physical systems.

The two papers in the biometry section are somewhat misleadingly placed, for both raise questions of general interest. Cochran writes on improvement by means of selection, an important but neglected topic. Berkson, who is building up a reputation as the *enfant terrible* of the biometric world, shows by experiment and example that minimum chi-squared can be better than maximum likelihood in certain cases, a result which will make many of us think again about certain problems in statistical estimation.

In the econometrics section, Kuhn and Tucker write on non-linear programming, Marschak on "Why should Statisticians and Businessmen Maximize Moral Expectation?" (nobody claims that they do, but it is an interesting problem in decision-theory to ascertain why they should), and Arrow on classical welfare economics. Papers in the traffic engineering section on the distribution of vehicle speeds and travel times are significant contributions to congestion problems; and to conclude there are two interesting papers on the analysis of ocean waves by the correlogram. It is tragic to have to record that the author of the last paper in the book, H. R. Seiwell, like the author of the first, Abraham Wald, lost his life in an accident since the symposium was held.

A mere list of these papers indicates the enormous range of statistical methods at the present time. A glance through them will show what demands many of the subjects make on mathematical expertise, experimental skill and computational patience. A statistician is torn between pleasure at the extensive use made of his methods and regret at his inability to keep up with so many different developments. One of the most useful features of a collection like this—some of the papers being in the nature of reviews of current work—is that it enables one to see the main currents and to form a broad picture of what is going on. It only remains to say that the book is handsomely produced. The price may put it beyond the reach of the student, but all statistical libraries should possess it.

M. G. Kendall

# INSTRUMENTATION OF NUCLEAR REACTORS

AT a general meeting of the Institution of Electrical Engineers, held in the Institution's Lecture Theatre on January 8, a symposium of papers on the instrumentation of nuclear reactors was organized, at which about five hundred members and visitors attended, including guests from nuclear energy projects in France, Holland, Sweden, Norway and Italy. Colonel B. H. Leeson, president of the Institution, took the chair and introduced Sir John Cockcroft, whose lecture on "Nuclear Reactors and their Applications" provided a general background for the three specialized papers which followed.

Sir John began by describing the fission process, in which interaction between a neutron and a uranium atom may result in absorption of the former followed by fission of the latter, accompanied by the liberation of further neutrons and the release of energy. The probability of occurrence of this reaction depends upon which isotope of uranium is concerned, and upon the energy of the incident neutron. A system designed to enhance this probability is known as a nuclear reactor, and a classification into three main types is possible: these are known as fast, intermediate and thermal reactors, according to the energy-level at which it is intended that the incident neutron will cause fission. The critical state of a nuclear reactor occurs when, out of the neutrons released in an average fission, one survives all the processes leading to neutron waste, and initiates a further fission. If, however, more than one survives, a cumulatively increasing or divergent reaction results. If the number surviving is smaller than unity, the reaction diminishes until the fissions occur at a rate proportional to their rate of spontaneous occurrence in an isolated sample of uranium. The number of survivors thus defined is known as the reproduction factor, denoted by the symbol $K$; while the reactivity is denoted by $(\delta K) = K - 1$.

Fast-fission reactors require a predominating proportion of the uranium-235 isotope in their design, as the 238 isotope can absorb high-energy neutrons quite strongly without fission occurring. Thermal reactors overcome this difficulty by surrounding the uranium in which the fission occurs by a moderator, the function of which is to absorb the energy of the neutron in a series of scattering collisions. Neutrons of thermal energy (about a fortieth of an electron-volt) are only slightly absorbed by uranium-238. The size of such a reactor is quite large, the mass of 'natural' uranium in the Harwell British Experimental Pile known as BEPO being forty tons and the mass of moderator (graphite in this case) eight hundred tons; 'natural' uranium occurs in the proportions 140 parts of uranium-238 to 1 part of uranium-235. The critical size of a thermal neutron reactor may be reduced by artificially increasing the proportion of uranium-235 present in the uranium, and this sub-type of thermal reactor is known as an enriched reactor.

The third reactor-type employs a neutron energy for causing fission intermediate between fast and thermal, that is, some moderator is used. This is known as an intermediate reactor, and is likely to have importance for mobile nuclear power-plants.

The most important characteristic of a reactor is its neutron balance. A typical balance-sheet for a graphite-moderated thermal neutron reactor is as follows:

| | |
|---|---|
| Neutrons produced in fission of uranium-235 and in fast fission | 2·56 |
| Neutrons carrying on the chain reaction | 1 |
| Neutrons absorbed in uranium-238 to produce plutonium-239 | 0·9 |
| Neutrons absorbed in uranium-235 to produce uranium-236 | 0·2 |
| Neutrons absorbed in moderator | 0·3 |
| Neutrons absorbed in structural materials | 0·05 |
| Neutrons escaping from core | 0·09 |
| Excess neutrons | 0·02 |
| | 2·56 |

Temperatures and neutron-absorbing properties of fission residues affect this balance-sheet and adequate excess $K$ must be allowed for. Since, however, steady-state operation means that $K = 1$, control rods have to be provided to absorb any excess of neutrons not required at any particular time.

The plutonium-239 mentioned on the balance sheet can be split by slow neutrons, so that this provides a means of utilizing some of the uranium-238 in addition to the uranium-235. An ideal reactor would produce more secondary fuel (that is, plutonium-239) than primary fuel burnt (that is, uranium-235). With such a 'breeder' reactor we could expect to burn up a great part of the uranium-238.

Having briefly surveyed the principles of nuclear reactor operation, Sir John Cockcroft then discussed some of the technical problems of reactors, under the four groupings of physical, metallurgical, chemical and engineering. The physicists are responsible for the calculations of critical size, supplemented and checked by 'exponential experiments' on a sub-critical reacting-core. They must also determine the adequacy of the means of control and the shielding required. Metallurgists are concerned with the preparation of the uranium fuel elements. Due to the peculiar lattice-structure of uranium, serious distortion may be caused by thermal cycling and exposure to radiation. The uranium is sheathed in a suitable metal to seal it completely, and this metal must resist radioactive irradiations, not absorb too many neutrons and withstand the temperatures required by the engineers. Chemical reactions may be accelerated under irradiation, and chemists are required to study corrosion effects between reactor materials. The engineers have to weave together all these components into a feasible design, including the heat-transfer arrangements, the provision of adequate cooling in all circumstances, control and safety.

Turning next to reactors for producing power, Sir John distinguished between the production of substantial quantities of economic power and the development of specialized power-units, for example, for ship propulsion. The first stage in achieving the former target might well be the construction of thermal neutron reactors using natural uranium as a fuel, and either heavy water or graphite as a moderator. Design studies of this type of plant indicate that sizeable blocks of power could be generated at 20–25 per cent efficiency and that, making the conservative assumption that the capital cost of the nuclear station would be twice that of its coal-fired counterpart, and taking realistic figures for the cost of uranium, the cost of the power generated would not be greatly different from conventional practice.

Sir John stressed that no credit is allowed in the above figures for the value of the residual plutonium. If, for example, of the uranium-235, one-third were consumed, or 2·3 kgm./ton, the reactor would have produced 1·5–2 kgm. of plutonium per ton. This would then be available as a basic fuel for the second stage of the power development programme, the breeder reactor stage.

The first approach to breeder reactors will be to develop fast-fission reactors for this purpose, taking advantage of the greatly reduced absorption of fast neutrons by the materials of construction in reactors, and probably using plutonium as the fuel because its average neutron release is nearer 3 than 2·55. An experimental power-producing fast reactor has been working for some time in the United States and made up of a core, "about the size of a regulation football", consisting of uranium with a very high proportion of uranium-235 canned in some suitable metal. The heat developed by the burning of the uranium-235 is removed by the circulation of liquid sodium – potassium alloy. The liquid metal passes through a heat exchanger, and steam is developed to drive a 250-kW. power unit. It has not been made public whether breeding has been achieved, although it is said to be "a promising youngster".

Sir John next reviewed the contribution of nuclear power to the resources of world energy, taking his figures (which are in $10^{18}$ B.Th.U.) mainly from the recent report of the Materials Policy Commission to the President of the United States: the present world annual output of energy is 0·2; the world reserves of coal are United States 7·6, Canada 2, United Kingdom 1, China 6, U.S.S.R. 10 and others 6, the whole totalling 33; and the total world reserves of oil are, proved 1 and unproved 4·6, totalling 5·6. The same report estimates that about 25 million tons of uranium are available if we are prepared to pay 100 dollars per lb. of uranium in the ore. If breeding and 100 per cent utilization of uranium were achieved, this would add 1,700 × $10^{18}$ B.Th.U. to world reserves. If we were prepared to pay only 50 dollars/lb., the available reserves would be 250 × $10^{18}$ B.Th.U. Even at the higher figures, the primary fuel cost would be negligible if breeding were successful. This can be seen at once, since, on these assumptions, the needs of the United Kingdom can be met by 10–15 tons uranium a year at a primary fuel cost of less than 10 million dollars.

In conclusion, Sir John said that the time is not far off when nuclear power using natural uranium fuel will become feasible. These plants would work at reasonable efficiency and would produce power probably at a cost not very much more than from conventional power stations. This would seem to be sufficient to ask from the first experimental units, as all experience shows that costs may be expected to come down as experience accumulates.

Sir John Cockcroft was followed by Mr. R. V. Moore, who introduced his paper on "The Control of a Thermal Neutron Reactor". The operating characteristics of such a reactor were described, both on theoretical grounds and in the light of five years of operation of the Harwell reactors. The importance of the phenomenon of delayed neutrons on the controllability of the reactor was emphasized, and the following self-induced changes in the reactivity of the system were described: fuel depletion due to burning of uranium-235; poisoning due to the accumulation (owing to fission of uranium) of elements near the centre of the periodic table, certain of these elements (notably xenon-135) being powerful neutron-absorbers; and effects of temperature on reactivity.

The large thermal capacity inevitable with this type of reactor was mentioned, being illustrated by temperature – time curves for BEPO. The self-stabilizing phenomena of thermal reactors were described—that is, if the reactivity is increased for any reason so that the pile becomes divergent, by suitable design the reaction can be made to terminate itself. This is because the temperature coefficients are negative—namely, increased temperature involves a self-induced diminution of reactivity. Conditions at starting up and shutting down a reactor were described, as special safety considerations then apply. When starting up, there is an interval during which the neutron density is being raised from an infinitesimal level, which normally applies in the sub-critical state, to the lowest level that the installed instruments are capable of measuring. It is important that the reactor should arrive at this lowest detectable level still diverging sufficiently slowly to enable control to be established. If the reactor has been allowed to acquire excessive reactivity during this 'blind' period, the rate of divergence might be dangerous. On the other hand, advanced types of thermal reactor must be equipped with considerable potential reactivity to counteract the self-induced changes already mentioned. It was Mr. Moore's suggestion that this difficulty could be safely resolved by limiting the rate at which the reactivity might be increased. By studying the self-induced changes, a rate of withdrawal of the control rod may be determined which is normally adequate to compensate these, but which avoids the dangerous start-up condition. At shut-down the difficulty arises that the nuclear reaction cannot be completely cut off at will. This implies that adequate cooling to balance the residual heating must always be available.

The paper concluded by postulating various fault conditions and examining their consequences, and it was Mr. Moore's conclusion that a system of control for thermal nuclear reactors could be evolved which would be inherently safe.

Mr. J. H. Bowen then introduced his paper on "Automatic Control Characteristics of Thermal-Neutron Reactors". From an operating point of view, it is a convenience to abolish all consideration of the rather complex relation between the variation of reactivity and the subsequent variation of power, by installing an automatic power-controller. This device measures the instantaneous reactor power-level and adjusts the reactivity to bring the power automatically to some predetermined or desired level. The differential equations describing the operation of this device include terms involving the response of the reactor to variation of reactivity. These terms, described in the paper as the reactor "transfer function", have been obtained analytically and confirmed by experiment. Typical complete control-system responses have been calculated and checked by experiment, with good agreement, and a design method for reactor control-systems was suggested.

The final paper, "Neutron Detectors for Reactor Instrumentation", by T. A. J. Jaques, H. A. Ballinger and F. Wade, was introduced by Mr. Jaques. It discussed the principles involved in the detection of thermal neutrons and described two new types of detector recently developed in connexion with the operation of thermal reactors. The first is mainly used as a flux-scanning detector—that is, for local measurements of flux density—and is essentially a thermopile with its hot and cold junctions placed adjacent to each other to share equal ambient temperature conditions. One set of junctions, however, is embedded in boron. Under neutron irradiation, the boron – neutron reaction causes unbalanced heating of the junctions, and the instrument thus develops a thermal E.M.F. proportional to the neutron flux density. The response time-constant is of the order of ten seconds.

The second new type is an ionization chamber. These chambers are normally slightly sensitive to incident gamma-ray radiation, in addition to the intended response to neutron flux. This effect has some importance when the reactor is operating at low power following conditions of high-power running, since the residual gamma-radiation may then be comparatively intense whereas the neutron flux is weak. The new chambers are intended partially to overcome this difficulty by measuring separately the gamma-radiation and the neutron-plus-gamma-radiation. The former measurement is then automatically subtracted from the latter to leave the quantity required.

In opening the discussion which followed these papers, Dr. Dennis Taylor suggested the use of pulse counters at start-up. These could best be used in conjunction with a logarithmic rate-meter, and the possibility then exists of obtaining directly a measure of the pile reactivity. A period-meter or reactivity-meter of this sort is under development at Harwell. When considering extending the range of power measurements, an inevitable question which arises is whether or not electrometer valves can be considered sufficiently reliable for important applications. In this connexion Dr. Taylor reported the experience gained on BEPO: in the past two years not a single failure due to electrometer valves has been recorded in the log-book.

Dr. A. Lundby (Norway) stated that, in the operation of a heavy-water thermal reactor, photo-emission of neutrons from deuterium by gamma-radiation has some important effects on reactor control. He believed that the gamma-radiation mainly responsible for this effect is due to the reaction Ba $\rightarrow$ $^{140}$La which has a period of 12·8 days.

Mr. R. Westergaard (Sweden) suggested that Mr. Bowen's paper would be improved by the consideration of the effects of time delays at various points in the system. In particular, he had in mind the use of pulse counters or rate-meters for power measurements at low flux, as this provides an excellent method of discriminating against gamma-radiation. But the statistical fluctuations involved in such measurements can only be reduced by rather long integrating-times at the rate-meter, and this must involve corresponding time delays in the automatic-control loop.

Referring to Section 8 of Mr. Moore's paper, M. M. Surdin (France) said that it is the practice to start up the French reactors in the manner suggested, namely, by slowly withdrawing the control rods at constant speed. This speed has been chosen so that the maximum reactivity during the starting transient will not exceed the arbitrary value of 0·3 per cent. This speed corresponds to a rate of reactivity increase of $10^{-3}$ per sec. In this connexion he referred to a calculation by M. M. Ravievski which showed that, when starting up in this manner, the power at which the critical condition is reached depends only on the rate of reactivity increase. (It may be noted here that similar calculations by J. Woodrow, of Harwell, show that this power is also proportional to the spontaneous or starting power in the shut-down state.)

Mr. W. Kealy (Department of Atomic Energy) made the comment that a reactor entirely devoted to isotope production would be controlled to work continuously at maximum power. This would be limited by temperature considerations, and it is found in practice that fluctuations in the frequency of the electricity supply are sufficient to vary these temperatures by as much as 6 per cent. The system of automatic power control described in Mr. Bowen's paper has to be supplemented by a temperature-sensitive control which, in fact, adjusts the set point of the power controller.

Reference was made by Mr. L. C. Ludbrook (British Thomson-Houston Co., Ltd.) to a few experiments he has made in connexion with the design of a reactor-power controller. These lead to a reactor transfer function in close agreement with Mr. Bowen's, although the approach has been entirely different.

Mr. S. A. Ghalib (Metropolitan-Vickers Electrical Co., Ltd.) said that, in addition to the corrosion problems mentioned by Sir John Cockcroft, a further difficulty for engineers in reactor design work is the problem of friction and wear in these mechanisms, which have to function, often without lubrication and maintenance, in the gas chosen as the reactor coolant. Another point concerns the range of the level of reactor power, quoted in Mr. Moore's paper, as $10^{14}$. This obviously applies between the shut-down and full-power states, but Mr. Ghalib suggested that in normal power-producing operations a range of 20 to 1 would be more probable.

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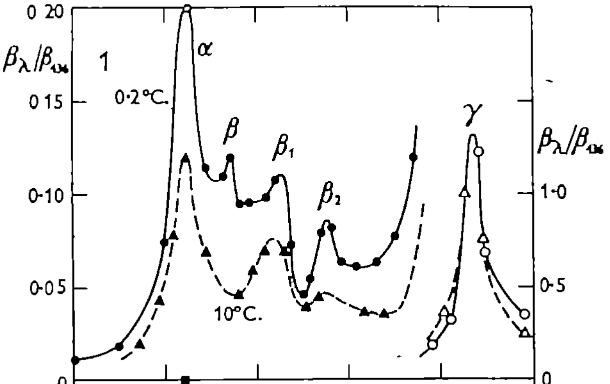
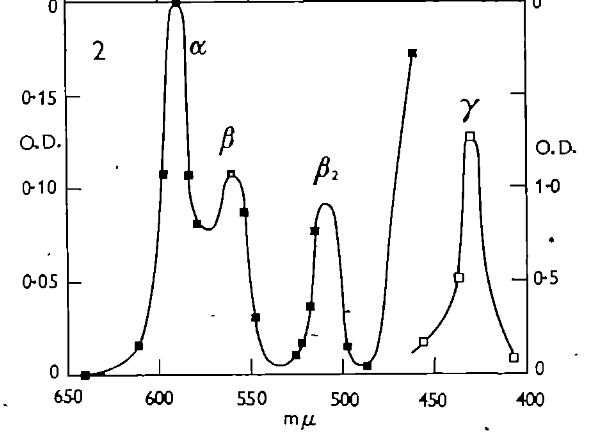
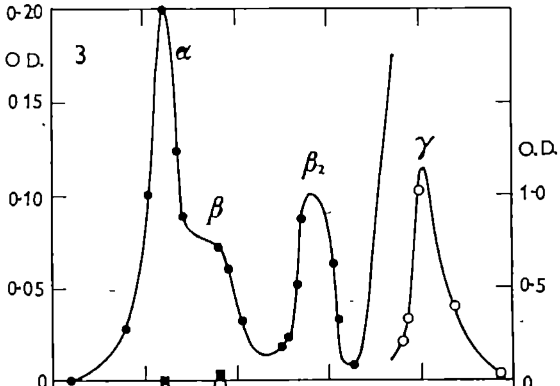
# CYTOCHROME OXIDASE AND THE 'PASTEUR ENZYME'

By PROF. D. KEILIN, F.R.S., and DR. E. F. HARTREE
Molteno Institute, University of Cambridge

IT was shown in 1925 that the multibanded absorption spectrum of cytochrome belongs to three hæmochromogen-like components, denoted as cytochromes *a*, *b* and *c*, the oxidation and reduction of which—that is, their catalytic activity in respiration—can easily be observed in living intact cells[1]. However, further spectroscopic studies[2] of the activity of a typical cytochrome system in heart muscle preparations or in suspensions of certain micro-organisms in the presence of different substrates and inhibitors revealed that the absorption bands, at about 605 mμ and 448 mμ (α- and γ-bands), do not belong solely to cytochrome *a* but represent the superimposed and fused bands of two cytochrome components *a* and $a_3$. Cytochrome $a_3$, unlike cytochromes *a*, *b* and *c*, is very autoxidizable and combines reversibly with respiratory inhibitors such as cyanide, azide, hydrosulphide and carbon monoxide. These properties of cytochrome $a_3$, together with the fact that the absorption bands of its carbon monoxide derivative (α 590 mμ, and γ 432 mμ) occupy approximately the same position as the α- and γ-bands in the photochemical absorption spectrum of yeast[3,4], enabled us[2] to identify it with cytochrome oxidase or Warburg's "respiratory ferment". Cytochromes *a*







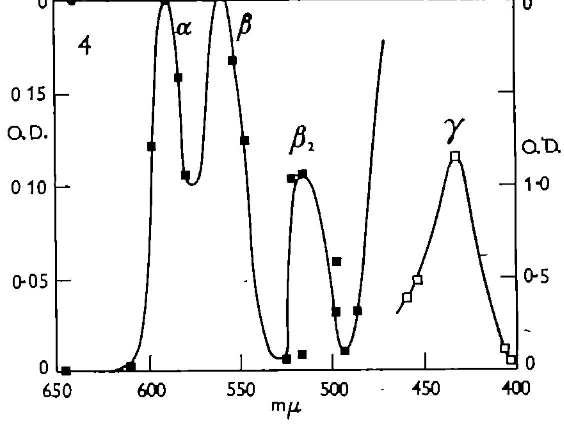


Fig. 1. Relative photochemical absorption spectra of *Torula utilis* at 0·2° and 10° C. from data of Kubowitz and Haas (ref. 4). Ordinate scale reduced ten-fold for Soret or $\gamma$-bands in Figs. 1–5

Fig. 2. Relative photochemical absorption spectrum of bakers' yeast replotted from data of Melnick (ref. 5) with ordinate scale adjusted as described in the text. O.D. = optical density

Figs. 3 and 4. Relative photochemical absorption spectra with adjusted ordinate scale: (3) heart muscle preparation + succinic acid from data of Melnick (ref. 6); (4) area vitellina of chick embryo from data of Philips (ref. 8)

and $a_3$ probably have identical chemical structures so far as both the hæm and protein are concerned. The difference in their reactivities may be due to differences in the mode of attachment of the hæm to the protein.

Since the introduction of a photochemical method[3] for the study of the absorption spectrum of the carbon monoxide derivative of the 'respiratory ferment', photochemical absorption spectra have been obtained for *Torula utilis* and *Acetobacter pasteurianum* by Warburg and Negelein[3] and by Kubowitz and Haas[4], for bakers' yeast and a colloidal heart muscle preparation by Melnick[5,6], and for the area vitellina of the chick embryo by Philips[7,8]. To this list can be added two photochemical absorption spectra ascribed to the 'Pasteur enzyme': one obtained for rat retina by Stern and Melnick[9], and the other for bakers' yeast by Melnick[9].

The very limited use that has so far been made of the photochemical method since its introduction more than twenty years ago[3] is not due solely to its elaborate and specialized technique but also to certain restrictions in the type of material which can be studied by this method. In fact, the respiration of cells and tissues, even when it depends upon the cytochrome system, is not always inhibited by carbon monoxide, and, when a marked inhibition by carbon monoxide is obtained, it is by no means invariably reversed by light. Moreover, in micro-organisms the components of cytochrome, including cytochrome oxidase, may show marked variations in absorption spectra and other properties.

## Comparative Study of Photochemical Absorption Spectra

Of the photochemical absorption spectra so far recorded, those obtained by Kubowitz and Haas[4] are of special interest since they are based upon determinations at thirty different wave-lengths ranging from 253 to 671 mμ.

In order to compare the absorption spectra enumerated above and to bring into evidence the characteristics they have in common, they have been replotted (Figs. 1–5) in the following manner. The height of the $\alpha$-band was taken as a point of reference, and the optical densities were recalculated to give equal densities of 0·20 at the peak of the $\alpha$-band. This figure is the value for $\beta_{587}/\beta_{436}$ obtained by Kubowitz and Haas[4] in their determination of the photochemical absorption of *T. utilis* at 0·2°. Examination of these absorption spectra reveals marked variations in the number, shape, positions and the relative heights of the bands. Among the most striking features of these spectra are the following: the great complexity of the absorption spectrum in the visible region of *T. utilis* recorded by Kubowitz and Haas[4] at 0·2° C. (Fig. 1); the prominence of $\beta_2$ bands in the remaining spectra, including those ascribed to the 'Pasteur enzyme'; the obliteration of the $\beta$-band in the heart muscle preparation (Fig. 3); the unusually high $\beta$-band in the case of the chick embryo (Fig. 4) where this band is, if anything, higher than the $\alpha$-band and where the trough between $\alpha$- and $\beta$-bands is unusually deep for

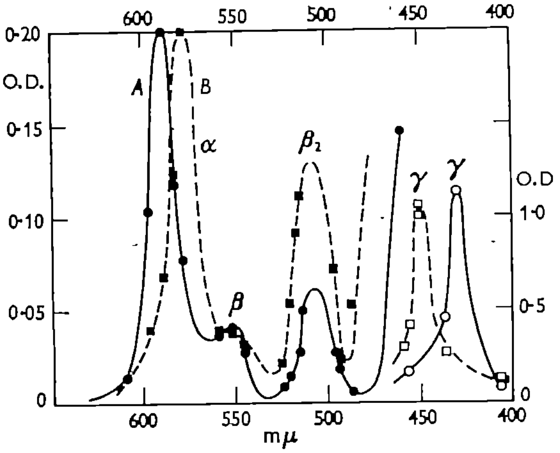


Fig. 5. Relative photochemical absorption spectra of the 'Pasteur enzyme' with adjusted ordinate scale: (*A*) bakers' yeast from data of Melnick (ref. 5); (*B*) retina of rat from data of Stern and Melnick (ref. 9)

the carbon monoxide derivative of a hæmoprotein; the position of the γ-band in the photochemical absorption spectrum of the heart muscle preparation which is at about 450 mμ, whereas direct spectroscopic study of this preparation revealed that on treatment with carbon monoxide the γ-band of cytochrome $a_3$ moves from 445 to about 432 mμ [2].

The differences between the photochemical absorption spectra of the 'Pasteur enzymes' (Fig. 5) in bakers' yeast (*A*) and retina (*B*) are much more marked than the differences between either of them and some of the photochemical spectra of the 'respiratory ferment'. In fact, the spectra of the 'Pasteur enzyme' and of the 'respiratory ferment' in bakers' yeast (Figs. 5 and 2), as determined by Melnick[5], are virtually identical except that the β-band is much lower in the 'Pasteur enzyme' spectrum, where it is more comparable with the β-band of the 'respiratory ferment' in the heart muscle preparation (Fig. 3). On the other hand, the γ-band of the latter and of the 'Pasteur enzyme' of the retina (Fig. 5,*B*) were recorded at 450 mμ, which is 18–20 mμ nearer the red end of the spectrum than the corresponding bands in all the other photochemical absorption spectra. Thus, an analysis of the photochemical absorption spectra does not support the view that the 'Pasteur enzyme' and cytochrome oxidase are two distinct enzymes. Similar doubts as to the distinction between the two enzymes have already been expressed by Dickens[10].

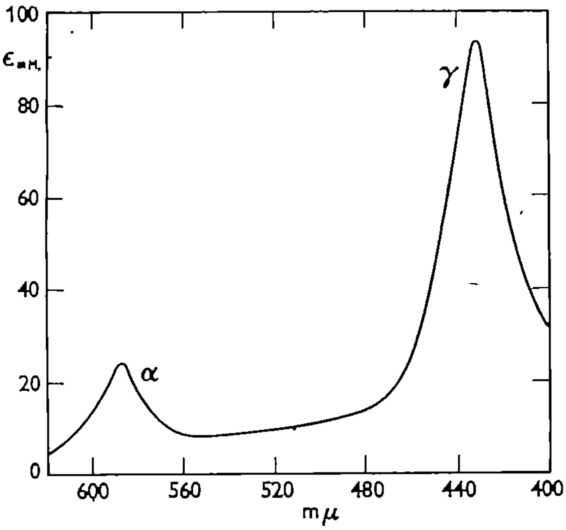


Fig. 6. Absorption spectrum of pyridine hæmochromogen obtained from hæmatin of cytochrome *a* (after Rawlinson and Hale (ref. 13))

## Interpretation of the Photochemical Absorption Spectra

The foregoing discussion of the photochemical absorption spectra suggests the following possible explanations of their great complexity and variability.

(*a*) The lack of agreement between the curves may be due to experimental errors inherent in the method and to great technical difficulties in its application. This is partly supported by marked differences in the spectra recorded for *T. utilis*[4] at 0·2° and 10° C. (Fig. 1).

(*b*) It is, on the other hand, possible that the differences in the spectra are genuine and that they reflect differences in the structure of the cytochrome oxidase of different cells, such as would be expected to arise from variations of the protein portion of its molecule. However, this would scarcely explain the marked differences in the spectra obtained for *T. utilis* and bakers' yeast, or for the heart muscle preparation and the chick embryo.

(*c*) Finally, one cannot exclude the possibility that, although in the main the photochemical absorption spectrum represents the carbon monoxide compound of cytochrome oxidase, the complexity and variability of the spectrum may reflect the influence upon it of light absorption by other intracellular components, and in particular by the cytochromes that are intimately linked with the oxidase. This hypothesis is supported by the presence of the protein band in the photochemical absorption spectra of *T. utilis* and *A. pasteurianum* recorded by Warburg and Negelein[3], by Kubowitz and Haas[4] and by the recent finding by Bücher and Kaspers[11] of the protein band in the photodissociation spectrum of carbon monoxide myoglobin. In all these cases the light energy absorbed by tyrosine and tryptophane residues of the protein at about 280 mμ is transmitted to the hæm and utilized for photodissociation of the iron – carbon monoxide link in the same way as light energy absorbed directly by the hæm nucleus.

Considering that all components of the cytochrome system are intimately linked together through their proteins, which probably provide suitable pathways for electron transfer from the iron of one to that of another component, it is conceivable that some of the light energy absorbed by components which react neither with oxygen nor with carbon monoxide may nevertheless be transmitted to carbon monoxide–cytochrome oxidase compounds of *Torula* and *Acetobacter* and be involved in their photodissociation in the same manner as light energy absorbed by tyrosine and tryptophane of the protein. Such a possibility may help us to understand the remarkable difference between the complex photochemical spectra and the simple one-banded absorption spectrum in the visible region of the pyridine hæmochromogen obtained from hæm *a* and $a_3$ by Negelein[12], by Rawlinson and Hale[13] (Fig. 6), and by Dannenberg and Kiese[14]. We have found, in addition, that the globin hæmochromogen of hæm $a + a_3$ shows the same single band at about 587 mμ which, in presence of carbon monoxide, shifts slightly towards the red end of the spectrum[15].

The foregoing view of the nature of the photochemical absorption spectra allows a simpler interpretation of their variability, since the relative proportions of the cytochrome components vary from one kind of cell to another[1]. The contribution to the photodissociation of the cytochrome oxidase – carbon monoxide compound by other components of the cytochrome system and possibly by some other light-absorbing substances would, in these circumstances, be a variable one. On the other hand, if more than one hæmoprotein contributes to the photochemical spectrum in the Soret region, the experimental γ-band should be somewhat asymmetric with shoulders representing the smaller contributions of components other than cytochrome oxidase. Unfortunately, sufficient data to decide this matter are not available, nor could they be easily obtained, since many experimental points would be required within a very limited spectral region to provide the exact shape of the γ-band.

However, the problem whether the carbon monoxide compound of cytochrome oxidase does exhibit a multibanded spectrum in the visible region, as the photochemical spectra appear to suggest, will be finally solved either by study of the isolated and purified native cytochrome $a$ and $a_3$ hæmoproteins completely free from other native or denatured hæmoproteins, or by the study of absorption spectra of carbon monoxide complexes of compounds reconstructed from hæm $a$ and different proteins. Until this is accomplished, the most plausible explanation of the great complexity and variations of the photochemical absorption spectra lies in the assumption that several light-absorbing components of the catalytic system contribute to the pattern of these spectra.

Since all the components of the cytochrome system are intimately linked together to form an integral part of certain structural elements of the cell such as mitochondria or sarcosomes, it is conceivable that the spatial distribution of cytochrome oxidase in relation to the other cytochrome components and other oxido-reduction systems varies from one structural element to another, or from one region of the same element to another. According to its localization, cytochrome oxidase may be linked in different manners and in different proportions to other components of catalytic systems and therefore may not be equally saturated in each case with electron donors. It is only in places where cytochrome oxidase is fully saturated with electron donors that its activity can become the rate-determining step and that its susceptibility to carbon monoxide will be reflected in the over-all reaction in which it takes part. This may explain the differences in the susceptibility to carbon monoxide of respiration and the Pasteur reaction discovered by Laser[16]. Thus his important observation that in certain tissues it is not the respiration but the Pasteur reaction that shows light-sensitive inhibition by carbon monoxide does not necessarily imply the existence of a specific 'Pasteur enzyme' which is distinct from cytochrome oxidase.

It is therefore reasonable to assume that cytochrome oxidase is the component, showing the light-sensitive inhibition by carbon monoxide and the photochemical absorption spectrum, of the catalytic system involved in the Pasteur reaction. As to the susceptibility of this reaction to other factors[16], which do not affect cytochrome oxidase, it may well be due to their action upon some other components of the catalytic system responsible for this reaction.

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# OBITUARIES

## Prof. W. H. Hobbs

William Herbert Hobbs was born at Worcester, Massachusetts, on July 2, 1864, and died at Ann Arbor, Michigan, early in January 1953. He was educated at the Worcester Polytechnic Institute, where he made a special study of industrial design. Upon graduation in June 1883 he taught for a year at a country school, and then went to Johns Hopkins University at Baltimore to study first chemistry and physics and later geology, in which he took his degree in 1888. After a year's postgraduate work at Heidelberg, Hobbs returned to the United States as an instructor in the University of Wisconsin and curator of the geological museum there. In 1891 he was appointed assistant professor of mineralogy and petrology, and nine years later became full professor. Between 1885 and 1900 he was also employed from time to time by the United States Geological Survey in New England, and made a special study of methods of discovering faults by means of surface relief. Hobbs was in Italy at the time of the Calabrian earthquake in 1905 and formed the opinion that there was no epicentrum, or centre of heavy shock, but many intersecting 'seismotectonic' lines of shock with the heaviest shocks at their junctions. He published this novel conclusion in "Earthquakes: an Introduction to Seismic Geology" (New York, 1907).

As a result of these investigations, Hobbs had become more interested in dynamic and structural aspects of geology than in mineralogy and petrology, and in 1906 he accepted the post of professor of geology at the University of Michigan, where he remained until retirement in 1934. He first became interested in glaciology in 1906, when he visited Switzerland, and five years later published "Characteristics of Existing Glaciers" (New York, 1911), in which he emphasized the wide differences between valley glaciers and ice sheets.

Hobbs was a keen traveller and spent much time in Europe, North Africa and on the islands of the Pacific Ocean. In 1926, when he was more than sixty, he led the first University of Michigan Expedition to Greenland. His object was to find evidence in support of his belief that a permanent 'glacial anticyclone' over Greenland governs atmospheric circulation in the northern hemisphere. Although his hypothesis was later shown to be inconsistent both with the observed facts and the theory of the polar front, Hobbs continued to assert that the characteristic circulation of the northern and southern hemispheres depends upon the existence of the ice sheets of Greenland and Antarctica, acting as downshafts for the restoration of air to lower latitudes. Again, in 1927 and in 1928, he led parties to southwest Greenland, and later published a general account of their achievements in "Exploring about the North Pole of the Winds" (New York, 1930). During the Second World War it was Hobbs who suggested Søndre Strømfjord, where his expeditions had worked, as a site for the United States air base which came to be known as Bluie West Eight.

After his retirement Hobbs turned his attention to the historical aspects of polar exploration. As might be expected, he had entered whole-heartedly into the bitter controversy between Frederick A. Cook and Robery E. Peary, and wrote a biography entitled "Peary" (New York, 1936) in vehement support of the American admiral's attainment of the North Pole. Hobbs also devoted much attention to the discovery of the antarctic continent, and published the results of his investigations in 1937. In exceptionally harsh and acrid terms he sought to show that it was an American sealer, Nathaniel Brown Palmer, who first sighted Antarctica, although there is no doubt whatever that Edward Bransfield was, in fact, the first to do so. Hobbs's attempt to discredit men like Bransfield and James Weddell, and his ruthless misrepresentation of original documents, was a source of great embarrassment to his many friends in Britain.

Whatever doubt there may be as to the worth of Hobbs's contribution in some fields, of his vigour and enthusiasm there can be no question. He was never afraid to state his views, however controversial; but it is regrettable that he was so rarely prepared to admit, in the face of overwhelming evidence, that he had been mistaken. J. D. M. BLYTH

## Prof. David Katz

THE death of Prof. David Katz on February 2 at the age of sixty-nine removes from psychology a gifted and versatile experimentalist of the first rank. Born in Cassel, Hessen-Nassau, in 1884, he studied natural science and mathematics at Göttingen and later turned to psychology, under the direction of G. E. Müller. It was characteristic of him that his interest in psychology was aroused by acting as a subject in an experiment. He pursued these early studies at Munich and Berlin, and it was during this time that he came under Husserl's influence, which remained throughout his life. On receiving his doctorate in 1906, he spent some months in military service and then proceeded to Munich, where Theodore Lipps was a focus of interest, and afterwards to Würzburg, where Kulpe's laboratory was the main attraction.

He took up his first appointment at Göttingen in 1907 as G. E. Müller's assistant, and remained there until the outbreak of the First World War, when he enlisted and served for nearly four years. In 1918 he had the opportunity of working for some time at the Engineering School in Hanover, being engaged in the study of sensory-motor reactions of Sauerbruch amputees, thus introducing psychological methods into the field of prosthesis.

In 1919 he married Rosa Heine, a psychologist in her own right, who has always been closely associated with her husband's work, particularly on child and animal behaviour.

In the same year Katz accepted the new chair of psychology and education at the University of Rostock. He stayed there until 1933 when he was forced to leave because of the Nazi regime. Fortunately, an invitation was extended to him to work in Prof. T. H. Pear's laboratory in the University of Manchester and later in Sir Cyril Burt's Department at University College, London. While in England he also carried out experiments on monkeys at the London Zoo and for two years acted as psychological adviser to the British Research Association of Flour Millers. In 1937, he was appointed to the first chair of pedagogy and psychology in the University of Stockholm, where he remained until his retirement in 1951.

The wide scope of Katz's experimental interests is indicated by his original work on sense perception (especially colour-vision, touch, taste and vibration), child development, processes of thought and learning, and animal behaviour. He preserved until the end an originality and freshness of approach in all his varied work, and his writings are characterized by simplicity, directness and lucidity.

During 1930–33 he was co-editor of the *Zeitschrift für Psychologie*. In 1950, he went to the University of California to deliver the Hitchcock Lectures, and in 1951 he was president of the Thirteenth International Congress of Psychology. His numerous publications include "Psychologie und Mathematische Unterricht", "Studien zur Kinderpsychologie", "The World of Colour", "The World of Touch", "Hunger and Appetite", "Conversations with Children" (jointly with Rosa Katz), "A Psychological Atlas", "Gestalt Psychology", and "Animals and Men".

Prof. Katz possessed great charm of personality and a sense of humour, and his unfailing kindness won him numerous friends in many countries. He leaves a widow and two sons. JOHN COHEN

## Dr. Edward Hope

DR. EDWARD HOPE, who died at Caterham on February 7, was born on December 19, 1886, and received his chemical training under W. H. Perkin, jun., at the University of Manchester. His earliest researches included studies in the preparation and reactions of several interesting alicyclic and aliphatic acids, as well as some notable investigations, conducted in collaboration with Sir Robert Robinson, in the narcotine and gnoscopine group of alkaloids.

Perkin had moved to Oxford in 1913, and, during the First World War, British Dyes, Ltd., organized a team of chemists to investigate, under his direction, difficulties which had arisen in the manufacture of dyes and their intermediates. Hope went to Oxford in 1916 to join this team and worked in the newly opened Dyson Perrins Laboratory. In 1919 he accepted an appointment as lecturer and demonstrator in the new laboratory, and at the same time became a Fellow and tutor in chemistry at Magdalen College.

The immediate post-war period was one of considerable reorganization and development in the chemistry school at Oxford. The research year had just been introduced as an integral part of the honours course, and Hope applied himself wholeheartedly to the problems of the laboratory and the needs of a large body of pupils at Magdalen. He maintained his interest in research and published a number of papers jointly with his students, mostly on the chemistry of substances related to the indigo dyes; but he was carrying a heavy burden of work and showed early signs of the ill-health which marked his later years. Although he found it necessary to relinquish his teaching duties at Magdalen in 1933, he remained at the College, where he filled various offices and ultimately became Senior Fellow. He continued his work at the Dyson Perrins Laboratory as a University demonstrator and lecturer until he reached the normal age of retirement in September of last year. For many years he edited the "Chemists' Year Book".

Hope will long be remembered with affection by his pupils and colleagues. He was a popular and successful tutor, and countless numbers of Oxford chemists will recall with gratitude the friendly advice and encouragement which they received from him in the laboratory. S. G. P. Plant

# NEWS and VIEWS

## Organic Chemistry in the University of Leeds: Prof. F. Challenger

Prof. F. Challenger, who retires from the chair of organic chemistry in the University of Leeds at the end of the present session, studied under Jamieson Walker, Kipping and Wallach, and held appointments in the Universities of Birmingham and Manchester before succeeding Ingold at Leeds in 1930 (see *Nature*, 126, 187; 1930). He has seen the department move from its old outgrown quarters to the present large building, opened in 1933, and has seen that in turn strained to the utmost to contain the greatly increased numbers of post-war students. However, university expansion with its concomitant administrative problems has not kept Challenger away from the laboratory bench, nor has he shared the post-war doubts of some about the aims of a university; whether in the Senate, in the chair at the Ph.D. Committee, or in discussion with individual students, his influence has always been emphatically on the side of the pursuit of new knowledge. Challenger's friendly and generous disposition has not only established good relations between the Chemistry Department in Leeds and those elsewhere (particularly the Dutch schools of organic chemistry), but has also shown itself in the way he has helped a succession of postgraduate students who have worked with him, and in his unfailing courtesy and kindness to his colleagues.

Challenger's researches have been concerned principally with biological methylation and with the synthesis, structure and properties of heterocyclic sulphur compounds, particularly the thiophthens, the solid isomer of which he was the first to isolate. His studies of the methylating properties of moulds have revealed many interesting reactions, such as the fission and methylation of organic disulphides, the production of alkyl mercaptans from methionine and alkyl cysteines, as well as the methylation of inorganic and organic compounds of arsenic, selenium and tellurium. The last-named reaction is analogous to that which takes place in animals. His views on the similarity of the transmethylation mechanism in moulds and in animals have recently been confirmed by his own elegant experiments with compounds labelled with carbon-14. With Dr. Simpson he showed that the dimethyl sulphide evolved by the marine red alga *Polysiphonia fastigiata* arises from the decomposition of the thetine $(CH_3)_2\overset{+}{S}.CH_2.CH_2\,COO^-$; this compound, the first of its class to be found in plants, was shown later by du Vigneaud and by Dubnoff to act as a methyl donor in the conversion of homocysteine to methionine in rats, and a valuable link was thus forged between the parallel investigations in Leeds and Cornell. He has also demonstrated the presence of dimethyl sulphide (shown by Haas to occur in *Polysiphonia*) in numerous other plants.

### Dr. B. Lythgoe

Dr. B. Lythgoe, who succeeds Prof. Challenger, is a Lancashire man. He was educated at Leigh Grammar School and the University of Manchester, where he graduated in 1934, and commenced postgraduate work in organic chemistry under the leadership of Sir Ian Heilbron. In this early phase of his career he was introduced to the chemistry of natural products and made important contributions to the study of algal carotenoids, including the isolation of myxoxanthin, the characteristic pigment of the Myxophyceæ. After a brief spell in industry, Dr. Lythgoe joined the staff of the Chemistry Department at Manchester in 1938, and there he began an association with Prof. A. R. Todd which, starting with some vitamin studies on the liver filtrate factor (pantothenic acid), developed into a co-operative attack on the problem of nucleoside structure. In a series of well-known investigations, spread over a number of years, the structure of the natural ribonucleosides was completely elucidated and their synthesis effected. It was during the development of this field that Dr. Lythgoe moved in 1944 with Prof. Todd to Cambridge, where he is at present lecturer in chemistry and a Fellow of King's College.

Parallel with the development of the work on nucleosides in Cambridge, Dr. Lythgoe's wide ranging interest in natural products caused him to initiate a series of brilliant researches on some unusual natural toxic principles, including the remarkable substance macrozamin, obtained from members of the Cycadaceæ, which he showed to be a derivative of azoxymethane, and the acetylenic substances responsible for the toxic effects of the British plants *Oenanthe crocata* and *Cicuta virosa*. These investigations and his other related studies have attracted much attention, both for their elegance in experimentation and for the theoretical insight which they display. Indeed Lythgoe's unusual combination of theoretical and natural product interests, coupled with his strong personality, assure a vigorous future for organic chemistry in Leeds.

## Royal Society of Edinburgh: New Fellows

At the sixth ordinary meeting of the Royal Society of Edinburgh held in the Society's Rooms, 24 George Street, Edinburgh 2, on March 2, the following were elected Fellows of the Royal Society of Edinburgh: Prof. F. Bell, Department of Chemistry, Heriot-Watt College, Edinburgh; Mr. L. J. F. Brimble, joint-editor of *Nature*; Prof. J. L. Burchnall, Department of Pure Mathematics, University of Durham; Dr. E. A. C. Chamberlain, divisional chief scientist, Scottish Division, National

Coal Board; Prof. C. G. C. Chesters, Department of Botany, University of Nottingham; Dr. A. Clow, British Broadcasting Corporation; The Right Hon. the Earl of Crawford and Balcarres; Mr. A. A. Fulton, chief hydraulic engineer, North of Scotland Hydro-Electric Board; the Right Hon. the Earl of Haddington; Dr. J. Heslop Harrison, lecturer in the principles of plant taxonomy, University of London; the Right Hon. the Earl of Home, P.C., Minister of State, Scottish Office; Dr. D. B. McIntyre, lecturer in petrology, University of Edinburgh; Mr. B. G. McLellan, formerly director of the Scottish Seaweed Research Association; Sir James Irvine Masson, formerly vice-chancellor of the University of Sheffield; Dr. A. D. Merriman, registrar-secretary of the Institution of Metallurgists, London; Dr. A. R. Mitchell, lecturer in applied mathematics, University of St. Andrews; Dr. A. T. Phillipson, deputy director and head of the Physiology Department, Rowett Research Institute, Bucksburn, Aberdeenshire; Mr. K. S. M. Rae, officer-in-charge, Oceanographic Laboratory, Edinburgh; Dr. Edith P. Smith, lecturer in botany, University College, Dundee; Dr. J. T. Stamp, head of the Veterinary Department and veterinary investigation officer, Edinburgh and East of Scotland College of Agriculture; Dr. D. M. Steven, lecturer in zoology, University of Edinburgh; Prof. M. M. Swann, Department of Natural History, University of Edinburgh; Principal T. M. Taylor, vice-chancellor of the University of Aberdeen; Prof. W. L. Weipers, Department of Veterinary Surgery, University of Glasgow; Dr. L. H. Wells, senior lecturer in physical anthropology, University of Edinburgh.

### Meteorological Expedition to the British West Indies

Prof. P. A. Sheppard, of the Department of Meteorology, Imperial College of Science and Technology, London, has recently left the United Kingdom to lead a small meteorological expedition from his department to Anegada (lat. 18° N., long. 64° W.) in the British Virgin Islands, British West Indies. The expedition, in which the National Institute of Oceanography is collaborating, is planning to study for about a month the transfer of momentum, heat and water vapour from the ocean into the Trade Wind air, to relate these transfers with the vertical variation of mean wind speed and direction in the first kilometre or two of the atmosphere and with the pattern and structure of Trade Wind cloud, mainly cumulus. This expedition follows an earlier expedition to the Scilly Isles during January 1951. There, momentum transfer processes were studied in the variable westerlies of middle latitudes, and the results indicated that the classical concept of the terrestrial friction layer, a layer half a kilometre or so in thickness, in which turbulence and momentum transfer drop off to zero at the top of the layer, needed revision. The results could be interpreted on the assumption that the momentum transfer was maintained or even increased with height by means of turbulence of moderate scale which was found to exist in the air. Unlike the classical boundary layer beneath a uniform stream of air, the wind speed in the westerlies increases with height up to the level of the tropopause, not through friction at the underlying ocean surface but because of the temperature drop towards higher latitude. In the Trade Winds a similar temperature drop causes easterlies near the surface to give way to westerlies (anti-Trades) aloft. This difference between Trade Winds and westerlies is likely to lead to markedly different patterns of momentum transfer in the two fields, a difference which if substantiated must be important in the understanding of the general circulation of the atmosphere. Anegada is a small low-lying island in a Trade Wind area, and the expedition will use it as a fixed platform to observe the variation in wind from one five minutes to the next, that is, the moderate-scale turbulence, in the first kilometre or two of the Trade air, using balloons. Time-lapse photography of the clouds will also be undertaken. The Woods Hole Oceanographic Institution in Massachusetts will collaborate with the Imperial College expedition by using an aircraft to take observations of cloud structure in the same region at the same time.

### Photoelectric Studies of the Night Sky Light

A paper by Masaaki Huruhata on "Photoelectric Studies of the Night Sky Light" has been published in *Tokyo Astronomical Observatory Reprints*, No. 89 (reprinted from the *Report of Ionosphere Research in Japan*, 6, No. 1; 1952), which describes the method of study of the horizontal drift of the night sky. The measured emission of the infra-red radiation between 8500 and 11000 A. was identified as due to the OH ion; this radiation is so strong that it can be easily measured over the whole sky without suffering from the effects of bright star-light. The instrument consists of a photoelectric photometer furnished with a cæsium cell, the current being amplified by the electrometer tube. An infra-red filter placed in front of the photocell cuts out the visual light shorter than 8500 A. Observations were carried out at Yawatano, Shizuoka-ken, and the results are plotted for each hour for various periods between January 1, 1949, and December 11, 1950. On most nights the drift of intense or weak clouds of the night sky could be recognized, the direction of drift being mostly from north-north-east to south-south-west or in the opposite direction, and this direction is perpendicular to the geomagnetic parallel. On December 23, 1949, the velocity of the drift was estimated to be 1,000 km./hr., but this appears to be exceptional and several hundred km./hr. seems to be the normal speed. It is remarkable that the speed of the southward drift averages about 20 per cent more than that of the northward drift. Attempts were made to find some correlations between drift and the position of the moon, on the theory that wind in the upper regions of the atmosphere—about 300 km. high—might be caused by tidal movements, but none could be found, nor could any correlation be found between the drift and the ionospheric and geomagnetic disturbances observed in Japan proper.

### Study of Forest Seeds in Sweden

An article by Einar Huss, entitled "Methods used in the Swedish Forest Research Institute in Seed Experiments", has been published in *Reports of the Forest Research Institute of Sweden* (*Meddelanden från Statens Skogsforskningsinstitut*, 40, 53; 1952), in which it is stated that during the past few years, owing to the growing interest in forest culture in Sweden, a thoroughgoing study of questions touching the appropriate methods of treating forest seed and the characters determining the effect on plant results has been undertaken. There were also the problems of supplying the forest industry with enough seed, because of the greatly increased demand, and the necessity, owing to this increased demand, of producing the best possible quality of seed, which is a commercially expensive commodity. There are few forestry departments in the world at the present day in which the demand for high-quality forest seed of many varying species does not exist, and, in the case of exotics, this often has to be imported. The objective of the study was to provide a "real average sample". At the beginning of the past decade, a new experimental selection method was introduced by Prof. Lars Tirén, director of the State Forest Research Institute's Forest Department, in the seed experiments of the Institute, which was described in 1948 in an essay published in the Institute's *Proceedings* (37, No. 5). Einar Huss's paper reviews the manner of treating cones and seed from Scots pine and Norway spruce. In eight short sections he deals with definitions and quantitative units, collection of cones, storage, selection, extraction of seed, de-winging and cleaning, sampling and germination. The ninth section treats of storage and the methods in use. The whole article merits close study by all foresters having to deal with this important seed problem.

## Pea Embryos in Sterile Culture

AN interesting contribution to our knowledge of the hormonization of seeds by growing dissected-out pea embryos in sterile culture has recently been made by W. Kruyt (*Proc. Koninkl. Nederlandse Akad. van Wetensch.*, Ser. C., LV, 4, 503; 1952). The peas were sterilized externally and the embryos removed with or without the attached cotyledons and grown in a sterile culture medium. Various pre-soaking treatments, for example, with and without growth-regulating substances, were investigated, and also the effects of factors in the culture medium and of leaving larger or smaller amounts of cotyledon attached to the growing embryo. It was found that the ratio of the amount of reserve material (in the cotyledons) to the size of the embryo has an important effect on development, that is, nutrition affects the morphogenetic development, the growth of root and sprout being stronger in proportion to the amount of cotyledon tissue left on the embryo. No development of leaves takes place in the dark, and, even in the light, embryos from which the cotyledons have been removed scarcely form leaves: leaf development, in fact, is in proportion to the amount of cotyledon left on the embryo. The author also reports the liquefaction of agar gels, especially by embryos with attached cotyledons. The development of lateral roots is mainly dependent on the amount of cotyledon tissue present. In a considerable series of experiments the action of various growth substances was also examined, the conclusion being reached that the greater part of the action of a growth substance, administered by pre-soaking the seeds, takes place by way of the cotyledons.

## Life Insurance Medical Research Fund of Australia and New Zealand

THE Life Offices' Association for Australasia has established the Life Insurance Medical Research Fund of Australia and New Zealand to promote and assist scientific and medical research. For the present it is intended to use the resources of the Fund to stimulate and support research in the field of cardiovascular function and disease, and for this purpose the Fund is offering grants-in-aid and research fellowships. Grants-in-aid will be given to non-profit institutions with basic facilities and qualified personnel for medical research and will be used in support of specific programmes of research, both fundamental and clinical, under the direction of a particular investigator; the grants will be worth £1,000–3,000 a year (or more, in exceptional circumstances) for one to three years and are designed to cover all the financial requirements of a programme, except the salary of the head of the department or institute concerned. Research fellowships will be awarded to medical graduates, or those with equivalent scientific training, for full-time research, and will be divided into three categories: fellowships taken up in Australia and New Zealand, of £1,250–1,500 a year in value, which will be for one year (but renewable for further periods); travelling fellowships, of £1,500–2,000 a year in value plus travelling expenses, which will be for two years abroad, followed by a third year in an approved institution in Australia or New Zealand; and senior fellowships, which will be granted in special circumstances. Application forms (to be returned by March 31) and further information can be obtained from Dr. John H. Halliday, Medical Director, Life Insurance Medical Research Fund of Australia and New Zealand, 87 Pitt Street, Sydney, N.S.W.

## Book Service for Industrial Operatives

THE National Book League is seeking information regarding the availability and use made of works libraries, with the view of the eventual establishment of a consultative service to factories, as visualized in a report of its Books in Industry Committee in 1949. Factory managements or their libraries are being invited to supply details regarding the size of the technical library they maintain from their budgets, the number of general books thus maintained, and whether or not a works librarian is employed and the library regularly brought up to date and at what cost. Information regarding facilities invited from public libraries includes the accessibility of books to operatives and the extent to which the books are used. The service contemplated is for the man at the bench rather than for scientific or research staffs. Information should be sent to Mr. R. Lusty, chairman of the Books in Industry Committee, National Book League, 7 Albemarle Street, London, W.1.

## British Agricultural History Society: Meeting in Reading

A NEW Society, to be known as the British Agricultural History Society, has recently been formed, and it is hoped that, besides the academic backing which it already enjoys, it will receive the support of a wide circle, including both farmers and townsmen, for whom the history of British rural life is of real interest. The first general meeting of the Society will be held in the University of Reading during April 13, and all who are interested are welcome to attend. The conference will open at 10.30 a.m. with the adoption of the constitution of the Society, which has been drafted by the provisional committee elected at the inaugural meeting last September, and with the election of officers. Following this formal business, Sir James Scott Watson will read a paper on "The Scope of Agricultural History". In the afternoon, Sir Frank Stenton will read a paper on "The Manor in English History". Visits to the Museum of English Rural Life, Reading, will be arranged during the day. The registration fee for the conference is 3*s*., and should be sent to the secretary of the Society, Mr. J. W. Y. Higgs, Keeper of the Museum of English Rural Life, Shinfield Road, Reading, Berks, from whom all further information can be obtained.

### Eighth International Congress of the International Society for Cell Biology

The date of the eighth international congress of the International Society for Cell Biology (Cytology Congress) has been changed from this year to 1954. It will be held in Leyden during September 1–7, under the presidency of Prof. E. Newton Harvey, of Princeton University, with Prof. P. J. Gaillard, of the Laboratory for Experimental Histology, University of Leyden, as secretary. Correspondence concerning the Congress should be addressed to Dr. W. H. K. Karstens, Botanical Laboratory, State University, Nonnensteeg 3, Leyden. Full members of the Society and candidates for membership approved by the International Committee are automatically entitled to attend the Congress, and to introduce two guests. Non-members are admitted as space permits, after provision has been made for members and their guests. Any member of the Society may nominate a new member from "those who have made outstanding contributions to cell biology over a period of years". The nominations, with a statement of qualifications and a list of the nominee's publications, should be sent to the secretary of the Society, Prof. J. F. Danielli, Zoology Department, King's College, London, W.C.2.

### *Endeavour* Prizes for Science Essays

In order to stimulate younger scientific workers to take an interest in the work of the British Association for the Advancement of Science and to raise the literary standard of scientific writing, Imperial Chemical Industries, Ltd., publishers of *Endeavour*, are offering a number of prizes for an essay, not exceeding four thousand words, on one of the following subjects: radio-astronomy; colour and chemistry; biology in world affairs; science and safety in transport; science and art; scientific contributions to medicine; scientific societies and their role; and power and civilization. Competitors must be less than twenty-five years of age and must send in their essays by June 1. The prizes will be 50, 25 and 15 guineas, respectively, with two special awards of 5 guineas for competitors less than eighteen, and in addition prize-winners will have their expenses paid for attendance at the British Association meeting to be held in Liverpool during September 2–9. Further details of these awards, which are known as *Endeavour* prizes, can be obtained from the Assistant Secretary, British Association for the Advancement of Science, Burlington House, Piccadilly, London, W.1.

### University of Leeds

Donations have been made to the University of Leeds as follows: £2,500 from the Cement and Concrete Association to the Department of Civil Engineering towards the cost of a universal testing machine; £1,100 from Bolton Leathers, Ltd., to the Department of Leather Industries, for the Boltonia Fellowship for 1952–53 and 1953–54; a gravity-feed stoker, valued at £1,085, from Crosthwaite Furnaces, and Scriven Machine Tools, Ltd., Leeds; and a grant of £500 a year (for one year in the first instance), with provision for superannuation purposes for half-time assistance and with up to £1,000 a year for expenses, from the Medical Research Council, to the Department of Experimental Pathology and Cancer Research, for work on the carcinogenic action of mineral oils.

### Colonial Service: Recent Appointments

The following appointments have recently been made in the Colonial Service: E. W. Momber (principal agricultural officer, Nigeria), assistant director of agriculture, Northern Region, Nigeria; B. E. V. Parham (senior agricultural officer, Fiji), deputy director of agriculture, Fiji; A. M. Anderson (fisheries officer, North Borneo), fisheries officer, Uganda; M. P. Benjamin (assistant agricultural superintendent, British Guiana), agricultural officer, Jamaica; J. O. Jaine (land ranger, Tanganyika), senior land ranger, Tanganyika; I. G. Lumsden (assistant conservator of forests, Northern Rhodesia), assistant conservator of forests, Nigeria; G. H. Rulf (assistant director of grain storage, Tanganyika), director of grain storage, Tanganyika; G. G. Rushby (senior game ranger, Tanganyika), deputy game warden, Tanganyika; E. H. Jones, agricultural officer (economist), Uganda; C. A. Waldron, agricultural officer, Tanganyika; H. I. Williams, bacteriologist, Federation of Malaya; A. Rogerson, scientific officer, East Africa High Commission; D. Bates, agricultural survey (cocoa) officer, Gold Coast; J. Forsyth, entomologist, Gold Coast; I. A. S. Gibson, mycologist, Forestry Department, Kenya; I. A. Hoffe, veterinary officer, Federation of Malaya; G. S. Scott, provincial tsetse officer, Tanganyika; W. E. Webb, senior scientific officer, forest entomologist, Timber Pest Research Unit, Gold Coast; T. W. W. Wood, assistant conservator of forests, Sarawak.

### Announcements

Two Ramsay Memorial Fellowships, worth £400 a year plus a grant for expenses not exceeding £100 a year, are being offered for chemical research; they will normally be tenable for two years. One of the Fellowships will be limited to candidates educated in Glasgow. Further information can be obtained from the Joint Honorary Secretaries, Ramsay Memorial Fellowships Trust, University College, Gower Street, London, W.C.1, to whom application forms must be sent not later than April 17.

The Ministry of Education is arranging a short course in chemistry for teachers from technical colleges, to be held in the Municipal Technical College, Coventry, during July 15–24. The instruction will deal with modern chemical techniques relating to chromatography and to semi-micro-analysis, and will consist of lectures and practical laboratory work. The course will be residential, but local teachers may be accepted as day students; the total charge for board and lodging is £8. Further information can be obtained from the Ministry of Education (Teachers Short Courses), 36–38 Berkeley Square, London, W.1.

The British Columbia Research Council at the University of British Columbia, Vancouver, has announced the following new appointments: *Chemistry Division:* H. Friedeberg (formerly of the University of Birmingham), W. F. Gruber (University of Vienna), H. G. Khorana (University of Cambridge), J. F. Smith (Imperial College of Science and Technology, London) and J. D. H. Strickland (formerly with the Ministry of Supply in Great Britain); *Metallurgy Division:* I. D. G. Berwick (University of Cambridge), J. G. Parr (University of Liverpool) and J. E. Srawley (formerly with the British Cast Iron Research Association).

# SOME SOCIAL AND PSYCHOLOGICAL PROBLEMS OF AGEING

THE programme of the British Association meeting last year in Belfast included a session by Section J (Psychology) on the problems of ageing. Mrs. M. Gilmore was in the chair. In the opening paper, which was a review of the problems of ageing in relation to medical science, read by Dr. G. F. Adams, physician to the Geriatric Department of the City Hospital, Belfast, the reasons were considered why old age should present problems in modern times any more than in the past. There has been a progressive increase, both absolute and relative, in the proportion of old people in the population, this increase being the result of the decline in infant and young adult mortality produced by the medical and social advances that have been made possible by the application of the scientific method during the past century. As a result of this, more old people must be supported by a diminished proportion of wage earners. There is a corresponding increase in the numbers of elderly invalids to be cared for, who are suffering from the degenerative diseases of old age which medical treatment may ameliorate, but not cure. Meanwhile, the expense of medical treatment, especially hospital treatment, has risen enormously and continues to rise, and it has been suggested that the community is faced with a gloomy prospect of unlimited 'medicated survival' to be met by diminishing resources. Dr. Adams disagreed with this view. Pointing out that medicine has long evaded its responsibilities to the clinical and social medicine of old age, being preoccupied in other fields of research, he outlined the new approach being made to the medical care of the elderly through the clinical work of hospital geriatric departments and the influence of social medicine in surveys of the problems of ageing. Much success has already been achieved in the prevention of unnecessary invalidism among the elderly sick, and many elderly patients hitherto regarded as 'chronic invalids' have been restored to activity, reducing the burden of nursing and domestic care otherwise necessary for them. Dr. Adams concluded that estimates of future needs for the elderly sick should be based on the results of such work rather than on limits set by the out-dated system of social and medical care of the past.

The second paper was read by Miss S. R. Burstein, of the Wellcome Historical Medical Museum, who urged that the problems of many old people are essentially mental rather than matters of physical infirmity or disease. The problems of adolescence have been the subject of a great deal of careful psychological and social research; there is a need for similar research upon the emotional problems concerned with the transition from middle to old age and especially upon the ways in which the years of old age can be used. It should be recognized that old age is not something which comes suddenly—ageing is continuous from birth—and that it is fundamentally wrong to segregate old people as 'problem cases' away from the functioning life of the community.

Miss Burstein stressed that one of the difficulties for those doing research upon problems of old age is that they are usually younger, and that it is thus difficult for them to understand fully the outlook of the people with whom their research is concerned. She urged that discussion with old people individually or in small groups, if done with patience and respect, yields far more insight into their attitudes and needs than can methods such as questionnaire studies which are more immediately convenient to the research worker.

The traditional pattern in which the whole family, old and young, lived together under one roof has largely broken down, with the result that many old people are extremely lonely. A return to the traditional pattern is clearly impossible, and, even if it were, it might involve satisfying the needs of old people at an undue cost in terms of freedom and privacy for those younger. Intermediate solutions where, for example, old people live alone but close to younger relatives often work well. The point needs to be stressed, said Miss Burstein, that old people themselves must carry a large share of the responsibility for making such arrangements successful. Although they are often glad of the opportunity of leisure afforded by retirement, many of them are capable of useful work, and this applies not only to work at a job but also to help in the family as a functioning group.

Mrs. A. V. Hill, a member of the Advisory Council of the National Corporation for the Care of Old People, read the third paper, which was an account of some emotional changes observed in advanced old age—mainly between eighty and a hundred years. Although these emotional changes may accompany physical changes, the emotional needs of old people cannot be met by physical care alone. Little study has been made of old people's needs, and physical care without attention to emotional needs often constitutes actual cruelty. While certain main lines of emotional change can be observed, it should be emphasized that, on one hand, striking exceptions occur among very old people and that, on the other, changes can take place before any great old age in terms of years alone has been attained.

The behaviour of very old people can often be explained in terms of fear of death, or of illness or of change of environment. The will to live is as strong as ever, and fear of illness or accident may dominate the life of an old person. At the same time they may unconsciously feign illness in order to gain attention. Movement from one dwelling to another frequently produces a 'transference shock' with signs of mental and physical deterioration which can sometimes result in death. Usually, however, old people settle down in the new dwelling, although they may take some weeks to do so. This has been frequently noticed among new residents in old people's homes, and, when it seems likely to occur, the old people are persuaded not to cut adrift completely from their old haunts until they have come to know the new. Among other emotional attitudes, affection, friendship and concern for the opinions of others suffer a marked reduction. In the extreme, apathy and general indifference may appear, especially after long periods in bed. Interest in what immediately concerns oneself may increase: thus small treasures are hoarded, and interest in food may grow. At the same time, the gift of being able to "enjoy other people" often continues to the end of a very long life.

Mrs. Hill urged that, broadly speaking, bed is bad for old people unless absolutely necessary on account of severe illness or weakness. Where possible, old people should be provided with small convenient dwellings where they can live alone. The independence and the effort involved in living alone can, as an example in one housing trust has shown, help old people to remain young for their age. Old people's clubs can help to relieve any loneliness which may be involved, and so also can part-time employment. An important experiment in the employment of people between seventy and eighty years of age for two hours daily is being made in Finsbury.

It is to be emphasized that people do not "suffer from old age": they suffer from illness, unhappiness and loneliness, but not from old age as such. There seems to be an increasing tendency to resist and resent old age. Those old people who accept and understand its inevitability are emotionally in a much stronger position than others.

Dr. John A. Oliver, principal officer in the Ministry of Health and Local Government, Northern Ireland, read an address entitled "Thinking About Old Age", in which he gave an account of present-day social problems of the elderly, with some reflexions on social thought and social policy. He outlined the main features of the social problems of old age to-day—more people surviving into old age in a community distressed by a housing shortage and a dearth of domestic help; and a weakening sense of family responsibility towards their elderly relatives on the part of parents anxious to give their children the best possible chance in difficult circumstances. This decline in family responsibility is encouraged, perhaps, by the lack of any legal obligation to provide for elderly relatives and by the increasing State provision being made for them. Dr. Oliver considered that the progress in social work and social legislation made in the last ten years has been largely pragmatic and has been "achieved without any real preparation in fundamental thinking". The practical workers beset by immediate problems have tackled them empirically as they arose, and our new social legislation, as it applies to the problems of ageing, has been launched in a philosophical vacuum. A philosophy of the social work, the social policy and the social services which we are operating must be evolved from experience and thought. Both legal and moral duties are involved in family responsibility for the aged, and we must recognize the fact that the State cannot be committed to an unlimited liability for the care of old people. Moreover, the hopes and desires of the old people themselves must be considered; and, since home is the normal place for most of them to live and end their days in, social services designed to make it easier to look after elderly relatives at home should be augmented and their potential contribution to industry encouraged by suitable work under suitable conditions. Is progress henceforward to depend on individual enterprise, asked Dr. Oliver—"the effort of the old person, the effort of the relatives and the neighbours or on community services devised by the State"? He said that he believes that this choice between individualism and collectivism is the central philosophical problem in the so-called Welfare State. In conclusion, he suggested that the British Association might establish a new section devoted to social science, or social philosophy, so that "British science may demonstrate its concern for social well-being and spiritual values".

Mr. A. T. Welford, director of the Nuffield Research Unit into Problems of Ageing, spoke of changes of human performance with age which affect capacity for industrial work. He stressed that many such changes associated with old age begin early in middle age, so that problems of employment for older people are not concerned only with those over the normal retiring-age. At some jobs ability seems to be well maintained into old age, and for almost all jobs a few older people can be found who are able to put up a performance comparable with that of a young man. At other jobs difficulties of maintaining adequate performance appear as early as the late forties. Difficulties of taking up a new job may appear earlier still.

The main difficulties for older people appear to be of three types, the first being where the form or the pace of the action involved is rigidly determined so that any slowness leads to an error of omission which cannot be afterwards redeemed. When the task is more flexible and the speed under the operator's control, an older person is often capable of compensating for slowness by increased care and accuracy. As a result of these compensatory tendencies, difficulties for people in later middle age in industrial work may go undetected—people maintain performance under an increasing strain until a suitable opportunity occurs to move away. Such moves are sometimes made following an illness which would not in itself warrant a change of job. Detailed examination of performance shows that often, contrary to popular opinion, slowness even in a manipulative task is due not to any limit set by the sense organs or by the effectors, but by the central brain processes which integrate and interpret information and form action.

The second type of difficulty occurs where the task is in some way complicated or confusing. So long as the relation between signals and the action required in response to them is simple and straightforward, performance by older people differs relatively little from that of younger. When, however, the relation is indirect or where several pieces of information have to be put together before action is taken, many older people are at a severe disadvantage.

The third type of difficulty is that of learning new tasks. This is, of course, generally recognized. The nature of the difficulty is not, however, clear. To some extent it is due to the application to the new task of previous habits which are not appropriate. In some cases, however, it appears to be due to inability to modify an erroneous method built up during early stages of practice.

In studying changes of performance with age, concluded Mr. Welford, it is important that we should not be led astray either by generalizations or by particular exceptional individuals. The ability of older people to do a job will depend both on the detailed demands of the job and upon the particular abilities which each individual can bring to it. Rigid general policies about retirement cannot therefore be justified on grounds of ability. The appropriate retirement-age will differ for the majority from one job to another, and from one individual to another at any job.

G. F. Adams
A. T. Welford

# CARNEGIE INSTITUTION OF WASHINGTON

## ANNUAL REPORT FOR 1951–52

THE report of the president of the Carnegie Institution of Washington, Dr. Vannevar Bush, for the year ending June 30, 1952[*], reviews the progress of the Institution during the fifty years since its foundation and then briefly summarizes the research activities of the past year. The aim prescribed for the Institution was to "encourage, in the broadest and most liberal manner, investigation, research and discovery, and the application of knowledge to the improvement of mankind". In furtherance of this aim, the Institution has always devoted its main resources to fundamental research, which Dr. Bush distinguishes from applied research in terms of purpose rather than of method, and it has no thought of changing its policy. While he welcomes the growing realization in the United States that basic and applied science are two parts of one endeavour, and the consequent expansion of fundamental research with increased support from the Government, Dr. Bush believes that the Institution's primary responsibility remains to carry on fundamental scientific research with no initial view to its industrial application. Where, however, in its fundamental research, ideas and principles emerge that promise material advantage to society, it is proper for the Institution to explore some of the broader possibilities of application for human betterment.

In the main, the Institution has fulfilled its duty, in Dr. Bush's view, if it is diligent in making the results of its work generally known as promptly as possible. This preoccupation with fundamental research has simplified many of the Institution's problems and its relations with other bodies, as it has determined the policy in regard to patentable inventions which Dr. Bush outlines in some detail. He does not consider, however, that the absence in the United States of any effective organization for bringing the fruits of disinterested research to the point where they invite industrial development warrants the Institution plunging into the application of science. The Institution may sometimes, nevertheless, need to look ahead beyond its immediate programme of research and publication.

Dr. Bush justifies this policy by citing the part which the Institution has played, in collaboration with the National Research Corporation and the Stamford Research Institution, in exploring the practical aspects of the mass cultivation of algæ following the investigations on photosynthesis in its Department of Plant Biology which demonstrated the possibility of growing the green alga *Chlorella* so as to produce 56 per cent dry weight of protein. Other instances are also cited in the report of researches which have been conducted by the Institution during the past half-century so as to contribute to an understanding of the cosmos, the earth and its inhabitants, and which have later provided the basis of important developments or practical undertakings. They include early work in 1925 on pulsations and their echoes from the ionosphere, which was one of the pioneer researches in radar, investigations in the Geophysical Laboratory on low-expansion quartz glass, which led to the development of 'Pyrex' and similar glasses, and the basic study of the soda-lime – silica system in the same Laboratory, which contributed to a scientific understanding of the glass industry. Later, a modified formula for annealing 'Pyrex' glass in large castings was fundamental to the successful manufacture of the 200-in. 'Pyrex' mirror for the Hale telescope, and the Laboratory studies of the ternary system lime – alumina – silica contributed to the development of the Portland cement industry. The researches of the Department of Embryology form an important part in every text-book on human embryology published during the past decade, and the Soil Conservation Service of the United States Department of Agriculture has drawn extensively on the basic knowledge of the evolution of new plant species gained in the range-grass experiments of the Department of Plant Biology during the past decade.

Turning to current research activities, the report refers to the co-operation between, on one hand, W. Baade and R. L. Minkowski, of the Mount Wilson and Palomar Observatories, and, on the other, groups of radio observers in Australia and England which has led to the identification of the strongest radio source, Cassiopœia *A*, with a galactic emission nebula about five minutes of arc in diameter, and of the second strongest source, Cygnus *A*, with an extragalactic nebula the structural pattern of which Baade interprets as probably representing two nebulæ in collision. A twelfth satellite of Jupiter was discovered by S. B. Nicholson on September 28, 1951. Investigations by E. H. Vertine, of the Department of Terrestrial Magnetism, afford an explanation of the major changes in the rate of the earth's rotation during the past fifty years, while, under a joint project with the Geophysical Laboratory, methods have been worked out for measuring the ages of virgin granite and of unaltered rocks found in close association with such massive igneous monoliths as, for example, the Sierra Nevada range. New methods and apparatus developed by the latter Laboratory have permitted rapid and easy measurements at pressures up to four thousand atmospheres and concomitant temperatures up to 800° C.

The Department of Plant Biology has continued its studies of the alga *Chlorella*, including the rate of photosynthesis with intermittent light over new ranges of intensities and flashing schedules, while urea has been found to be an excellent source of nitrogen for the growth of algæ. Some four hundred new hybrids have been produced between different species of blue grass, and a basic study of the genetic and ecological systems that characterize natural races and species is being advanced using the milfoils or yarrows. In the Department of Genetics investigations on mutability in *Escherichia coli* indicate that the rate of spontaneous mutation varies with temperature according to the van t'Hoff rule, and that an intimate relation exists between spontaneous mutation and cell division. It has been established that a typical bacterial virus consists of a membrane (chiefly protein) containing almost pure nucleic acid and that the function of the viral membrane in the infection of the bacterial cell begins with the anchoring of the viral particle to the cell wall and quickly ends with the injection of the viral nucleic acid into the cell. An enzyme capable of breaking down isolated, but not intact, intracellular deoxyribonucleic acid has been discovered in onion root tips, and studies on maize have indicated that at least two classes of functional genetic unit are carried by the chromosomes: one of them, the gene, is potentially capable of determining a particular course of cellular reactions; the other is associated with the control of this particular action.

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[*] Report of the President of the Carnegie Institution of Washington for the Year ending June 30, 1952. By Dr. Vannevar Bush. Pp. 20 (Washington, D.C.: Carnegie Institution, 1952.)

In the Department of Embryology the discovery that there is extensive formation of neural-crest cells by the early embryonic eye (optic vesicle) throws light on the origin of the pigmented cells which appear early in the development of the eye. The development of the earliest human kidney rudiments has been thoroughly re-investigated, and further investigation of the physiology and biochemistry of uterine muscle has demonstrated that the 'staircase phenomenon', long known in heart muscle, occurs also in uterine muscle, and that the slope of the staircase is reversed by treatment with the corpus luteum hormone, progesterone. The discovery points to an essential role of potassium ions in uterine muscle contraction, and suggests that progesterone can modify the movement of potassium in and out of the muscle cell.

# OPTICAL SOCIETY OF AMERICA

## ANNUAL MEETING IN BOSTON

THE thirty-seventh annual meeting of the Optical Society of America was held during October 9–11, 1952, at Boston, Mass. Twenty-two invited papers covering spectroscopy, computational aids and atmospheric effects, in addition to other fields of science bordering on optics, were presented. The titles and abstracts of these papers and of the other contributed papers, together with a brief report of the proceedings of the meeting, are printed in the November issue of the Society's *Journal* (42, 868; 1952).

The invited papers include a discussion by N. Wiener on optics and the nature of spectra, a review of hyperfine structure investigations by F. Bitter, and a description of germanium phototransistors by J. N. Shive, of the Bell Telephone Laboratories. Various aspects of spectroscopy and radio astronomy are covered by communications from G. H. Harrison, R. Tousey, E. M. Purcell and others, including, in particular, one on multi-channel spectrometry by F. B. Follgett, of the University Observatories, Cambridge. In addition, a review of recent developments in infra-red spectroscopy is given by R. C. Lord.

Three papers are devoted to the subject of "Flying Saucers". It is pointed out by D. H. Menzel, of the Harvard College Observatory, that about one-fifth of the numerous reports received by the United States Air Forces did not admit of a simple explanation but that the majority of these, when examined carefully, could be explained as due to atmospheric physical phenomena, such as mirages, or reflexions from layers of fog or haze, or from ice-crystals. From a study of several hundred reports of unidentified aerial objects, it is concluded by A. Hynek, of the Ohio State University, that only one phenomenon, that of a hovering nocturnal light, is not readily explicable on an astronomical basis, and, finally, it is definitely stated by U. Liddel, of the Bendix Aviation Corporation, that no evidence exists for any phenomena not explicable by standard physical concepts.

The annual business meeting of the Society was held on the morning of October 10, and the annual banquet, preceded by a cocktail party given by the American Optical Company, during the evening. At the banquet, over which the Society's president, Brian O'Brien, presided, the Adolph Lomb Medal was presented to Dr. A. B. Meinel, of the Yerkes Observatory, and the Frederic Ives Medal to Dr. Ira S. Bowen, director of the Mount Wilson and Palomar Observatories. The after-dinner speaker was Dr. Harlow Shapley, of the Harvard College Observatory, who spoke on the subject of galaxies. The Adolph Lomb Medal is awarded to a promising scientist under thirty years of age, and the Frederic Ives Medal, which was established in 1928 by Herbert Ives in honour of his father, is for distinguished work in optics. Both medals are awarded every two years.

On receiving his medal, Dr. Bowen gave an address, entitled "Optical Problems at the Palomar Observatory", in which he described the support systems and the testing of the mirror and methods of increasing the effectiveness of the 200-in. Hale telescope, the main instrument at the Observatory. The mirror is a paraboloid of 660 in. focus; but, in addition, convex hyperboloids are provided which, when combined with the main mirror, give telephoto systems of which the focal lengths are 3,200 in. at the Cassegrain focus and 6,000 in. at the coudé focus. In addition to the mirror, the equipment of the Observatory includes three Schmidt cameras of 8, 18 and 48 in. apertures and operating at focal ratios of 1, 2 and 2·5, respectively. Dr. Bowen remarked that the cameras have remarkably fine definition over fields 9–20° in diameter and are efficient instruments for the rapid photography of large areas of the sky. Nearly all the equipment described has been in operation for from six months to three years, and the performance has come well up to expectation.

# BRITISH ASSOCIATION OF CHEMISTS

## HINCHLEY HOUSE

THE British Association of Chemists has recently acquired a freehold property, 14 Harley Street, London, W.1, for use as its headquarters. It was decided to name the premises 'Hinchley House' in memory of Prof. J. W. Hinchley, a founder member and the first president (1918–23). It was due to his influence and skill in directing its policy that the Association survived its first four difficult years. Prof. Hinchley was also instrumental in founding the Institution of Chemical Engineers, and his name will always be associated with chemical engineering, for many of the advances it has made in Great Britain are due to his conviction of its importance to industry and the necessity of making it a specialized branch of scientific study. The name of Prof. Hinchley had earlier been perpetuated through the annual award of the Association's Hinchley Medal, which is given for outstanding services to the profession of chemistry.

An opening ceremony was held at the new headquarters on February 27, when a number of members and guests, representing other bodies connected with the profession of chemistry, were present. Mr. F. Scholefield, president of the Association, in declaring the premises open, said that this function was indeed a red-letter day in the history of the British Association of Chemists, which thus became the first society of chemists to possess its own freehold property in London. The Association was formed in 1917 owing to the strong feeling among chemists in industry that there was no body having the prime function of looking after the economic interests of chemists. The Institute of Chemistry, as it was in those days, was a qualifying body, and it was outside its scope to look after such interests. After meetings in Birmingham, Manchester and London, the Association was formed.

Before long there was established, on the initiative of the London Section, a scheme whereby unemployment benefit was made available to members. The Unemployment Benefit Fund has been so well managed that to-day it is possible for the Association to pay as much as nine guineas per week to members temporarily unemployed. Although more than £20,000 has been paid out in benefit, there is to-day a balance of £52,000. It appeared to the House Committee, which included Mr. Norman Sheldon (chairman), Mr. C. S. Garland, Mr. G. T. Gurr and Mr. H. L. Howard, that it would be possible to invest some of that money to the advantage of the Fund and at the same time provide a worthy headquarters for the Association. Mr. Scholefield said that the greatest credit should be given to the House Committee, and that he would like to congratulate those who have been responsible for this really magnificent result. He then declared Hinchley House to be open.

After the ceremony, a tablet, inscribed with the names of the past-presidents and Hinchley medallists, was unveiled by Dr. Herbert Levinstein, who was president of the Association during 1923–24, immediately after Prof. Hinchley. This tablet was presented in memory of the late Mr. C. A. Wylie, president during 1951–52, by his family and friends.

Afterwards Dr. Levinstein gave this year's Hinchley Medal address entitled "Our Changing Chemical Industries : an Appraisement".

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# SURVEY OF FOOD CONSUMPTION AND EXPENDITURE IN GREAT BRITAIN

IN Great Britain the War-Time Food Survey was almost entirely limited to urban working-class households, and, as the National Food Survey, it continued in the same form until the end of 1949. Since then, however, an attempt has been made to obtain a more representative sample, so that all classes and types of consumer are included. A recent report, issued by the Ministry of Food* is the first of an envisaged annual series, setting out full details of food consumption and expenditure by families throughout the country.

Records were obtained from 4,723 families, of which 70 per cent were "urban working class", 11 per cent were "other urban households", and 19 per cent were "rural". The first group provides data suitable for direct comparison with results obtained in the earlier surveys and permits long-term trends to be followed through. The new material, however, is subjected to much more detailed analysis in an attempt to bring out economic, dietetic or nutritional differences between one group and another. Families are divided according to "composition" and to "social class", and numerous tables are presented which show the effects of increasing numbers of children in the household. Seasonal variations are demonstrated, and also the varying ability of the different social groups to maintain their normal standards in the face of price increases (temporary or progressive).

As a social document this report is probably as valuable as any ; the data on which it is based are considerable and there is every sign of the greatest care having been taken to obtain a high degree of accuracy at every stage. Yet, as a contribution to nutritional knowledge in Great Britain it is disappointing ; it does not establish the caloric and nutrient levels at which these families were actually living, and yet that is the information which would be of most value.

The factual material, on the food consumption side, is confined to the amounts bought or obtained "free" during the survey week, together with appropriate additions or deductions according to "changes in stocks". The amounts discarded by the housewife in preparing the food for table have not been measured, nor has any record been made of the amount of edible material that was not actually eaten. It is a great weakness in this type of survey that, on both scores, arbitrary adjustments have to be made. The allowance for wastage of edible material made here is an overall ten per cent; but do we really throw away one loaf in every ten, every tenth bottle of milk, one-tenth of our butter, our sugar and all the other foodstuffs of which so many communities stand in the direst need ? If we do, it is time that the crime of so doing was brought home to us more strongly. It is good that a footnote promises that this matter is to be examined further ; certainly, it seems unlikely that all foods are wasted in the same proportion and to the same extent by all social groups.

Despite these deductions, however, it appears that intakes were more than adequate in practically all respects, although households with four or more children, or with both adolescents and children, were only marginal and were adversely affected by the lowering of the extraction rate of flour from 85 to 80 per cent in the middle of the year. There is, however, ample room for further errors in the estimates of requirements and in the arbitrary deductions made from the standards used, to allow for meals obtained outside the home. It is to be hoped that modifications will be introduced into the survey technique so that the necessary adjustments may, in future, be made on a more factual basis.

M. W. GRANT

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* Ministry of Food. Domestic Food Consumption and Expenditure, 1950, with a supplement on Food Expenditure by Urban Working-Class Households 1940–1949. Annual Report of the National Food Survey Committee. Pp. 132. (London : H.M.S.O., 1952.) 4s. 6d. net.

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# WINTER CASCADING FROM AN OCEANIC ISLAND AND ITS BIOLOGICAL IMPLICATIONS

By BRIAN P. BODEN and ELIZABETH M. KAMPA
Bermuda Biological Station, Bermuda

THE circulation of Bermuda waters during the summer, and the possibility that this circulation acts as a mechanism for conserving insular plankton, have already been discussed[1]. Since that discussion presented only the summer picture, it became of interest to determine the winter circulation in order to understand the existence of an endemic plankton population.

It must be emphasized again that the marginal reefs around Bermuda are not at all continuous ;

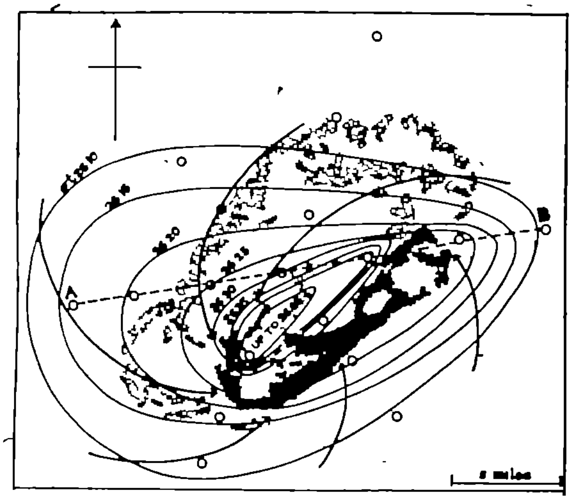

Fig. 1. Map of Bermuda and station plan. The islands are represented in solid black and the reefs are stippled. The stations are indicated by small circles. The intersections of $\sigma_t$ surfaces with the sea-surface are shown. The direction of the arrows is the probable direction of the water-movement. The section *AB* is shown in vertical profile in Fig. 2

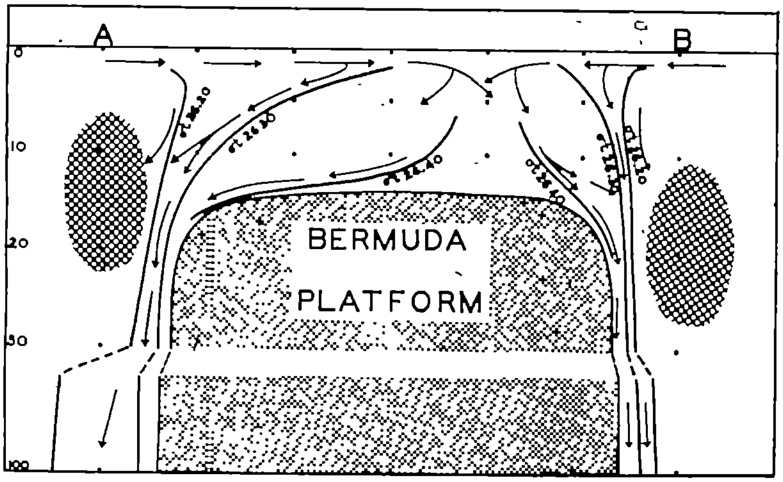

Fig. 2. Vertical density structure through section marked *AB* in Fig. 1. $\sigma_t$-Surfaces are shown and probable direction of flow is indicated by arrows. The cross-hatched areas represent density inversions in the water-column

they present no real barrier to free exchange between the lagoon and oceanic waters.

During a winter cruise, nineteen radially arranged hydrographic stations were occupied around the island and in the lagoon. Ekman reversing bottles and Negretti and Zambra reversing thermometers were used for obtaining water samples and temperatures at standard depths from the surface to 100 m. or to the bottom. Bathythermograms were made with both shallow and deep bathythermographs. The weather in Bermuda in late February frequently makes oceanographic work from a small, open boat rather hazardous, and for this reason it was considered desirable to complete as many stations as possible in as short a time as possible. Plankton sampling was therefore eliminated, making it possible to occupy enough stations to determine the hydrographic conditions.

The average surface salinity in the lagoon was 36·48 ‰, and at the oceanic stations it was 36·45 ‰. Surface temperatures in the lagoon averaged 18·60° C., while outside the lagoon the average was 19·11° C.

The intersections of $\sigma_t$ surfaces (equal density at zero pressure) with the surface of the sea are shown in Fig. 1. This density distribution must be associated with a cyclonic vortex. Both thermal and haline circulations exist and reinforce each other.

The vertical distribution of density along the section marked *AB* in Fig. 1 is shown in Fig. 2. The probable direction of water movement is indicated by the arrows. The surface water flows into the lagoon where (its specific gravity increased by cooling) it sinks and flows out along the lagoon floor and down the sides of the island. The cross-hatched areas at the edge of the platform represent density inversions in the water column, the water in the cross-hatched areas being heavier (by 0·02 $\sigma_t$-unit) than the water above it or immediately below it. This anomaly exists all around the island, probably because the momentum of the heavy water flowing over the edge of the platform is sufficient to carry some of it over the lighter water to the cross-hatched areas where mixing takes place. This vertical circulation is the type of local cascading over shallow banks discussed by Cooper and Vaux[2].

In general, then, the winter circulation can be described as a cyclonic, convergent movement about a sinking centre (as indicated by the arrows in both figures), and a certain amount of vertical mixing across the $\sigma_t$ surfaces takes place. This convergent movement and general cyclonic drift during winter are a complete reversal of the summer circulation, and have been noted in early Bermuda Biological Station reports (unpublished) as a result of drift-bottle surveys and of the inshore presence of oceanic plankton forms. In common with the summer circulation discussed previously, this circulation may be typical of the majority of islands in temperate latitudes.

The summer circulation about Bermuda has been shown to favour the survival of an endemic plankton population and of a benthos with planktonic larval stages[1]. With the exception of those forms which have dormant winter stages, enabling them to survive in local pockets until the return of favourable summer conditions, such an endemic insular plankton could not persist through an adverse winter circulation. The vertical circulation discussed here certainly does tend to carry the plankton down, probably to considerable depths, where it may be carried away from the island by the large-scale currents flowing past it. Singularly enough, the more feeble swimmers such as the larger medusæ, the powers of vertical migration of which are limited, do not appear in the plankton until the summer. The shallower summer circulation, which concentrates them around the island, tends to keep them also in the upper layers. This is doubly favourable, for most of these medusæ carry symbiotic algæ which would perish at depth.

The greater part of the zooplankton, however, migrates to the surface at some time during the day or night. It is thus returned to waters which are converging upon the island. [Aug. 11.

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# RESONANCE RADIATION FROM HYDROGEN FLAMES CONTAINING ALKALI METALS

By C. G. JAMES and DR. T. M. SUGDEN
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PREVIOUS workers[1,2] have shown that the intensity of the resonance radiation emitted by alkali metal atoms in flames (transition $nP_{3/2,1/2} \rightarrow nS_{1/2}$) varies linearly with concentration for small amounts, and with the square root of the concentration for large amounts, of the metal. This change of order depends on the self-absorption in the flame, which is in turn a function of the broadening of the lines by Doppler and collision effects. The present work demonstrates how these considerations may be applied to the problem of the formation of stable gaseous hydroxides in flame gases, and further to the elucidation of the collision diameters of the excited alkali atoms, using the results at low and at high concentrations respectively.

On the basis of the treatment of Mitchell and Zemansky[1], it can be shown that the measured intensity $I$ of the light emitted from a flame, of thickness $l$ cm. and temperature $T°$ C., in the form of resonance radiation from an added alkali metal is:

$$I = \frac{8\pi\alpha hc}{\lambda^3} \cdot \left(\exp - \frac{hc}{\lambda kT}\right) \int_0^\infty \{1 - (\exp - k_\nu l)\} d\nu, \quad (1)$$

where $\lambda$ is the wave-length of the centre of the line, and the integration is performed over the whole line with absorption coefficient $k_\nu$ at frequency $\nu$. The constant $\alpha$ depends on the measuring instrument only. At low concentrations the integral reduces to:

$$l \int_0^\infty k_\nu d\nu = \frac{\lambda^2}{8\pi} \cdot \frac{g_2}{g_1} \cdot \frac{Nl}{\tau} \equiv \frac{\pi e^2}{mc} \cdot Nfl, \quad (2)$$

where $\tau$ is the mean life of an excited atom, $f$ the '$f$ value' of the transition, $N$ the number/c.c. of alkali atoms in the ground state, and $g_2$ and $g_1$ the statistical weights of excited and ground states respectively.

Introducing the total absorption $A_G$, defined by Ladenburg and Reiche[3]:

$$A_G = 2\pi \int_0^\infty \{1 - (\exp - k_\nu l)\} d\nu, \quad (3)$$

equations (1) and (2) give rise to:

$$\frac{A_G}{\Delta\nu_D} = \frac{2\pi^2 e^2}{mc} \cdot \frac{Nfl}{\Delta\nu_D}, \quad (4)$$

where $\Delta\nu_D$, the Doppler broadening, has been introduced for reasons seen later. Plots of log $(A_G/\Delta\nu_D)$ against log $(Nfl/\Delta\nu_D)$ for the various metals should therefore coincide at low concentrations, and have unit slope.

Measurements of $I$ and hence $A_G$ have been made by adding fine sprays of alkali metal salts of known strength from an atomizer to the air-supply of a pre-mixed hydrogen/air flame, burned in a Méker-type burner with a surrounding flame of similar composition but without spray, so as to give a shield against self-reversal at the boundary, and observing the light emitted about 1 cm. above the small cones with a photocell. The light was chopped by a sector disk, which synchronized an amplifier so as to enhance selectively the photoelectric signal. Lines were isolated by Ilford spectrum filters and a dilute copper sulphate filter. Apart from a constant factor $\alpha'$, the measured intensities on a meter were converted by filter and photocell factors to absolute values. The results are shown in Fig. 1, plotting log $(A_G/\alpha'\Delta\nu_D)$ against log $(Cfl/\Delta\nu_D)$, where $C$ is the concentration of salt solution (chloride) in the atomizer. Complete dissociation of the salt is expected at the temperatures and concentrations used in the flame.

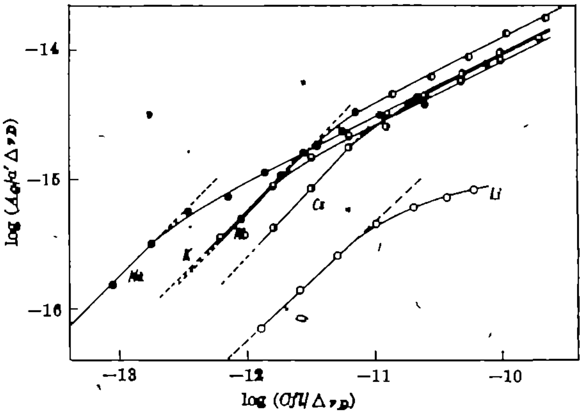

Fig. 1. Variation of 'total absorption' with concentration for various alkali metals in hydrogen/air flames

The results have the general form described above, but do not coincide, as equation (4) requires, at low concentration. It is suggested that this divergence arises from formation of gaseous hydroxide molecules, by reaction with the free hydroxyl radicals of the flame gases:

$$AOH \rightleftharpoons A + OH; \; K = \frac{[A]\,[OH]}{[AOH]} \equiv \frac{[OH]}{\varphi}. \quad (5)$$

[OH] is constant, being buffered by the flame gases, and is approximately $10^{-8}$ atmospheres, while the alkali metal concentration is in the range $10^{-4}$–$10^{-8}$ atmospheres. These results support previous work by Smith and Sugden[4] on ionization in flames and on the theoretical values of the equilibrium constant $K$ of equation (5): in particular, that work suggested that gaseous NaOH was negligible in these flames, but that the relative stability of the other hydroxides was LiOH > CsOH > RbOH > KOH, corresponding with the conclusion which may be drawn from Fig. 1, namely, that the concentration $C$ is not a measure of $N$, but of $(1 + \varphi)N$, and that this factor $(1 + \varphi)$ is responsible for the non-coincidence of the lower portions of the plots of Fig. 1. The values of $\varphi$ derived from Fig. 1 are somewhat higher than those from the ionization work.

If this hypothesis be correct, then the relative corrections from $C$ to $N$ may be made by shifting the curves along the abscissa so that the dilute portions coincide with that of the sodium (since its hydroxide may be neglected). The remaining (square-root) portions of the curves may now be compared.

The general expression for the absorption coefficient $k_\nu$ is very complicated, but we have shown that the following simple form is valid in the square-root portions of our plots:

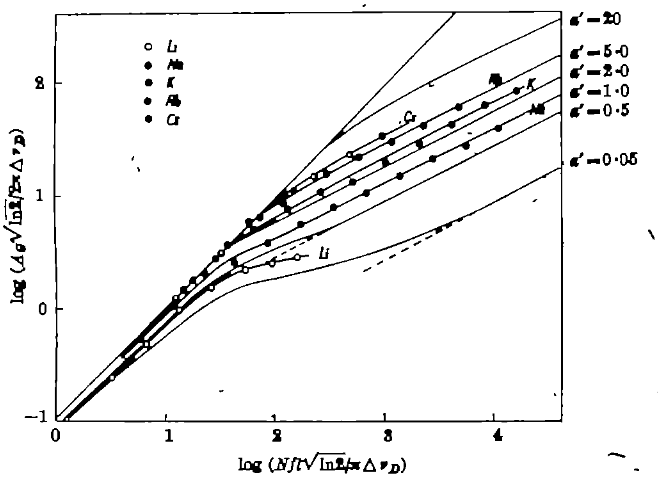

Fig. 2. Plots of 'total absorption' for determination of collision diameters

$$k_\nu = k_0\left(\frac{a'}{\omega^2\sqrt{\pi}}\right), \tag{6}$$

where $\omega = \dfrac{2(\nu-\nu_0)\sqrt{\ln 2}}{\Delta\nu_D}$, $a' = \dfrac{\Delta\nu_N + \Delta\nu_L}{\Delta\nu_D}\cdot\sqrt{\ln 2}$

and $$k_0 = \frac{2}{\Delta\nu_D}\sqrt{\frac{\ln 2}{\pi}}\cdot\frac{\pi e^2}{mc}\cdot Nf,$$

in which $$\Delta\nu_D = \frac{2}{\lambda}\sqrt{\frac{2RT\ln 2}{M_1}},$$

$\nu_0$ is the frequency of the centre of the line, $\Delta\nu_N$ is the (negligible) natural broadening and $\Delta\nu_L$ the Lorentz collisional broadening

$$\left(= \frac{2}{\pi}\,\sigma_L{}^2\,N_2\sqrt{2\pi RT\left(\frac{1}{M_1}+\frac{1}{M_2}\right)}\right),$$

where $M_1$ is the atomic weight of the alkali metal, $M_2$ the molecular weight of the colliding species of population $N_2$/c.c., and $\sigma_L$ the collisional diameter of the excited alkali atom in the flame. This leads to equation (7):

$$\frac{A_G}{\Delta\nu_D} = 2\pi\sqrt{\frac{2\pi e^2}{mc\sqrt{\ln 2}}}\cdot\sqrt{a'}\cdot\sqrt{\frac{Nfl}{\Delta\nu_D}}, \tag{7}$$

with expected variation with $\sqrt{N}$. The family of curves of log $(A_G/\Delta\nu_D)$ against log $\left(\dfrac{Nfl}{\Delta\nu_D}\cdot\dfrac{\sqrt{\ln 2}}{\pi}\right)$ with various $a'$, as depicted by van der Held[5], will be absolute. The theoretical forms for various $a'$ are shown in Fig. 2 (thin lines). To accord fairly closely with the recent work of Sobolev, Mezhericher and Rodin[2], and the results of Schutz[6], the experimental curve of Fig. 1 for sodium has been superposed on $a' = 1{\cdot}0$, and the hydroxide correction above made to bring the others into their correct relative positions (thick lines with points).

| Metal | $a'$ | $\sigma_L{}^2 \times 10^{16}$ cm.$^2$ |
|---|---|---|
| Lithium | 0·3 | 22 |
| Sodium | 1·0 | 68 |
| Potassium | 2·8 | 125 |
| Rubidium | 5·3 | 180 |
| Caesium | 6·3 | 164 |

The ordinates of the square-root parts give values of $a'$ from which the collision diameter $\sigma_L$ can be deduced, assuming the colliding species to be mainly nitrogen. These are given in the table.

The last column is of the expected order, with the exception of cæsium, which is rather anomalous. Further support is given by the results for lithium, which are beginning to show the characteristic flattening of very low $a'$ in Fig. 2.

Since van der Held's curves are absolute, these results can be used to give the absolute concentration $N$ in the flame. Thus 1$N$ sodium solution in this case gives, from Figs. 1 and 2, $2{\cdot}3 \times 10^{14}$ atoms/c.c. of flame, in the ground-state, corresponding with a partial pressure of $7 \times 10^{-5}$ atmosphere.

This type of study can provide, therefore, information which is useful in practical flame photometry, in measuring concentrations and therefore in studying equilibria at high temperatures, and in the study of collisional phenomena connected with radiation.

[July 28.

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# STRUCTURE OF STARCH

## By Prof. R. H. HOPKINS

British School of Malting and Brewing and Department of Applied Biochemistry, University of Birmingham

IN a recent communication, Blom and Schwarz[1] conclude that the molecules of starch contain, in addition to the generally accepted α-1,4- and α-1,6-glucopyranosidic linkages, an additional type of glucosidic link. The type which is considered by them to fit the facts is the α-1,5-link connecting a glucopyranose to a glucofuranose residue, this occurring alternately with the 1,4-link. In other words, the part of starch which is susceptible to the action of β-amylase is composed of unbranched chains consisting of alternate pyranose and furanose rings. The authors do not develop their hypothesis, but merely indicate how, under it, β-amylase would function. The experimental evidence furnished is, briefly, that on hydrolysis by acids the fall in optical rotation is abnormally small in the first stages of fission, rising considerably as the reaction proceeds. The existence of an additional type of link is indicated, and this leads straight to the above conclusion. A re-examination of the evidence for the accepted structure is called for, attention being confined to the unbranched part of starch, for example, amylose.

The hypothesis of alternate pyranose and furanose links has its attractions for the enzyme chemist. For example, the action of β-amylase, which, starting from the non-reducing end of a chain, by-passes the first link but breaks the second one although this is identical with the first one, and produces β-maltose from an α-link, presents features which are unusual in enzyme action. On their hypothesis, although the authors do not state so, it is necessary to assume that the first two glucose residues from the non-reducing end are in the pyranose form linked as in maltose, and that a 1,5-link to furanose follows. We may assume that hydrolysis by enzymes proceeds by such mechanism as this:

β-*Amylase* breaks the 1,5-link liberating α-maltose. It must be presumed also to open the furanose ring of the adjoining group, leaving it in an open-chain form, from which a new pyranose ring is formed, thus accounting for the mutarotation in the upward sense. The estimated rise in rotation would be about sufficient to mask the downward change in the liberated α-maltose and leave a resultant upward change equivalent to that observed by Kuhn[2]. Two pyranose residues are now at the end of the chain in position for the next fission by the enzyme.

α-*Amylase* splits 1,5-links at various parts of the chain, similarly opening the adjoining furanose residue but catalysing also its closure to the pyranose ring. This enzyme must be assumed to combine functions of fission with those of the 'mutarotase' recently described[3] which catalyses mutarotation of glucose. Indeed, the opening of the furanose ring might facilitate the accompanying fission at its fifth carbon atom. Thus α-amylase splits off α-mutarotating fission products; the upward mutarotation due to the furanose–pyranose change is not observed, it being as rapid as the enzyme action.

*Hydrogen ions* function to the same effect as α-amylase, attacking the 1,5-links much more readily than the 1,4-links. The high (for example, 80 per cent) yield of acetobromomaltose from starch by the action of acetyl bromide[4] would require the same mechanism for the hydrolysis.

Calculation of the specific rotatory power of starch (in water) on the basis of that of the α-glucosidic link and residue in maltose leads to higher values[5], + 229°, than those observed (200°). On the hypothesis put forward, it would approximate to the latter.

The adverse side of the picture must be presented. Including the usual arguments[6,7] in favour of the α-glucopyranoside chain there are the following:

(1) Furanose forms are rare in naturally occurring glucose compounds.

(2) The rates of hydrolysis of furanosides by acids, for example, ethyl glucofuranosides, are some 50–200 times faster[8] than those of the corresponding pyranosides. To answer this it would be necessary to assume that the furanoside group in the middle of a chain, with its fifth carbon atom anchored to the chain beyond, could be quite stable; and, in fact, that its 1,4-glucosidic link is not attacked by the hydrogen ion as readily as the pyranosidic 1,5-link, while the latter in its turn is hydrolysed more slowly than the link in maltose[5,8]. But the exposure of a furanose residue by fission of the 1,5-link adjoining it should leave it susceptible to rapid acid hydrolysis, as with the ethyl glucofuranosides, so that each 1,5-fission should be, in effect, accompanied by an α-1,4-fission. The latter would cause such a fall in optical rotation as to mask the small fall caused by the 1,5-fission, and no maltose would be formed. Blom and Schwarz do not consider that such a furanoside is necessarily unstable and furnish argument in support of their view.

(3) α-Amylase splits amylose to produce not only maltose, as required by the hypothesis, but also appreciable quantities of glucose and maltotriose. This requires the enzyme to attack two very different α-glucosidic links and at different rates. Alternatively, the mutarotase function postulated above could, if slowly operated, give opportunities for the open chain to break away at its reducing end. This would be assumed to happen in a certain proportion of the cases, depending on the relative rates of exercise of these two functions. The different types of α-amylase might vary among themselves in this respect. (Incidentally, any lag in this liberation of glucose could well account for the anomaly reported by Kuhn[2], a sudden rise in rotation during the action of pancreatic amylase.) The removal of glucose in such a way would give rise to a dextrin with an odd number of glucose residues in it, ultimately yielding maltotriose. But this maltotriose would contain a furanose residue in the middle position.

(4) The structure of maltotriose has recently[9] been established as that of three glucopyranose units. It is true that the material investigated might have originated from a portion of the starch (amylopectin) near the branch-points to which the pyranose–furanose structure need not apply. However, maltotriose is definitely formed from amylose by α-amylases[10,11], and appears in some cases in the comparative absence of glucose.

(5) The mechanism of action of phosphorylase[12] and amylo-glucosidase[13] in forming respectively glucose-1-phosphate and glucose from a chain with alternate pyranose and furanose residues is difficult to work out, and, as with α-amylase, requires specificity for two different links. On the other hand, the need for a primer of three or four groups in length to initiate synthesis of phosphorylase[14] could be well accounted for.

Altogether, it must be concluded that the hypothesis put forward by Blom and Schwarz creates more difficulties than it clears up. Nevertheless, their experimental results call for explanation. These and the discrepancy in the $[\alpha]_D$ of starch, referred to above, are due to the same cause, with which the upward mutarotation of β-amylase fission products may also be associated. Explanation may well be found along the line that the α-glucosidic residues in the middle of a chain are pyranose but nevertheless possess very decidedly lower optical rotatory power than in maltose. Calculation of the value of $[\alpha]_D$ of maltotriose from the values of α-glucose and maltose leads to + 168° for the solution in water at equilibrium. If maltotriose derived from amylose, possessing $[\alpha]_D$ + 158° as found in these laboratories (cf. French *et al.*[15]), can be shown to be composed solely of α-glucopyranose units, as Wolfrom has done for what appears to be the same compound, this would go far to account for the $[\alpha]_D$ of starch, since the value 158° is in good agreement with the Freudenberg rule. [Oct. 3.

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# LETTERS TO THE EDITORS

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## A New Blood-Group Antibody, Anti-$Jk^b$

THE human blood-group system called *Kidd* was discovered in 1951 by Allen, Diamond and Niedziela[1], who found an antibody, anti-$Jk^a$, which distinguished two phenotypes, $Jk(a+)$ and $Jk(a-)$. Family investigations[2] showed that the antigen $Jk^a$ is inherited and that the gene $Jk^a$ is capable of expressing itself in single and in double dose; the existence of an allelomorphic gene $Jk^b$ was assumed. In tests on 390 unrelated persons[2], the phenotype frequencies were $Jk(a+)$ 76·92 per cent and $Jk(a-)$ 23·08 per cent, from which the following gene and genotype frequencies were calculated:

| Genes | | Genotypes | |
|---|---|---|---|
| $Jk^a$ | 0·5196 | $Jk^aJk^a$ | 0·2700 |
| $Jk^b$ | 0·4804 | $Jk^aJk^b$ | 0·4992 |
| | | $Jk^bJk^b$ | 0·2308 |

The finding of the antibody corresponding to the antigen, and gene, $Jk^b$ is here reported. It has been found in the serum of Mrs. W. Mrs. W. gave birth to full-term healthy infants in 1937 and 1940 and had miscarriages in 1944 and 1951. There is no history of hæmolytic disease of the newborn. She was transfused with blood after the second and again after the fourth delivery. The latter transfusion had to be stopped owing to a rigor, and because of this her serum was examined.

The blood groups of Mrs. W. are *O*, *MsMs*, *P*+, *cDE/cde*, $Lu(a-)$, *K*−, $Le(a-b+)$, $Fy(a-)$, $Jk(a+)$. Her serum contains anti-$Fy^a$ as well as anti-$Jk^b$. The more powerful anti-$Fy^a$ was recognized first; the presence of anti-$Jk^b$ was suspected from the results of tests on $Fy(a-)$ red cells. The anti-$Fy^a$ was removed by absorption, leaving in the serum anti-$Jk^b$ alone. The cells used for this absorption were from a person known to be homozygous $Fy^aFy^a$ and thought, from previous dosage work with anti-$Jk^a$ sera, to be homozygous $Jk^aJk^a$.

That the antibody left in the absorbed serum is indeed anti-$Jk^b$ is shown as follows.

(1) Ninety-eight members of the staff of the Lister Institute have been tested, with the following results:

| | | $Jk(a+)$ | $Jk(a-)$ |
|---|---|---|---|
| Mrs. W.'s serum absorbed | + | 44 | 19 |
| | − | 35 | 0 |

If the new antibody were not related to the *Kidd* groups the 'exact' probability of getting such a result would be only 1 in 14,129. There is no association with any of the other blood-group antigens, with sex or with the ability to taste phenyl thio-carbamide.

(2) All 19 $Jk(a-)$, that is, $Jk^bJk^b$, persons so far tested are positive, and so are all of 22 persons known from family studies to be heterozygous $Jk^aJk^b$. (Seven of these heterozygotes are in the Lister 98; a further 15 were selected and do not appear in the 2 × 2 table.) If the new antibody were not associated with $Jk^b$ the chance that all 41 persons should be positive is but one in many thousands.

(3) The positive reactions of the new antibody are, on the average, a little stronger with $Jk(a-)$ than with $Jk(a+)$ red cells.

The new antibody in the serum of Mrs. W. is therefore anti-$Jk^b$. Of the 79 $Jk(a+)$ persons in the 2 × 2 table it can be calculated that about 51 should be $Jk^aJk^b$, and therefore positive with anti-$Jk^b$, while 28 should be $Jk^aJk^a$ and therefore negative; in fact, 44 were positive and 35 negative, which is not a significant departure from expectation ($\chi^2 = 2 \cdot 9$ for 1 degree of freedom).

The presence of anti-$Jk^b$ in this serum was first demonstrated by the indirect anti-globulin method, but was not detectable by the trypsin or other tests. The reactions were weak. It was then found, however, that an indirect anti-globulin test on trypsinized cells, a combination of tests recommended by Unger[3], gave very clear results.

The existence of the antibody anti-$Jk^b$ promotes the *Kidd* system to fourth place in the order of 'usefulness'[4] of the nine blood-group systems. 'Usefulness' is a measure, suggested by Fisher, of the potential value of the systems in human genetics and in problems of identity, parentage and paternity.

We are grateful to Mr. Norman White and Dr. Martin Hynes, of the Royal Northern Hospital, Holloway, for their co-operation; we also acknowledge, once again, the kindness of our long-suffering colleagues at the Lister Institute in giving innumerable samples of blood.

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[2] Race, R. R., Sanger, Ruth, Allen, F. H., Diamond, L. K., and Niedziela, Bevely, *Nature*, 168, 207 (1951).

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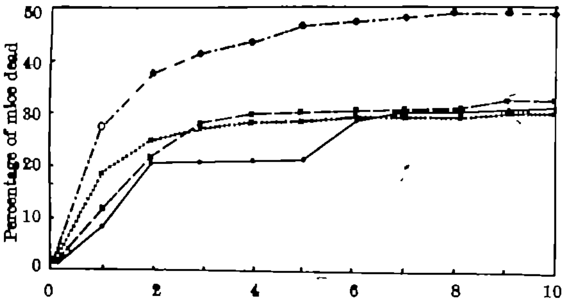
## Effect of Hyaluronidase on the Mortality from Experimental Burns

IN treating secondary shock, the intravenous route of fluid administration may not be possible under certain conditions, as, for example, in small infants or in the event of a catastrophe when sufficient trained personnel are not available. In lieu of the intravenous route, the interstitial administration of fluids containing hyaluronidase to assist assimilation has been used clinically in recent years[1]. With the addition of this enzyme to break down hyaluronic acid, the fluid spreads more rapidly throughout the connective tissue, thereby entering the capillaries more rapidly, with a consequent increase in the effectiveness of the shock therapy.

If hyaluronidase is to be used in hypodermoclysis, however, it is important to establish that it exhibits no adverse effects otherwise on the shocked individual as, for example, in burns. For this reason, the effect of hyaluronidase on burned, shock-treated animals was studied experimentally.



Influence of hyaluronidase on mortality of mice after an experimental burn.
○ —·— — ○, 'Hydase' applied at burn site (80 mice); × ...... ×, heated 'Hydase' (control) at burn site (80 mice); ■ — — — ■, 'Hydase' injected distally (60 mice); ● —— ●, heated 'Hydase' (control) injected distally (60 mice)

Adult, male, Connaught strain white mice deeply anæsthetized with 'Nembutal' were subjected to a standard burn produced over the dorsum by immersing a constant fraction (one-third) of their body weight in water at 70° C. for 20 sec. The mice were afterwards treated for shock with 1 c.c. of physiological saline administered intraperitoneally in two doses: 0·5 c.c. immediately after the burn, the other 0·5 c.c. two hours later.

Three sets of paired experiments were carried out, one in which the hyaluronidase (Wyeth 'Hydase') was added to the saline given intraperitoneally, one in which the hyaluronidase was injected subcutaneously (0·1 c.c.) in an area remote from the burn, and a third in which the hyaluronidase was applied locally to the burned area in 0·25 c.c. saline. The latter two studies were carried out in paired experiments in which the control mice received equal quantities of hyaluronidase which had been inactivated by heating at 100° C. for 15 min. The results are shown in the accompanying table. In addition, the graph illustrates the time-course of the mortality of mice treated locally to the burn and subcutaneously distally with 50 turbidity reducing units of hyaluronidase and of the controls similarly treated with the inactivated enzyme.

From these observations, it is seen that the mortality of the burned mice treated with hyaluronidase intraperitoneally or subcutaneously distal to the burn is essentially the same as that of the controls. The addition of even relatively large doses of hyaluronidase by these routes, therefore, has not otherwise prejudiced the chances of survival of the burned animals. Conversely, however, the local application of hyaluronidase directly to the burned surface has definitely increased the mortality in the burned animals. With 50 turbidity reducing units of enzyme, this increase is significant at the $P = 0{\cdot}03$ level. From the limited series of animals treated marginally with 15 units, it seems that an increased mortality is also produced with smaller doses of hyaluronidase applied locally in the burned area.

Effect of Hyaluronidase on the Mortality of Burned Mice

| Dose of hyaluronidase or inactivated hyaluronidase | Mode of administration | Total No. of mice burned | No. dead in 10 days | Per cent dead |
|---|---|---|---|---|
| 1·5 TRU* enzyme | Subcutaneously in 0·1 c.c. saline distal to burn | 40 | 12 | 30 |
| 1·5 TRU inactivated | | 40 | 11 | 28 |
| 15 TRU enzyme | | 39 | 10 | 26 |
| 15 TRU inactivated | | 38 | 11 | 29 |
| 50 TRU enzyme | | 60 | 20 | 33 |
| 50 TRU inactivated | | 60 | 19 | 32 |
| 0 TRU enzyme | Intraperitoneally (in saline) | 26 | 11 | 42 |
| 0·02 TRU ,, | | 26 | 10 | 38 |
| 0·5 TRU ,, | | 26 | 8 | 31 |
| 12·5 TRU ,, | | 26 | 8 | 31 |
| Saline | Subcutaneously into margin of burn (0·1 c.c.) | 20 | 10 | 50 |
| 15 TRU enzyme | | 20 | 13 | 65 |
| 50 TRU inactivated | Applied to burn surface in 0·25 c.c. saline | 80 | 25 | 32 |
| 50 TRU enzyme | | 80 | 40 | 50 |

* TRU = turbidity reducing units.

The increase in mortality observed when hyaluronidase was applied to the burned skin with the consequent breakdown of the hyaluronic acid in the wound may result either from an increased absorption of toxic material from the burn or from increased loss of fluid into the wound or from a combination of these factors. At post-mortem the burns treated locally with hyaluronidase seemed to be more œdematous than those similarly treated with the inactivated enzyme. Sections of the burned skin treated with hyaluronidase or with inactivated hyaluronidase locally were therefore examined for œdema. The mean full-skin thickness from the burn in seven sections of mice treated with hyaluronidase was indeed found to be slightly but measurably greater when compared with seven sections from mice treated with the inactivated hyaluronidase. The areas were measured quantitatively by projection. This small sampling thus tends to confirm objectively the post-mortem impression.

From this experimental work in animals, it is concluded that tests to establish the safety of using hyaluronidase in hypodermoclysis in the treatment of burned patients are probably justified clinically in areas away from the burn, since no adverse effects could be shown with relatively large doses of hyaluronidase, provided the enzyme was given subcutaneously distal to the burned area or intraperitoneally.

This work was carried out under contract between the Defence Research Board of Canada and the Hospital for Sick Children, Toronto.

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[1] Burket and Gyorgy, *Ann. N.Y. Acad. Sci.*, **52**, 1172 (1950).

## Lipoids and Cholesterol in New-born Rats

The organism of new-born rats is subjected to many post-natal changes. Certain organs, and probably all the body, will achieve in stages the functions which they have in the adult animals. It has been stated that the hypophysis develops its complete functions after birth. Heller[1] found in the hypophysis of new-born rats ten times less adiuretine than in adults. Schreiber[2] noticed the embryological, anatomical and physiological relation of the neurohypophysis, hypothalamus and visual organs, and was led to look for correlation with the evolution of the water metabolism of new-born rats as the expression of the action of the diencephalo-pituitary system and the functional evolution of the eye. He observed that, in rats just beginning to see, the dry matter is increasing and chlorides decreasing with

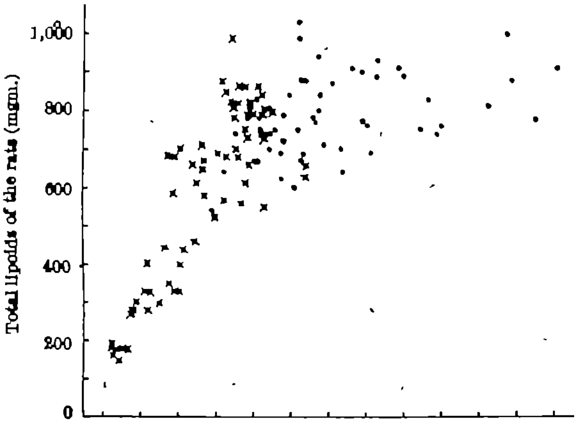

Fig. 1

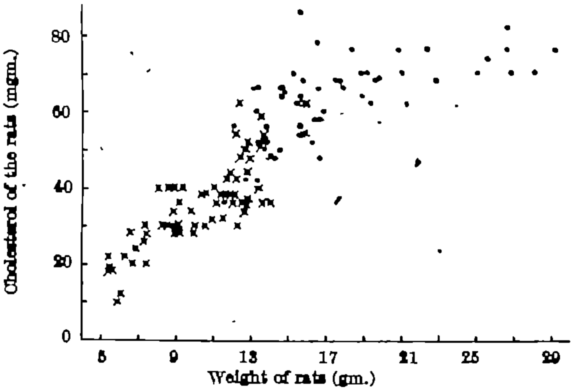

Fig. 2

Fig. 1. Relation of total lipoids to the body-weight of new-born rats. ×, Rats which could not see; O, rats which could see

Fig. 2. Relation of cholesterol to the body-weight of new-born rats. ×, Rats which could not see; O, rats which could see

the growth in weight. The decrease is quicker in rats before their eyes are open. He explains his results as the completion of evolution of the neurohypophysis at the time when the rat is just beginning to see.

In the present work, the content of total lipoids and cholesterol in albino rats was found from birth to the age of twenty days, with particular regard to that time when they begin to see.

Young rats from twenty-one litters, each litter of average number six rats, were used, and it was noted whether each animal could see or was blind. This change happens normally at about the thirteenth day after birth. The animals were minced, and extracted three times with excess of boiling alcohol–ether (3 : 1). In the whole extract, total lipoids were determined gravimetrically after extraction with petroleum ether. Cholesterol, of the same extract, was determined colorimetrically by the Liebermann–Burchard reaction.

From the graphs it is evident that the amount of total lipoids increases more quickly with increasing weight in the blind rats than in the rats which could see. A less distinct increase occurs for cholesterol.

This smaller increase of lipoids is not shown in the amount of dry matter of rats, which Schreiber describes in his work. On the other hand, dry matter increases more in rats which can see than in blind rats. Therefore it is evident that at this time the increase of proteins must be higher than the increase of lipoids.

Treatment of animals with anterior lobe of hypophysis results in increased utilization of lipoids, especially of glycerides[3]; cholesterol is not affected in this way. It is possible that the smaller increase of lipoids and greater increase of proteins in rats when they begin to see may be related to a certain state of development of the hypophysis.

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[1] Heller, H., *J. Physiol.*, 106, 28 (1947).

[2] Schreiber, V., *Čas. lékařů českých*, 89, 549 (1950) (in Czech)

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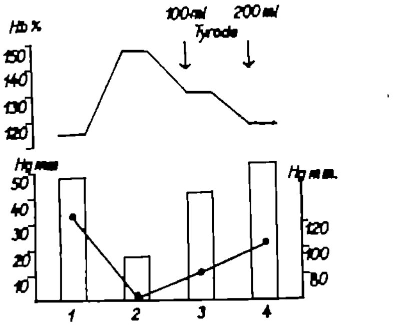
## Response of the Vascular System to Sympathetic Stimuli during Shock

SHORR and co-workers[1], in studying the state of the vascular system in shock, showed that in the later stages of variously induced shock a vasodepressor substance appears in the blood of dogs, and that this substance, injected into rats, reduces the spontaneous vasomotion of the vessels of the mesoappendix and sensitivity to adrenalin. They later identified the substance as ferritine[2]. In their opinion, the vaso-depressor substance has an important role in the patho-mechanism of shock.

In our experiments, we have studied the effect on the blood pressure of splanchnic stimuli and of adrenalin injections in animals in hæmorrhagic or tourniquet shock. Experiments were carried out on seventy-nine dogs under chloralose anæsthetic. Hæmorrhagic shock was induced by gradually drawing 35 ml./kgm. blood; ischæmic shock by 4–5 hr. ligature of the rear limbs (tourniquet). In both types of shock, 90 per cent of the animals succumbed within 7–8 hr. The adrenalin was given intravenously in 20–40 μgm. doses, choosing the dose so far as possible to bring about a rise in blood pressure equal to a 10-sec. splanchnic stimulus. Comparison of the adrenalin and splanchnic sensitivity was made in the same animal before and after inducing shock.

Our results show that, both in hæmorrhagic and in ischæmic shock, the blood pressure following splanchnic stimulus or as the effect of adrenalin pressor has a value of 17–21 mm. mercury, as against the initial 45–50 mm. mercury. Decreased splanchnic and adrenalin responsiveness could already be observed 1–2 hr. before death, when the systemic blood pressure was about 60 mm.

The phenomenon can be explained by Shorr's theory of a vaso-depressor substance; but it seemed possible that the hæmo-concentration, or the reduced quantity of circulating blood in shock, might bring about the diminished adrenalin and splanchnic response. To determine this, in further experiments we investigated the effect of re-injecting the blood drawn, or Tyrode infusions of varying quantity, on splanchnic and adrenalin sensitivity. The rise in blood pressure due to the adrenalin, the systemic blood pressure and percentage hæmoglobin are shown in the accompanying diagram (mean values for eight ischæmic shock experiments). From the diagram can be seen, on one hand, the degree of reduction in adrenalin sensitivity in shock, and, on the other, that when the hæmoglobin-level reaches its initial value as the result of the infusions, adrenalin sensitivity is also re-established. There is a correlation



Effect of adrenalin on blood pressure in millimetres of mercury, □; systemic blood pressure, ●—●; upper curve, hæmoglobin per cent; (1) before inducing shock; (2) during shock; (3) after infusing 100 ml. Tyrode; (4) after infusing 200 ml. Tyrode

between the two values ($r = -0{\cdot}86 \pm 0{\cdot}14$). The splanchnic stimulation behaves in essentially the same manner. In hæmorrhagic shock, transfusion of the drawn blood likewise normalizes the splanchnic and adrenalin responsiveness.

From these results it would seem that, conflicting with the theory of a vaso-depressor substance, the diminution in splanchnic and adrenalin sensitivity in shock is due primarily to the reduced amount of blood in circulation.

More detailed results will appear in the *Acta Physiologica Hungarica*.

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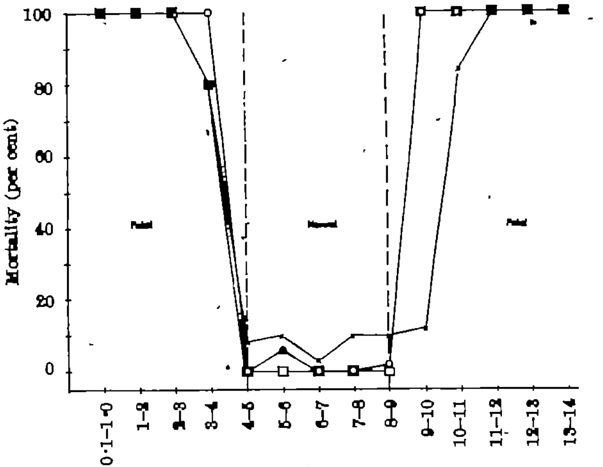
## Effect of Changing *p*H on Developing Trout Eggs and Larvæ

A change in the *p*H value of the surrounding water has been observed to have a marked influence on the life and growth of trout eggs and larvæ. Normally, they are reared in water of *p*H 7·30 ± 0·05 at 10·5° C. The *p*H value of the yolk in living eggs and larvæ is 6·50–6·55, and after death it has the same *p*H value as that of the surrounding water. As a starting point for an investigation of the effect of different *p*H values on eggs and larvæ, they were reared in tap water adjusted to different *p*H's with hydrochloric acid and sodium hydroxide. Such a system would not remain at constant *p*H. Since it was found that a particular quantity of water in a glass vessel containing fifty eggs did not change its *p*H in 6 hr. by more than 1·0 towards the acid side, the water of the experimental container was replaced after 6 hr. with fresh water adjusted to the original *p*H. Buffer solutions were not used to avoid the action of other ions. All the containers were kept in the same hatchery tray at a constant temperature of 10·5° ± 0·5° C., and each container received 50 eggs. The larvæ need more oxygen and give out more carbon dioxide than the same number of eggs, so the quantity of water in each container was increased to five times the original to ensure the proper aeration of the larvæ. A simple average of the mortality percentage of four experiments is shown in the graph. All *p*H values were measured with a glass electrode and Cambridge *p*H-meter at 10·5° C.



— —, Ova one day after fertilization; ○—○—, eyed ova about three weeks after fertilization; □—□—, larvæ one day after hatching

The graph shows that the eggs can develop normally in a fairly wide range of *p*H, outside which there is an abrupt rise in mortality. It also shows that the eyed ova and the larvæ are equally susceptible to *p*H changes, but green ova are more resistant.

*In alkaline medium.* There was endosmosis. The eggs swelled and the vitelline cavity was reduced very much. The yolk became white due to contamination with external water. The frozen sections of the eyed ova showed very little breaking of the yolk emulsion at its surface, and it appeared that metabolic activity was very much slowed down.

*In acidic medium.* In this case there was exosmosis. The egg yolk inside the eggs shrank, and the vitelline cavity widened. The yolk even in the dead eggs was not white, showing that it was not contaminated with external water. The frozen sections of the eyed ova showed an increase in the breaking of yolk emulsion at its surface. The metabolic activity appeared to be accelerated in this case.

It is suggested that the alkali saponifies the lipoids of the vitelline membrane, making it permeable to water, and also retards the activity of the extra-embryonic blastoderm in yolk metabolism. On the other hand, acid does not remove the lipoids of the vitelline membrane and its impermeability to external water is maintained. The acid appears to accelerate the metabolic activity of the extra-embryonic blastoderm on the yolk surface.

In these experiments there can be two factors which would affect the eggs and larvæ: (1) the change of *p*H value of the surrounding medium, and (2) carbon dioxide given out by the eggs and larvæ during respiration. The latter point was raised by Young[1] while studying the effect of changing *p*H values on adult fishes. In the present experiment this factor was negligible because the quantity of carbon dioxide given out by the eggs would be much smaller than that given out by adult fishes. In any event, it was found that the carbon dioxide factor was common to both treated and control containers.

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## Occurrence of Nicotine together with Hyoscine in *Duboisia myoporoides* R. Br.

The genus *Duboisia* comprises three species: *D. hopwoodii* F. Muell. is confined to the interior of the Australian continent, *D. leichhardtii* F. Muell. has a restricted occurrence in the highlands of south-eastern Queensland, and *D. myoporoides* R. Br. occurs along the eastern coast of Australia and in New Caledonia. The leaves of all three species contain major quantities of alkaloids; but the genus is unique in that one species, *D. hopwoodii*, contains the pyridine alkaloids nicotine and *nor*-nicotine, whereas the other two contain various alkaloids of the tropane group. Efforts to detect tropane alkaloids among the minor alkaloids of *D. hopwoodii* have failed. Similarly, although the other two Australian species contain volatile bases, the occurrence of nicotine or *nor*-nicotine has not been demonstrated.

A sample of seed of *D. myoporoides* from New Caledonia was recently obtained for us by the South Pacific Commission. Seedlings were established at Canberra both in the field and in a heated glasshouse. Although the plants in the field were stunted, those in the glasshouse grew well and were very similar to adjacent plants of *D. myoporoides* grown from Australian seed.

Alkaloid assays were carried out by a modification of the partition chromatographic method described by Loftus Hills and Rodwell[1]. Working with *D. hopwoodii*, it had been found that nicotine and *nor*-nicotine are well separated by the procedure in routine use for separation of tropane bases. In all chromatograms of material of New Caledonian origin, peaks were obtained in the positions for nicotine, hyoscine and *nor*-nicotine. The identity of hyoscine in each chromatogram was established by preparation of the picrate or reineckate, the melting points of which were not depressed on admixture with the compound prepared from authentic hyoscine. It gave a positive Vitali–Morin reaction, and when run on a paper chromatogram, using butanol – acetic acid – water to form the phase pair, a single spot was obtained with the same $R_F$ value as that obtained with hyoscine. To identify nicotine, the dipicrate was prepared and checked by mixed melting point with nicotine dipicrate prepared from tobacco. The *nor*-nicotine was similarly identified, using *nor*-nicotine from *D. hopwoodii* for comparison. Also, for both these fractions, paper chromatograms showed single spots in the expected positions.

The partition chromatograms also showed small amounts of other bases. Material eluted in the position where hyoscyamine would be expected gave a positive Vitali reaction, and a paper chromatogram showed a spot with the same $R_F$ value as hyoscyamine. The leaf samples contained approximately 0·1 per cent of this material.

The method of assay, although giving reliable quantitative data for hyoscine, only gives an indication of the amounts of nicotine and *nor*-nicotine present, as losses on drying are uncertain[2]. Of the seven samples of *D. myoporoides* from New Caledonian seed examined, the first was a composite bulk from eight field trees, and the remainder were from individual plants in the glasshouse. The amounts of hyoscine, nicotine and *nor*-nicotine, expressed as a percentage of the dry weight of the leaf, are shown in the accompanying table.

This appears to be the first occasion upon which alkaloids of the tropane and pyridine groups have been observed to occur in the same plant, or even in the same species. In the genus *Duboisia* in Australia, these two phytosynthetic mechanisms are sharply isolated by the species boundaries; but they exist together in this New Caledonian form, the origin of which is a matter of conjecture.

*D. myoporoides* (ex New Caledonian Seed)

| Origin of sample | As percentage of dry weight of leaf | | |
|---|---|---|---|
| | Nicotine | *nor*-Nicotine | Hyoscine |
| Field, Canberra A.C.T. | 0·9 | 0·2 | 0·4 |
| Single plants, glasshouse, Canberra, A.C.T. | 0·7 | 0·2 | 0·25 |
| | 0·6 | 0·3 | 0·4 |
| | 0·9 | 0·2 | 0·4 |
| | 0·5 | 0·25 | 0·35 |
| | 0·7 | 0·3 | 0·5 |
| | 0·7 | 0·2 | 0·55 |

The geographical remoteness of New Caledonia from the area in which *D. hopwoodii* occurs and the morphological similarity of this material with *D. myoporoides* do not support a theory of hybrid origin. Possibly internal changes involving the pattern or nature of the genes were responsible. On the other hand, the New Caledonian material may be a relict of a primitive form from which the genotypes of the Australian mainland originated.

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[1] Loftus Hills, K., and Rodwell, C. N., *Aust. J. Sci. Res.*, B, 4, 486 (1951).

[2] Bottomley, W., and White, D. E., *Aust. J. Sci. Res.*, A, 4, 107 (1951).

## Uptake of Dyes into Cut Leaves

The limitation of petiolar uptake of solutes by detached leaves shown in the following experiments does not seem to have been previously recorded.

Leaves of *Atropa belladonna* L. and of cherry laurel (*Prunus laurocerasus* L.) were placed with their petioles in dilute solutions of the basic dyes methylene blue and safranin, and of the acid dye acid fuchsin. In two to three hours approximately 0·25 ml. of the acid fuchsin had been taken up and could be seen by the naked eye, and by the microscope, to have reached the finest ramifications of the leaf vascular system.

Uptake of the basic dyes was very much slower; but the safranin experiment was prolonged until approximately 0·5 ml. had been taken in. No colouring of the leaf was noticeable, and lengthwise cutting showed that all the dye had been retained by the first half-inch of the petiole; methylene blue, which is not so basic, had stained approximately the first inch. Such an immovable accumulation of dye molecules in the xylem vessel lumen would naturally impede fluid intake, and the leaves did, in fact, wilt.

The experiment was repeated for cherry laurel leaves using penicillin and streptomycin, which are respectively acidic and basic antibiotics. The concentration in both cases was 1,000 units/ml., and the solutions were at pH 5. Uptake of penicillin solution was rapid, but of streptomycin solution very slow. At varying times disks were removed by means of a cork-borer from parts of the leaf distal and proximal to the petiole. These were finely chopped, and tested for antibiotic content in the usual manner with bacteria-seeded test plates. A well-marked concentration of penicillin was found to have entered the leaves in only 45 min., whereas streptomycin could not be detected after four hours.

Such facts are satisfactorily explained by supposing the xylem elements to be negatively charged. As such they would hinder, or prevent, the intake of basic organic molecules, which are positively charged, while not interfering with, or even accelerating, the intake of negatively charged acidic molecules. There seems to be no reason why this condition should not prevail in the intact xylem system; but it would scarcely affect such mobile positively charged particles as the sodium or potassium ions commonly found there.

The origin of the charge is possibly as follows[1]: negatively charged OH′ ions, formed from ionized water molecules, induce a dipole separation of charges in the non-ionizing cellulose and lignin of the xylem. This polarization causes an attraction to arise between the OH′ ions and the xylem surface, which is sufficiently great to overcome the thermal energy of the ions. Consequently, the OH′ ions are bound to the xylem surface, which thus becomes negatively charged. For explanation of the special ability of anions, particularly OH′ ions, to induce charged surfaces of this type, ref. 1 should be consulted.

Petiolar feeding of leaves may be said to have as its objective the administration of substances to the mesophyll cells in the most 'natural' way. The above results suggest that the method may be unsuitable for administering basic substances, in which case infiltration technique should be used.

It might further be added that while acidic substances, as judged from rapid petiolar intake of their solutions, enter the xylem with ease, this is no guarantee that they obtain rapid access to the chlorophyll-containing cells. Speed of access to these cells will be determined by the semi-permeable properties of the close-fitting cells sheathing the xylem and its branches; for an unstable substance like penicillin any considerable delay would be serious.

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## Orientation of Telotrematous Brachiopoda

A study of the development of the rhynchonellid, *Tegulorhynchia nigricans*, Sowerby, shows the larva to be furnished with two pairs of large tufts of long setæ set on the hind margin of the mantle rudiment. The members of one pair lie dorso-laterally, those of the other pair laterally. On the mid-ventral surface of the larval mantle is a longitudinal thickening of ciliated cells some 70 μ long and reaching to the hind edge. Two bands of muscle fibres pass forward inside the larval pedicle and are finally inserted one each side of the mid-dorsal line of the base of the mantle.

After attachment and mantle reversal, the dorso-lateral tufts of setæ are found on the edge of the brachial valve near the mid-line, and the lateral tufts are found laterally on the edge of the pedicle valve. Lying mid-longitudinally on the inner face of the pedicle valve is a short cellular thickening which is probably derived from that on the mid-ventral side of the larval mantle. Adjustor muscles pass between the stalk and the pedicle valve. Other muscle pairs are present, notably the divaricators. It is clear that the ventral part of the larval mantle gives rise to the pedicle valve of the young adult and that the dorsal portion of the larval mantle provides the brachial valve.

The fact that immediately after mantle reversal a pair of adjustor muscles passes between the stalk and the pedicle valve shows that the larval muscle bands consist of more than adjustor elements and that their inner portions give rise to other muscles, those likely being the divaricators, the upper ends of which lie alongside the ends of the adjustors inserted on the pedicle valve.

The well-marked features of the late larva of *Tegulorhynchia* make possible the ready relation of the external structures of that phase with those of the young adult immediately after metamorphosis.

In the case of *Terebratella inconspicua* Sowerby, the development of which has been described[1], the larva possesses little externally which can be reliably followed through metamorphosis. The setæ are minute, few, squarely set about the long axis, and useless for orientation. The median ventral thickening, about 35 μ long, has not been traced immediately after reversal; but a small thickening appears on the inner face of the pedicle valve when the mouth forms, and projects somewhat into the latter. Whether this is a reappearance of the original thickening is not certain. The guide through metamorphosis for orientation was taken as the pair of muscle bands in the larval pedicle, passing forward to the dorsal side. These muscles were considered to become the pair of adjustors of the young adult, thus making the pedicle valve morphologically dorsal.

The observations on the metamorphosis of *Tegulorhynchia* bring into question the value of the interpretation of the metamorphosis of *Terebratella inconspicua*. The interpretation of the latter metamorphosis in terms of that of *Tegulorhynchia* simplifies what would otherwise be complex and is in accord with similarities of other kinds which exist in the two developments.

The earlier interpretation of the metamorphosis of *Terebratella* is discarded and is replaced by one which makes it agree essentially with that of *Tegulorhynchia*. The orientation of the two young adult brachiopods is then similar to that of *Lingula*, as described by Yatsu[2].

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## Determination of Adrenalin and Noradrenalin in the Human Fœtal Adrenals and Aortic Bodies

The adrenalin content of the fœtal adrenals has been studied in experimental animals by biological and chemical methods to a relatively insignificant extent; corresponding studies on human material are scarce. Lelkes[1] has shown by biological methods that as early as towards the end of the third fœtal month the human adrenal gland already contains adrenalin, and beginning with the fifth month it can also be demonstrated more abundantly in Zuckerkandl's body. The noradrenalin content of the human fœtus has scarcely been studied at all. Therefore, we have attempted to make a chemical determination of the noradrenalin and adrenalin in human fœtal adrenals and Zuckerkandl's body at different stages of the intrauterine period.

The series comprised nineteen cases ranging from 230 up to 4,270 gm., in which determinations were performed by the micromethod. In collecting the material, particular consideration was given to its freshness. Noradrenalin and adrenalin were determined in a trichloracetic extract according to v. Euler's and Hamberg's iodine oxidation reaction[2], carrying out oxidation both at $pH$ 4 and 6.

During the last three months of the intrauterine period the total catechols of the adrenals averaged 71 μgm. The corresponding figures for the aortic bodies were 40 μgm. and 11 μgm. respectively. The ratio between the catechols of the aortic bodies and the adrenals remained constant throughout fœtal life. The total catechols of the adrenals and aortic bodies per kgm. of body-weight were somewhat less than the corresponding amount in normal adult adrenals (in cases of sudden death).

A considerable part of the total catechols in the adrenals consisted of noradrenalin; in three-quarters of the cases noradrenalin accounted for more than half, which is notably more than in adult humans. The preponderance of noradrenalin in the aortic bodies was even more pronounced, amounting on an average to five-sixths of the total catechols during the last three months of intrauterine life.

The concentration of catechols in the fœtal adrenals was found to be considerably less than in the adult glands (1 : 50), due to the large cortex characteristic of fœtal life.

No clear correlation could be established between concentrations of catechol in the organs studied and difficulties of labour. Normal amounts of catechol were found even in prolonged asphyxia.

A full account of this work is being published elsewhere[3].

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## Spontaneous Parthenogenesis in a Fish

THE guppy, *Lebistes reticulatus*, is a viviparous fish the reproductive physiology of which has been well studied (bibliography in Gordon[1]). A female, *D*9, of English domestic stock of this species born October 5, 1950, was separated from adult males twelve days after birth. The litter of which she was a member were placed in separate jars when thirty-nine days old. The first sign of differentiation of the anal fin into a gonopodium was seen in one of her brothers twelve days later, the family being raised at 20° C. The isolated female, at the age of 216 days, bore a female offspring which died at the age of 304 days. The mother was then mated to a male litter-mate, and bore four litters of at least twenty-six, of which twenty-four were females and one male. The male mated with *D*9 died before the birth of the second litter, consisting of seven females and one male which were separated from each other at the age of four days. One of these females, *DD*20, gave birth to three young at the age of 193 days.

The first example of unexpected births could be explained by fertilization of the female by an adult male during her first twelve days or by an immature brother during the first thirty-nine. The second could only be explained by fertilization of a female aged less than five days by a male of the same age, which, however, showed no sign of gonopodial differentiation until thirty-eight days old. Even if the gonads matured early, it is difficult to see how internal fertilization could have been achieved with an unmodified anal fin. Winge[2], after prolonged experience, states that "males and females should be separated as soon as the sex can be determined, i.e., 2–3 weeks before maturity is reached".

Amateur breeders have described parthenogenesis in fish verbally on several occasions; but do not seem to have published any repetition of their observation under controlled conditions. Considering the ease with which artificial parthenogenesis can be obtained in some vertebrate groups[3], the same phenomenon would be expected to occur spontaneously, and has been reported[4].

(*February* 14, 1953. Three further anomalous litters have been born. All nine fatherless fish old enough for the sex to be recognized are females.)

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## Somatic Reduction Division in the Development of the Sea Urchin

IN the sixteen-cell stage of the sea urchin egg, four micromeres occur around the vegetal pole. At the following division, which is delayed in the micromeres[1], these cleave off 'small micromeres', which behave in many respects differently from the rest of the embryo[2]. They do not flatten against their neighbours, appear optically empty in dark-field illumination, and cannot be vitally stained, for example, by nile blue sulphate. In all these respects the small micromeres resemble the polar bodies[2]. This suggests a deeper similarity, namely, that the small micromeres function as 'somatic polar bodies', the division leading to their formation implying a reduction of the chromosome number.

Studies were made of sections of *Paracentrotus lividus* (Lamarck) from Naples. The diploid chromosome number of this species[3] is 36. In three embryos with the micromere division in late telophase to early anaphase, the number was found to be 18. In some embryos with early anaphase stages and the chromosomes in two different sections, the chromosome number of the two groups varied between 17 and 21, the higher numbers probably depending on fragmentation of some chromosomes. In many divisions in metaphase the number of chromosomes could not be exactly counted, but was estimated to fall between 32 and 40. It is thus obvious that the division of the micromeres implies a reduction of the chromosome number to half.

Material of *Strongylocentrotus drœbachiensis* (O. F. Müller) was obtained on the west coast of Sweden. Also in this species the division of the micromeres yields haploid nuclei. The haploid number calculated from seventeen haploid and sixteen diploid chromosome counts was 20·2. This agrees well with that observed from an equatorial plate in polar view of a micromere. Here a pairing of the forty chromosomes is taking place, being equivalent to the 'secondary pairing' in mitosis (Diptera and polyploid plants) and meiosis (plants) (cf. Darlington[4]).

Somatic reduction divisions seem not to have been observed in animals, but are known to occur spontaneously in plants, and have also been experimentally induced (cf. Battaglia[5]).

The micromeres and their descendants have very important functions. During the blastula stage this material has a high potency in restraining the tendencies towards extension of the animal differentiations and, when transplanted into isolated animal halves, in inducing vegetal differentiations[6]. Later, it produces skeletal substance. Possibly these functions depend upon the haploid state. An experimental analysis of these and related problems is in progress.

A detailed account of this work will appear in *Experimental Cell Research.*

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## Reversal of Phototaxis in Prepupæ of Hymenoptera (Tenthredinidæ) caused by Amyl Acetate Vapour emanating from Marking Paint

In autumn the grass-feeding larvæ of *Tenthredopsis litterata* Geoff. and *T. nassata* F. undergo an ecdysis prior to entering the soil at plant roots, where they remain as overwintering non-feeding prepupæ until pupation occurs in the following summer.

The newly formed prepupæ, although lethargic, exhibit positive phototaxis; but within a period of two or three days they become more active and photonegative. This negative phototaxis appears to direct them to the pupation site in soil, and at present there is no evidence that a gravity reaction is involved.

While investigating the details of the taxis mechanism, a cellulose lacquer was used for occluding in part the vision of active photonegative prepupæ. For a period lasting from a few minutes up to two hours, prepupæ so treated became strongly photopositive, but afterwards reverted once again to their pre-treatment photonegative condition. Further experiment showed that paint placed on other parts of the body produced the same effect, and that this reversal of reaction to light could also be caused by previous treatment for a short period with the vapour of amyl acetate, or handling by instruments contaminated by this vapour. Prepupæ so treated, after being photopositive for a while, returned to their original photonegative condition fairly abruptly and usually within a minute of such a reversal tendency being observed. Ethyl acetate, acetone and chloroform vapours did not alter the reactions of prepupæ to light.

The above observations were made in a dark room on prepupæ moving in a horizontal plane with respect to a diffuse lateral beam of light. The beam emanated from a 100-watt lamp bulb placed 45 cm. from the experimental area and shone through an aperture 5 cm. × 3 cm., across which was placed a glass vessel containing water. Further experiments were conducted to ensure that variation in light intensity, heat gradients, nature of substratum and previous exposure of prepupæ to light were not responsible for the observed reversal of behaviour.

Since amyl acetate is a constituent of paints which may be used in various experiments involving insect behaviour, it is felt that these observations might be of particular interest to workers in such fields.

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## Manganese Requirements of Tomato Plants at Different Phases of Growth

During investigations on the iron and manganese requirements of plants[1], it was decided to determine whether tomato plants required a continuous supply of manganese throughout their growth or whether the element was more essential at one phase than at another. Investigations on similar lines have been reported by Gericke[2] for wheat and by Brenchley[3] for barley. These workers, however, were concerned with the major nutrient elements.

The method used was the water culture technique[1] and the general plan of the experiment is shown in Table 1.

Table 1

| Treatment designation | Period I 1st 2 weeks | Period II 2nd 2 weeks | Period III 3rd 2 weeks | Period IV 4th 2 weeks |
|---|---|---|---|---|
| *A* | + Mn | − Mn | − Mn | − Mn |
| *B* | + Mn | + Mn | − Mn | − Mn |
| *C* | + Mn | + Mn | + Mn | − Mn |
| *D* | + Mn | + Mn | + Mn | + Mn |
| *E* | − Mn | + Mn | + Mn | + Mn |
| *F* | − Mn | − Mn | + Mn | + Mn |
| *G* | − Mn | − Mn | − Mn | + Mn |
| *H* | − Mn | − Mn | − Mn | − Mn |

Manganese as manganese chloride and iron as ferric citrate were supplied at concentrations of 0·5 p.p.m. manganese and 1·0 p.p.m. iron in the culture solution. After a two-week germination period in the absence of iron and manganese, the seedlings were transferred to the various treatments (four replicates of each). The culture solution was changed weekly.

The plants in treatment *A* showed symptoms of manganese deficiency in the upper leaves five weeks after the beginning of the treatment. The plants in treatments *B*, *C* and *D* were quite normal and were setting fruit on the first truss at the end of the experimental period. In the second series (treatments *E*, *F*, *G* and *H*), the following observations were made: (1) treatment *E* produced normal plants; (2) manganese-deficiency symptoms appeared in treatment *F* five weeks after sowing but plants recovered two days after manganese was supplied; (3) in treatment *G* the plants developed manganese-deficiency symptoms and only partially recovered from these when manganese was supplied; and (4) treatment *H* produced severe manganese-deficiency symptoms and no flowers were produced.

The average yield (Table 2) of plants from treatment *A* was significantly less than the yields produced by treatments *B*, *C*, *D* and *E*, all of which were equivalent to each other. The plants from treatments *F*, *G* and *H* reflect the delayed manganese supply in their low dry-weight yields. These observational and yield data indicate that, for normal development, from germination to the formation of young fruits on the first truss, manganese must be available at least for four weeks after the initial two-weeks growth in its absence.

Table 2

| Treatment designation | Average dry weight (gm.) Roots | Tops | Whole plant | Conc. of manganese in tops (p.p.m.) |
|---|---|---|---|---|
| *A* | 1·09 | 10·19 | 11·28 | 10 |
| *B* | 1·43 | 12·45 | 13·88 | 62 |
| *C* | 1·68 | 12·50 | 14·18 | 120 |
| *D* | 1·66 | 13·74 | 15·40 | 123 |
| *E* | 1·54 | 12·80 | 14·34 | 109 |
| *F* | 0·99 | 6·78 | 7·77 | 120 |
| *G* | 0·41 | 4·08 | 4·49 | 94 |
| *H* | 0·33 | 3·44 | 3·77 | 5 |

From the manganese concentrations in the tissues (Table 2), it is clear that treatment *A* did not supply sufficient manganese, but that periods of treatment for the first four or more weeks provided adequate quantities for normal growth. This was also true when manganese was withheld for two weeks only (treatment *E* with 109 p.p.m. manganese). When manganese was available during the last four and two weeks of the experimental period, it accumulated to 120 and 94 p.p.m. respectively; but adequate utilization of this amount was not reflected in the dry-weight yields at the time of harvest. A response to this manganese might have been obtained if the experiment had been continued longer.

A further experiment was designed to investigate the manganese requirements during the first six weeks of growth. The treatments are summarized in Table 3.

Table 3

| | Treatments: *J* 8 weeks with Mn | *K* 3rd and 4th weeks only with Mn | *L* 3rd week only with Mn | *M* 4th week only with Mn |
|---|---|---|---|---|
| Average dry weight of plants (gm.) | 18·97 | 20·68 | 19·97 | 19·49 |
| Conc. of manganese in tops (p.p.m. dry wt.) | 108 | 46 | 27 | 25 |

All plants irrespective of treatment were normal at all stages, the dry-weight yields showed no significant difference between each other and the average manganese content of the tops was adequate (Table 3).

Thus, if manganese was available for only one week during the fifth or sixth week after sowing, no adverse effects resulted. It was observed that treatment *M* in the second experiment did not show any signs of manganese deficiency during the fifth week as did treatment *F* in the first experiment. This difference could only be attributed to external factors beyond control. It was unfortunate that a more comprehensive experiment was not possible at this stage. However, the results indicated that, for the period from germination to the setting of fruit on the first truss, manganese was necessary only during the fifth or sixth week after sowing. The manganese absorbed during this short period was sufficient for normal growth for a further five or four weeks. Addition of manganese to cultures deprived of this element for periods longer than six weeks had little beneficial effect by the end of the tenth week after sowing.

The work reported here was carried out in the University of Birmingham.

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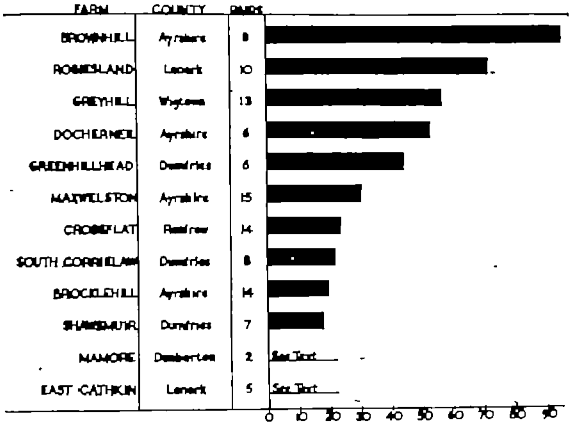
## Feeding of Seaweed Meal to Lactating Cows

The butterfat production of lactating dairy cows in the west of Scotland has been shown to be increased by the single addition of copper sulphate to the diet one to six days after feeding the supplement[1]. The response to the feeding of foodstuffs rich in trace elements (including copper) should show a similar effect on the fat production of the cows in this area. Such a foodstuff is available as seaweed meal.

A supply of the meal (dried, milled *Ascophyllum nodosum*) was obtained from the Institute of Seaweed Research, Inveresk Gate, Musselburgh, and a sufficient quantity was distributed to seventeen West of Scotland dairy herds whose owners co-operated in the experimental work. The method adopted in drawing up the groups of animals for the experiment on those farms has already been described[1]. The meal was delivered to each farm in hundredweight canisters; and, in the experimental group, one scoopful (200 gm.) of the afternoon production ration in the feeding trough of each cow was measured back, and in its place a similar quantity of seaweed meal was substituted. The thorough mixing of the seaweed meal with the production ration was effected in the trough.

A number of cows in the experimental group (those which had calved six months or more beforehand) experienced difficulty in consuming the whole of the production ration containing the seaweed meal, and in five herds the experiment had to be terminated after a day or two. In the other twelve herds, however, despite occasional refusals, the meal continued to be fed for a period of three weeks to one month. After this time a further daily test of the milk and



fat production of the experimental and control animals was carried out.

The full results of the experiment are shown in the accompanying chart. The responses obtained in two of the herds (markedly positive in both cases) are not shown; in all the other herds the number of comparable pairs is six or more.

In all cases a positive response was obtained in the fat production of the animals after the inclusion of seaweed meal in the ration. The magnitude of the response varied greatly between cows and between herds. It is noteworthy, however, that in the case of some of the herds in which the response was greatest (Brownhill, Greyhill and Docherneil) the disease 'swayback' in lambs was experienced during the 1951 lambing season in the sheep flock. Swayback has been shown to be controlled by the administration of copper sulphate to the ewe immediately before lambing[2].

The results were examined by the staff at Rothamsted Experimental Station, from whom the following was received: "The treatment has a real effect although apparently not large enough to be detected on most single farms. The standard error is calculated from $SW(y - \bar{y}_w)^2$, where $W$ is the number of pairs at a farm and is appropriate if the weights are inversely proportional to the within farm variances".

The storage of copper in the liver three days after drenching has been shown to be less than 10 per cent when comparable doses of copper sulphate (0·4–2 gm.) were administered to mature sheep. Usually the amount stored was less than 3 per cent of the dose administered[3].

In some herds the inclusion of seaweed meal in the ration (200 gm. per day) for a period of three weeks would appear to stimulate the fat production of the dairy cow to a greater extent than the administration of a single dose (10 gm.) of copper sulphate (cf. ref. 1).

Further experiments are being conducted to determine whether copper is the sole nutrient responsible for the increased fat production of the cow when seaweed meal is included in the ration.

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## Electron Diffraction Study of the Hydrogen Bonds in Boric Acid

IN recent years the techniques of X-ray diffraction structure analysis have been refined to such an extent that, with careful work, the positions of hydrogen atoms in a structure may be determined when each hydrogen atom is bound to a single atom. The detection of a hydrogen ion in a hydrogen bond, however, is a much more difficult task, since only a fraction of an electron can be considered as localized near the proton. This amount of ionization reduces the atomic scattering factor for X-rays. However, the atomic scattering factor for electrons is correspondingly increased since this is given by $\epsilon = (Z - f)\lambda^2/\sin^2\theta$, where $Z$ is the atomic number, $f$ is the X-ray scattering factor, $\lambda$ is the effective wave-length of the electron beam and $\theta$ is the Bragg angle. Hence, hydrogen ions in hydrogen bonds should be detected more readily in structure analyses based on electron diffraction data. Techniques for structure analysis using single-crystal electron diffraction patterns have been evolved and will be described elsewhere. They have been applied to the study of the structure of boric acid layers.

Zachariasen[1] has shown that boric acid has a layer lattice structure. The layers are composed of planar $BO_3^{3-}$ groups joined by hydrogen bonds, and have hexagonal symmetry. These layers are stacked in such a way that the unit cell is triclinic and contains portions of two layers.

Boric acid crystals, formed by evaporation from aqueous solution, which are small enough to give good single-crystal spot patterns (that is, a few hundred angstroms in thickness and a few microns in diameter) show a high degree of disorder in the stacking of the layers. Observations on a number of substances seem to indicate that such stacking disorder occurs almost without exception in very small crystals with layer-lattice structure. Many of the 'two-dimensional' or 'cross-grating' spot patterns reported in the literature may be explained in this way.

If the stacking of the layers were completely random except that all layers had the same orientation, the diffraction pattern would be the same as that of a single layer. For boric acid, although the electron diffraction spot patterns show very nearly a hexagonal symmetry when the beam is perpendicular to the plane of the layers, the intensities deviate slightly from those to be expected for complete randomness.

A method has been developed whereby the amount and nature of the stacking order can be determined provided that the structure of the layer is known approximately, and this information can be used for deriving the intensities corresponding to a single layer from the observed intensities. The details of this method will be published elsewhere.

The intensities measured from a single-crystal electron diffraction pattern, taken with the beam nearly perpendicular to the layers, were corrected in this way. The Fourier projection of the potential distribution in a boric acid layer, calculated from the corrected intensities, is shown in Fig. 1. The atomic positions are indicated clearly. The groups of three oxygen atoms surrounding a boron atom, and the arrangement of these groups in the unit cell, are exactly as found by X-ray work. However, whereas Zachariasen assumed that the hydrogen ions were located half-way between two oxygen atoms, it is

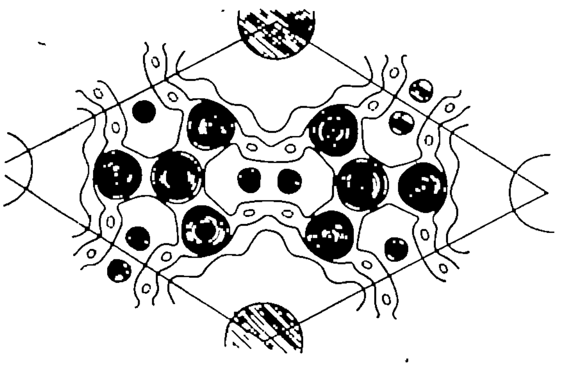

Fig. 1. Fourier projection of a boric acid layer. The full contours mark equal increments in potential in arbitrary units. The dotted contour represents a half increment

seen that the most favoured position for the hydrogen ions is close to one or the other of the two oxygens. The O—H distance is approximately 1·05 A. The hydrogen bonds occur in pairs between pairs of oxygen atoms in adjacent $BO_3^{3-}$ groups, and it is to be noted that the hydrogen positions do not lie on straight lines between oxygen atoms as might be expected, but are displaced in each case towards the neighbouring hydrogen bond. This appears to result from a tendency for the formation of a hydrogen bond from an oxygen atom not only to its nearest neighbour in the adjacent $BO_3^{3-}$ group, but also diagonally across to its second nearest neighbour. For such a diagonal bond it is to be expected that the most favoured position for the hydrogen ion would be approximately 1 A. from an oxygen atom. The resulting hydrogen distribution may be considered as resulting from the combination of the canonical arrangements shown in Fig. 2.

It seems probable that this type of interaction between parallel hydrogen bonds may occur in many crystals where the geometry of the structure is favourable, and may play an important part in determining the structure of some organic compounds, such as the carboxylic acids, and proteins.

Another point of interest in the Fourier projection (Fig. 1) is that the boron and oxygen peaks are very nearly equal in height in spite of the large relative difference in atomic numbers. This effect may be ascribed to the state of ionization of the atoms. The intensities of electron diffraction spots are much more sensitive to the degree of ionization than are the X-ray diffraction intensities, particularly for spots of low indices. Cations have more, and anions less, scattering power than the corresponding neutral atoms. Hence it seems possible that different ionization states may be distinguished readily by such an electron diffraction structure analysis.

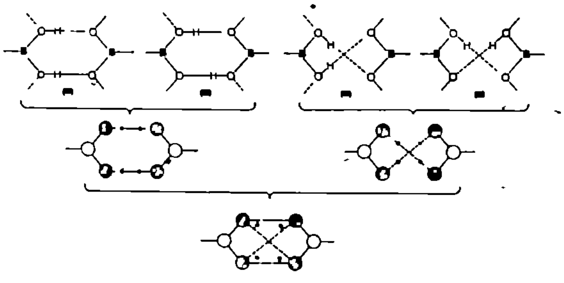

Fig. 2. Combination of arrangements of hydrogen ions in hydrogen bonds between four oxygen atoms to give the observed distribution

I wish to express my gratitude to Dr. A. L. G. Rees for discussion on the interpretation of the hydrogen-bond configuration.

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Commonwealth Scientific and
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Melbourne. Aug. 24.

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## Intermolecular Force and Transport Coefficients

The Chapman–Enskog theory of non-uniform gases expresses the transport properties in terms of a set of collision integrals[1] which depend on the law of molecular interaction. These integrals have been evaluated for various molecular models and the computed values of the transport coefficients have been compared with the experimentally observed values by Chapman and Cowling. Hirschfelder, Bird and Spotz[2], Winter[3] and others have shown that the Lennard-Jones 12 : 6 potential energy function

$$E(r) = 4\epsilon\,[(r_0/r)^{12} - (r_0/r)^6] \qquad (1)$$

is more in accord with the observed properties of gases than any other model, but the values of the force constants $\epsilon$ and $r_0$ employed by them were deduced from viscosity data. It is well known that the coefficient of thermal diffusion is far more sensitive to the type of molecular interaction than the three elementary gas coefficients. We have, therefore, utilized the data on thermal diffusion, and in particular the variation of the thermal separation ratio $R_T$ of argon isotopes with temperature, to calculate the force constant $\epsilon$.

As shown by Jones and Furry[4] and others, $R_T$ for the case of isotopes is given by:

$$R_T = \frac{16{\cdot}9\,(C-1)\,(1+A)}{A\,(11-4B+8A)}, \qquad (2)$$

where $A$, $B$, $C$ are known functions of the various collision integrals $W^l(n\,;\,kT/\epsilon)$. Equation (2) shows that $R_T$ does not involve $r_0$ and depends only on $\epsilon$ and $T$. It is therefore possible to calculate $\epsilon$ from equation (2) for argon at different temperatures, quite independently of whether $r_0$ is constant or not, by plotting $R_T$ $\epsilon$ versus $T$ and $R_T$ (from equation 2) versus $x$, where $x = kT/\epsilon$. Comparison of the two curves at various corresponding points readily gives $\epsilon$ at different temperatures, the values thus obtained being given in the accompanying table (col. 2). These values of $\epsilon$ are much more accurate than those obtained by others from viscosity and virial coefficient data, since this method, in addition to being far more sensitive, does not assume the constancy of $r_0$.

The figures in the table show clearly a slow decrease in the value of $\epsilon$ with decrease of temperature. It is true that the experimental values of $R_T$ have the

| Temp. (° K.) | $\epsilon/k$ (° K.) | $r_0$ in A., from viscosity | $r_0$ in A., from self-diffusion |
|---|---|---|---|
| 120 | 115·0 | 3·478 | 3·473 |
| 140 | 116·6 | 3·468 | 3·447 |
| 160 | 120·8 | 3·443 | 3·432 |
| 180 | 120·0 | 3·449 | 3·424 |
| 250 | 135·1 | 3·370 | 3·337 |
| 300 | 142·9 | 3·344 | 3·319 |
| 350 | 152·2 | 3·321 | 3·296 |
| 400 | 158·1 | 3·309 | |
| 480 | 165·5 | 3·300 | |
| 550 | 168·3 | 3·293 | |

most probable errors of ± 5 per cent, which is likely to produce an error of ± 15 per cent in the value of $\varepsilon$ at high temperatures and of about ± 5 per cent at very low temperatures. Nevertheless, the decrease in the value of $\varepsilon$ is definite and unmistakable, though the magnitudes may be much in error. These investigations thus show that the 12 : 6 potential function can represent the interaction even over a long range of temperatures, provided $\varepsilon$ and $r_0$ (as will be seen later) are varied very slowly with temperature. Exact calculations by us from viscosity data also show an unmistakable tendency for $\varepsilon$ to increase with increase of temperature. Using these values of $\varepsilon$ in the expressions for viscosity and self-diffusion, $r_0$ at different temperatures has also been found, the values being given in the table.

This variation of $\varepsilon$ and $r_0$ can be accounted for theoretically. Writing equation (1) in the form :

$$E(r) = \lambda r^{-12} - \mu r^{-6}, \qquad (3)$$

it can be shown that

$$\varepsilon = \tfrac{1}{4}\mu^2/\lambda, \quad r_0 = (\lambda/\mu)^{1/6}, \qquad (4)$$

where $\mu$ and $\lambda$ are supposed to remain constant. From London's quantum-mechanical formula for the dispersion energy leading to the van der Waals' attraction[5] :

$$E(r) = -\mu r^{-6} - \mu' r^{-8} - \mu'' r^{-10} - \ldots \qquad (5)$$

it is evident that if, for large distances, we limit the formula to the first term only, $\mu$ must be made to increase when the intermolecular distance $r$ is decreased, in order that the single term may still give the attraction correctly. Since at higher temperatures the most effective contribution of the molecular field to the transport properties will be for smaller intermolecular distances, it follows that $\mu$ must increase with increase of temperature. Similarly, it can be shown that the repulsion term $\lambda$ must decrease with rise of temperature. In consequence, $\varepsilon$ will increase and $r_0$ will decrease with rise of temperature. In fact, from equations (4) the effective $\mu$ and effective $\lambda$ can be calculated at different temperatures and are found to be fully consistent with the virial coefficient data. A similar procedure has been used for other gases also. Detailed investigations are being published in a series of papers.

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University, Lucknow. July 7.

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## Ion-exchanging Surfaces in Radiological Decontamination

THE adsorption of radioelements by the walls of glass vessels is recognized as a source of inaccuracy in radiochemical assessments, and the great affinity shown by many radioactive substances for working surfaces in the laboratory is shown by the vigorous chemical and mechanical treatments which are needed for their removal from these surfaces. Chemically resistant metals such as stainless steel and lead have been shown[1] to adsorb phosphorus-32, barium-140 and iodine-131, and complete removal was possible only by removing a thin layer of the surface. Organic materials such as polythene[2] and vinyl chloride-acetate copolymer have been found to be particularly resistant to contamination by aqueous solutions of radioisotopes, and they are extensively employed as constructional materials or protective coatings. We have found that films of unplasticized polystyrene, prepared by brushing a surface with a 30 per cent solution of 'Distrene' in toluene, possess very low adsorption for fission elements (which were in aqueous solution as nitrates). Results of experiments are given in the accompanying table.

RETENTION OF FISSION PRODUCT ISOTOPES BY POLYSTYRENE AND SULPHONATED POLYSTYRENE

| Surface | Beta/gamma count after 1 min. immersion in fission products solution (10,000 counts min.$^{-1}$, c.c.$^{-1}$) | Beta/gamma count after washing with 5 per cent ammonium citrate for 3 min. |
|---|---|---|
| Polystyrene | 108 counts/min.<br>58<br>65<br>85 | 5 counts/min.<br>3<br>2<br>19 |
| Sulphonated polystyrene (prepared by exposing to SO$_3$ for 2 min.) | 769<br>1,091<br>1,470<br>1,140 | 7<br>114<br>235<br>44 |

It was considered that decontamination might be more readily effected if a surface could be rendered ion-exchanging by some means, since it has been established[3] that isotopes of rare-earth elements can be adsorbed on ion-exchanging phenol formaldehyde resins and can afterwards be completely removed by treating the resin surface with an elutriating solution of citric acid. We have recently carried out a comprehensive series of experiments to determine the degree of attachment and relative ease of removal of fission elements from sulphonated polystyrene, which we prepared in the laboratory, and have come to the conclusion that the use of a cation-exchanging material of this kind does not facilitate complete decontamination to the extent that might have been expected. Full details will be reported in due course, but the table shows typical results.

It will be seen that the adsorption of fission elements is higher for the ion-exchanging surface and that elutriation does not bring the final level of activity down to that of untreated polystyrene.

We are indebted to the Admiralty for permission to publish this note.

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## Column Procedures for the Salt Fractionation of Enzyme Preparations

Two procedures for fractionating enzyme preparations on a column, somewhat different from the previously described chromatopile[1], have been found useful in preliminary tests.

In the first procedure, a column of the precipitated enzyme in the presence of an inert carrier and in a medium of high salt concentration is eluted with a dilute salt solution. The resulting fractions of effluent are then analysed for enzyme activity and for protein.

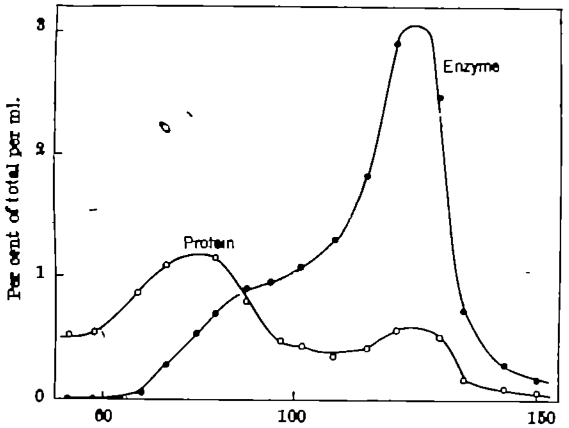

Fig. 1

For example, 50 ml. of saturated ammonium sulphate was added to 25 ml. of a concentrated culture fluid of *B. macerans*[2]. The slurry resulting from the addition of 15 gm. of 'Celite' was poured into a tube and washed with one-third saturated ammonium sulphate, and the effluent was analysed for starch-degrading activity[2] and 'protein' (turbidity of trichloracetic acid suspensions). The results are shown in Fig. 1.

In the second procedure, the impure enzyme preparation in dilute salt solution is allowed to pass down a column consisting of a water-absorbing, insoluble substance. The activity and protein are then eluted with a dilute solution and the effluent fractions are analysed as in the first procedure. For example, 25 ml. of an impure malt alpha-amylase preparation in 0·4 saturated ammonium sulphate was allowed to pass down a column consisting of 60 gm. of calcium sulphate hemihydrate. The amount of the latter was calculated from the experimental dead space of the column on the assumptions that a salt concentration gradient was to be established on the column ranging from 0·4 saturated to 0·7 saturated ammonium sulphate and that hemihydrate would take up the theoretical amount of water. The column was then washed with saturated calcium sulphate solution at 5°. The results are shown in Fig. 2. Equally effective fractionations were obtained using other amylase sources.

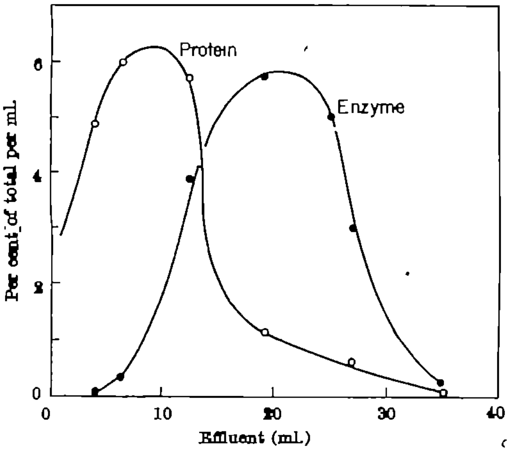

Fig. 2

The effectiveness of both these methods was probably due to the differential extraction-rates of the proteins[3], and possibly to the establishment of salt concentration gradients along the columns. Such a gradient might possibly be established upon properly impregnated paper. In principle, one might use a procedure of the type herein described as a specific activity – solubility test for purity[4].

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## An Electrostatic Single Lens permitting Rigorous Calculation

ALTHOUGH for magnetic electron lenses the field[1]

$$B_z(z) = B_0/[1 + (z/a)^2] \qquad (1)$$

is known to permit rigorous calculation, this is not the case for electrostatic single lenses as used in electrostatic microscopes, for which up to now no type permitting exact calculation was known. We shall show in the following that the electrostatic counterpart to (1), namely:

$$\Phi(z) = \Phi_0 - \Phi_0\kappa^2/[1 + (z/a)^2] \; ; \; 0 < \kappa^2 \leq 1 \qquad (2)$$

is also integrable. The differential equation of paraxial rays for this field, which approximates very well to the axial potential distribution of a three-aperture lens, can be transformed into an equation with constant coefficients. A magnetic field of the Glaser-type can be superposed. Inserting in

$$\sqrt{\phi}\, \mathrm{d}(\sqrt{\phi}\, \mathrm{d}r/\mathrm{d}z)/\mathrm{d}z + [\tfrac{1}{4}\, \Phi'' + eB_z^2/8m]\, r = 0 \qquad (3)$$

the new variables $v$, $\varphi$:

$$z = a \,.\, \mathrm{ctg}\, \varphi \; ; \; r = v(\varphi)/\sin \varphi, \qquad (4)$$

which is well known from the bell-shaped field (1), we get:

$$\sqrt{\phi}\, \mathrm{d}(\sqrt{\phi}\, \mathrm{d}v/\mathrm{d}\varphi)/\mathrm{d}\varphi + [\Phi + \tfrac{1}{4}\, (\mathrm{d}^2\phi/\mathrm{d}\varphi^2) + ea^2B_z^2/(8m \sin^4\varphi)\,]\, v = 0. \qquad (5)$$

The fields (1) and (2) become:

$$\Phi = \Phi_0\, (1 - \kappa^2 \sin^2\varphi) \; , \; B_z = B_0 \sin^2\varphi. \qquad (6)$$

Inserting in (5) we obtain

$$\sqrt{1 - \kappa^2 \sin^2\varphi}\, \mathrm{d}(\sqrt{1 - \kappa^2 \sin^2\varphi}\, \mathrm{d}v/\mathrm{d}\varphi)/\mathrm{d}\varphi + [1 + k^2 - \tfrac{1}{4}\kappa^2]\, v = 0 \; ; \; k^2 = \frac{eB_0^2a^2}{8m\Phi_0}. \qquad (7)$$

Changing the independent variable by means of

$$\mathrm{d}\varphi/\mathrm{d}\tau = \sqrt{1 - \kappa^2 \sin^2\varphi}, \qquad (8)$$

we get

$$\mathrm{d}^2v/\mathrm{d}\tau^2 + \omega^2 v = 0, \quad \omega^2 = 1 + k^2 - \tfrac{1}{4}\kappa^2, \qquad (9)$$

and the solutions:

$$v = A \cos \omega\tau + B \sin \omega\tau. \qquad (10)$$

The variable $\tau$ is, from (8), given by the elliptic integral of the first kind:

$$\tau = \int_0^{\varphi} \frac{d\varphi}{\sqrt{1 - \varkappa^2 \sin^2\varphi}}; \quad \text{or } \varphi = \mathrm{am}\,\tau. \qquad (11)$$

The paraxial electron trajectories are

$$r = (A\cos\omega\tau + B\sin\omega\tau)/\sin(\mathrm{am}\,\tau) = C\sin(\omega\tau - \zeta)/\mathrm{sn}\,\tau \qquad (12)$$

with

$$z = a \,.\, \mathrm{ctg}(\mathrm{am}\,\tau) = a \,.\, \mathrm{cn}\,\tau/\mathrm{sn}\,\tau = a \,.\, \mathrm{cs}\,\tau. \qquad (13)$$

Since these functions are tabulated exhaustively, the trajectories are known numerically. The calculation can be carried out on similar lines for the slightly generalized case,

$$\Phi = \Phi_0 + (A + Bz)/[1 + (z/a)^2]\ ; \quad A \gtrless 0. \qquad (14)$$

Mirror effects can be discussed. Third-order aberration coefficients have been calculated. It was even possible to determine the electron paths everywhere, without restriction to the neighbourhood of the optical axis. This can be done by reduction to the problem of two centres. The results will be published in detail in another journal.

I am indebted to Prof. W. Glaser for several discussions on the subject and for the opportunity of carrying out this work in his Institute.

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## Long-Delay Ionospheric Echoes at 150 kc./s.

IT is well known that in the ionosphere (a doubly refractive medium) a radio wave splits into two components, commonly designated as the ordinary and extraordinary modes. The propagation characteristics of the medium are determined from the corresponding ordinary and extraordinary indices of refraction. The modes may be appreciably coupled in certain ionospheric regions[1], depending upon the wave-frequency and other factors.

A common experimental technique used for studying these split components, at certain frequencies, involves the use of pulsed radio soundings, in which the components are received as echoes separated in time, since their corresponding heights of reflexion are different. These split echoes are commonly observed near the critical frequencies of the layer.

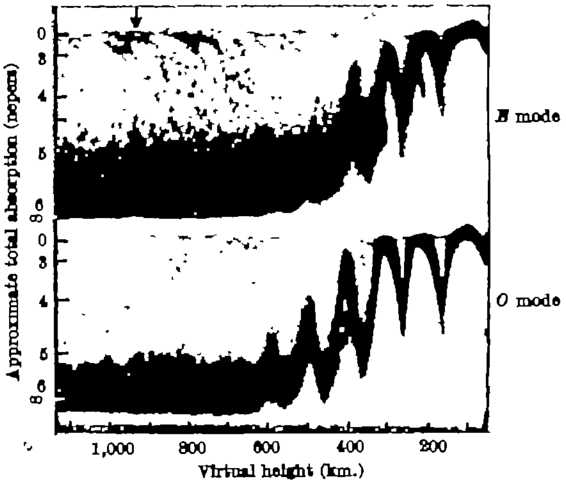
At the much lower frequency of 150 kc./s., the extraordinary mode does not usually, if ever, encounter a 'reflexion condition' below the maximum electron density in the $E$- and $F$-regions; and no great effort has hitherto been directed towards the further tracing of this component into the upper ionosphere. A recent analysis by us[2] employing an estimated equinox, midnight ionospheric model has indicated a strong possibility of substantial reflexion of the 150 kc./s. extraordinary component, from a region well above the maximum in electron density of the $F_2$ layer. This region corresponds to a 'fourth condition for reflexion'[3], and contains extremely rapid variations of refractive index with height. The analysis, involving laborious wave solutions by a special technique[4], indicates virtually total reflexion from a height of 940 km. in the assumed model. Absorption considerations indicate, further, that such an echo may be returned to earth with sufficient amplitude to be recorded by recording techniques which are fairly common. The reason why these echoes have not previously been observed may lie in the fact that no effort has been devoted, at this frequency, to high-altitude searching with high-gain receiving equipment.

The Ionosphere Research Laboratory at the Pennsylvania State College has been procuring regular, extended-range night-time recordings on 150 kc./s., at vertical incidence, for several months, employing a 2-MW. peak power pulse-transmitter and sensitive receiving equipment. The recording height-range during most of the observations extended beyond 1,200 km., with the receiver sensitivity limited by the atmospheric noise-level. To improve the signal-to-noise ratio, photographic time integration is employed, with a 5-min. exposure of 12·5 sweeps per sec.

Occasional 'isolated' echoes have been observed in the range 600–900 km., some of these undoubtedly belonging to the multiple hop system of echoes from the $E$-region, but augmented by ionospheric focusing. The signals were received on a single fixed-loop aerial and no polarization data were available.

Recently, however, a circularly polarized receiving-aerial system has been employed, making possible simultaneous recordings of the unsplit ordinary and extraordinary components. This modification was suggested by polarization considerations of the '940-km. echo' being sought, the latter containing an ordinary to extraordinary amplitude ratio that should be roughly inverse to the same ratio of the multiple-$E$ hop system[5]. The 5-min. recordings were taken every 30 min. during the hours 2000–0400 L.M.S.T.

On the night of November 9, 1952, there appeared, on three different records, an isolated echo corresponding to a height of approximately 900 km. They were visible only on the extraordinary mode. These were followed by similar observations on two additional nights. The record reproduced herewith was taken on November 10, 1952, at 0300 L.M.S.T. The upper and lower photographs display, respectively, the extraordinary and ordinary modes. Height increases horizontally from right to left; the first pulse being the first-hop $E$ reflexion. The vertical scale, indicating signal amplitudes, is quite non-linear due to receiver saturation effects. The amplitude of the echo of great delay (marked by an arrow) is of order of magnitude of that computed in ref. 2.



Among the possibilities for the interpretation of these long-delay echoes are: (*a*) ionospheric focusing of *E* reflexions, (*b*) oblique reflexions from distant ion clouds in the *E*-region, (*c*) large delays due to lateral deviation[6,7], and (*d*) reflexions from the 'fourth reflexion condition', above the maximum of the $F_2$-layer. Ionospheric focusing is immediately ruled out by the fact that the echo polarization is radically different from that of the *E* hops. Other records containing a definite focusing phenomenon do not show the reversed mode that is observed on the long-delay echoes. Oblique reflexions of detectable amplitudes would require an oblique surface of such proportions as to make this explanation extremely unlikely. No calculations have been made on possible time-delays due to lateral deviation; but it does not, at present, seem likely that this could account for the amplitudes and the time-delays of the orders observed.

We believe there is a strong possibility that these long-delay echoes are reflexions from above the maximum of ionization density in the $F_2$-region, and that the reflexion mechanism corresponds to the 'fourth condition for reflexion'. It is hoped that future observations will add further evidence regarding this possibility.

This investigation has been supported by the National Science Foundation under Grant NSF-066 and, in part, by the Geophysics Research Division of the Air Force Cambridge Research Center under Contract AF19(122)-44.

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Dec. 20.

[1] Gibbons, J. J., and Nertney, R. J., *J. Geophys. Res.*, **57**, No. 3 (Sept. 1952).

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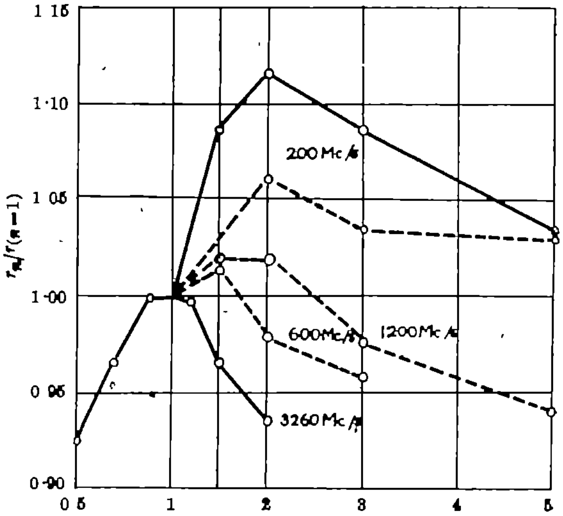
## A Method of Analysis of the Directivity of Solar Radio Emission from Sunspots

IT has been reported previously that the daily values of intensity of solar radio emission are approximately proportional to the whole disk Wolf's sunspot relative number or sunspot area[1,2]. On the other hand, there is a tendency for the intense radiation to be observed when active sunspots are near the central meridian, especially in the metre wavelength region. If the solar radio emission has such a tendency, the daily values of solar radio emission will show better correlation with the sunspot relative number, $nA_1 + A_2$, than the whole disk sunspot relative number, $A_1 + A_2$, where $A_1$, $A_2$ indicate Wolf's relative sunspot number in the central-circle zone (half-diameter circle) and in the outer zone respectively, and $n$ is a parameter which indicates the importance of the sunspots located in the central-circle zone compared with those in the outer zone. To investigate the directivity of solar radio emission from the sunspots quantitatively, the value of $n$ to give a maximum correlation coefficient was determined.



Correlation coefficient $r$ between solar radio emission and sunspot number *versus* $n$, which indicates the importance of the sunspots located in the central circle zone compared with the sunspots in the outer zone. ———, May to August 1951; – – – –, January to June 1951

In the accompanying graph the correlation coefficient $r$, between solar radio emission at 3,260 Mc./s. observed at our observatory and the sunspot relative number, is plotted against $n$, and this is compared with the radio emission at 200 Mc./s. observed at Tokyo Astronomical Observatory in Japan, and 600 Mc./s. and 1,200 Mc./s. observed at Pott's Hill, Sydney; the solid lines are for observations from May to August 1951, dotted lines for those from January to June 1951. The sunspot number is taken from the Tokyo Astronomical Observatory Report.

As shown in the graph, the correlation coefficients between solar radio emission and sunspot relative number have the following maxima:

$n = 1{\cdot}0$ at 3,260 Mc./s. and $r_{\max.} = 0{\cdot}86 \pm 0{\cdot}02$ (May–August 1951)
$n = 2{\cdot}0$ „ 1,200 „ „ „ $= 0{\cdot}68 \pm 0{\cdot}04$ (January–June 1951)
$n = 1{\cdot}5$ „ 600 „ „ „ $= 0{\cdot}54 \pm 0{\cdot}05$ ( „ )
$n = 2{\cdot}0$ „ 200 „ „ „ $= 0{\cdot}54 \pm 0{\cdot}05$ ( „ )
$0{\cdot}49 \pm 0{\cdot}06$ (May–August 1951)

Unfortunately, the standard errors are large at 200, 600 and 1,200 Mc./s. compared with the variations of $r_n/r_{(n-1)}$ shown in the graph, so the results obtained at these frequencies by this method are almost meaningless. The directivities at these frequencies are therefore being investigated using another method of analysis; but it also shows a tendency to result in similar directivities.

It may be concluded that the solar radio emission at 3,260 Mc./s. from sunspots can be observed on the earth at almost equal intensity whatever the location of the sunspots; but at present the directivities are not clear quantitatively at other frequencies.

It is also doubtful if these directivities may be applied to the radio emission at bursts or outbursts.

I should like to express my thanks to Mr. Martin Ryle, of the University of Cambridge, for his helpful criticism.

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[1] Waldmeier, M., and Muller, H., *Z. Astrophys.*, **27**, 58 (1950).

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# FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

## Monday, March 9

University of London (at Bedford College, Regent's Park, London, N.W.1), at 5.15 p.m.—Prof. S. Bergstrom : "Intestinal Absorption of Fats".*

Institution of Electrical Engineers (at Savoy Place, Victoria Embankment, London, W.C.2), at 5.30 p.m.—Discussion on "Is the Presentation of Technical Literature Adequate ?" (to be opened by Prof. M. G. Say).

Manchester Literary and Philosophical Society (in the Reynolds Hall, College of Technology, Manchester), at 5.30 p.m.—Prof. R. A. Fisher, F.R.S. : "The Evolution of Genetics" (Ramsden Memorial Lecture).*

Royal Geographical Society (at 1 Kensington Gore, London, S.W.7), at 5.30 p.m.—"Western Nepal" (Colour films with commentary by Mr. O Polunin).

University of London (at King's College, Strand, London, W.C.2), at 5.30 p.m.—Prof. R. Plank (Karlsruhe) : "Entropy and Probability".*

Pharmaceutical Society (at 17 Bloomsbury Square, London, W.C.1), at 7.30 p.m.—Dr. J. H. Burn, F.R.S. : "Progress in Biological Standardization".

Royal Institute of Chemistry, London Section (joint meeting with the Woolwich Polytechnic Scientific Society, at the Woolwich Polytechnic, Woolwich, London, S.E.18), at 7.30 p.m.—Dr. A. G. Maddock : "Developments in Experimental Techniques of Radio Chemistry".

## Tuesday, March 10

Zoological Society of London (at the Zoological Gardens, Regent's Park, London, N.W.1), at 5 p.m.—Scientific Papers.

Royal Institution (at 21 Albemarle Street, London, W.1), at 5.15 p.m.—Prof. G. C. Varley : "The Causes of Insect Abundance". (Further Lectures on March 17 and 24).

Institution of Chemical Engineers (at the Geological Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Mr. J. M. Coulson and Mr. R. R. Mehta : "Heat Transfer Coefficients in a Climbing Film Evaporator" ; Mr. F. H. Warner and Mr. K. A. R. Julian : "Natural Circulation in External Evaporators".

Institution of the Rubber Industry (at the Royal Society of Tropical Medicine and Hygiene, 26 Portland Place, London, W.1), at 5.30 p.m.—Mr. L. Landau : "Some Aspects of Latex Dipping" ; at 7 p.m.—Mr. J. M. Buist : "Ageing and Weathering of Rubber, and Methods of Assessment".

British Institution of Radio Engineers, London Section (at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 6.30 p.m.—Discussion on "The Standardization of Symbols and the Arrangement of Electronic Circuit Diagrams" (to be opened by Mr. L. H. Bainbridge-Bell).

## Wednesday, March 11

Society of Public Analysts and other Analytical Chemists, Biological Methods Group (joint meeting with the Food Group of the Society of Chemical Industry and the British Region of the Biometric Society, at the Wellcome Research Foundation, 183 Euston Road, London, N.W.1), at 2.30 p.m.—Symposium on "Flavour Assessment".

Institution of Electrical Engineers, Radio Section (at Savoy Place, Victoria Embankment, London, W.C.2), at 5.30 p.m.—Mr. H. McP. Leyton, Mr. H. A. Nind and Mr. W. S. Percival : "Low-Level Modulation Vision Transmitters, with special reference to the Kirk O'Shotts and Wenvoe Stations".

University of London (at King's College, Strand, London, W.C.2), at 5.30 p.m.—Prof. R. Plank (Karlsruhe) : "Steam Jet Refrigeration".*

## Thursday, March 12

Royal Society (at Burlington House, Piccadilly, London, W.1), at 11 a.m.—Discussion on "The Function and Location of Enzymes in Cells" (to be opened by Prof. J. Z. Young, F.R.S.).

Royal Society of Arts, Commonwealth Section (at John Adam Street, Adelphi, London, W.C.2), at 5.15 p.m.—Prof. Raymond W. Firth : "Social Changes in the Western Pacific".

University of London (at Bedford College, Regent's Park, London, N.W.1), at 5.15 p.m.—Prof. S. Bergstrom : "Formation and Interconversion of Bile Acids".*

Institute of Welding (joint meeting with the Institution of Structural Engineers, at 11 Upper Belgrave Street, London, S.W.1), at 6 p.m.—Mr. H. M. Lewis : "Construction of the New Testing Laboratory of the British Welding Research Association at Abington".

Royal Aeronautical Society (in the Rolls-Royce Welfare Hall, Nightingale Road, Derby), at 6.15 p.m.—Squadron-Leader W. A. Waterton : "Some Aspects of High Performance Jet Aircraft".

## Friday, March 13

Society of Dyers and Colourists, Manchester Section (in the Great Hall, College of Technology, Manchester), at 2 p.m.—Symposium on "Synthetic Fibres".

Royal Astronomical Society (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Scientific Papers.

Physical Society (at the Science Museum, Exhibition Road, London, S.W.7), at 5 p.m.—Prof. M. Born, F.R.S. : "The Conceptual Situation in Physics and its Prospects of Development" (Guthrie Lecture).*

Bedson Club (in Lecture Theatre I, Chemistry Building, King's College, Newcastle-upon-Tyne), at 5.30 p.m.—Dr. F. Fairbrother : "Catalytic Inorganic Halides and the Friedel-Crafts Reaction" (89th Bedson Lecture).

Institution of Mechanical Engineers (at Storey's Gate, St. James's Park, London, S.W.1), at 5.30 p.m.—"Steels for Steam Power Plant" : a review of work of a Sub-Committee of the British Electrical and Allied Industries Research Association between 1930 and 1951, compiled by A. M. Sage.

University of London (at King's College, Strand, London, W.C.2), at 5.30 p.m.—Prof. R. Plank (Karlsruhe) : "Absorption Refrigeration".*

Royal Institution (at 21 Albemarle Street, London, W.1), at 9 p.m.—Prof. L. Hawkes, F.R.S. : "Geology and Time".

# APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned :

Chemist (Senior Scientific Assistant) at the Central Laboratory, Chiswick, with responsibility for section concerned with wide variety of analytical and investigational work other than metals, fuels, lubricants and paints—The Staff Officer (F/EV.229), London Transport, 55 Broadway, London, S.W.1 (March 13).

Assistant Chemist and Bacteriologist—The Chief Engineer, Mid-Wessex Water Company, Frimley Green, Aldershot (March 14).

Assistant Inspector of Fisheries and Pollution—The Clerk to the Avon and Dorset River Board, Rostherne, 3 St. Stephen's Road, Bournemouth (March 14).

Experimental Officers in the Guided Weapons Department, Royal Aircraft Establishment, Farnborough, for work on design, development and performance of new weapons and associated guidance and control systems ; instrumentation of flight trials and investigation of trials results—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting D.508/52A (March 14).

Assistant Keeper (with honours degree in zoology or equivalent) in Zoology in the Manchester Museum—The Registrar, The University, Manchester 13 (March 20).

Senior Scientific Officer at the High-Speed Aerodynamics Laboratory, Salisbury, Australia, to be responsible, under the direction of a Principal Scientific Officer, for research into problems of stability and control at high speeds—The Senior Representative, Department of Supply, Canberra House, 87 Jermyn Street, London, S.W.1 (March 20).

Instructor/Lecturer of Forestry Field Training School, Forest Department, Ceylon—The High Commissioner for Ceylon in London, 13 Hyde Park Gardens, London, W.1 (March 21).

University Demonstrator in Physics—Dr. F. B. Kipping, Chemical Laboratory, Cambridge (March 21).

Lecturer in Physiology—The Dean of the Medical College, St. Bartholomew's Hospital, West Smithfield, London, E.C.1 (March 25).

Principal (with an industrial background, considerable administrative experience in education, and an intimate knowledge of the whole field of technical education) of the Technical-Vocational High School, Winnipeg—The Secretary-Treasurer, School District of Winnipeg, Winnipeg, Man., Canada ; or The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (April 1).

Tutor (Crop Husbandry) and a Tutor (Animal Husbandry) to train Staffs of Departments of Agriculture and others in the practice and theory of agriculture at sub-university level—The Principal, Eastern Caribbean Farm Institute, Arima P.O., Trinidad, B.W.I. (April 1).

Head of the Department of Biochemistry—The Academic Secretary, Weizmann Institute of Science, Rehovoth, Israel (April 15).

Agriculturist (with a degree in agriculture, preferably with technical, industrial or administrative experience) at the Technical and Scientific Register—The Ministry of Labour and National Service (K Section), Almack House, 26 King Street, London, S.W.1, quoting G.6/53A.

Analytical Chemist (temporary) for work arising from experiments with farm animals—The Secretary, Rowett Research Institute, Bucksburn, Aberdeenshire.

Assistant Lecturer (Grade B) in Electrical Engineering—The Registrar, Hatfield Technical College, Roe Green, Hatfield, Herts.

Assistant Works Manager (with honours degree in chemistry or chemical engineering, A.R.I.C., A.M.I.Chem.E., or equivalent) for Atomic Energy Factory at Salwick, Preston, to be responsible for operation of chemical plants—The Ministry of Supply, Division of Atomic Energy (Production), Risley, Warrington, Lancs, quoting Ref. 425.

Electrical or Mechanical Engineer (Scientific Officer grade) at the Royal Aircraft Establishment, Farnborough, for research and development in connexion with generation, conversion and control of electric power for aircraft—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting D.54/53A.

Lecturer in Chemistry, a Lecturer in Physics, a Lecturer in Mathematics, a Lecturer in Zoology and Botany, an Assistant for Geography and English, and an Assistant for Mathematics—The Principal, Adisadel College, Cape Coast, Gold Coast (by air mail).

Scientific Assistant, mainly to examine and abstract world scientific literature on grassland and field-crop research—The Director, Commonwealth Bureau of Pastures and Field Crops, Aberystwyth.

Scientists (M.A., M.Sc. or Ph.D. or equivalent in one of the physical sciences, mathematics, biomathematics, or mathematical economics, preferably with some industrial or laboratory research experience) for Operational Research and Systems Analysis—The Director, Research Personnel, Defence Research Board, Department of National Defence, 'A' Building, Ottawa, Canada.

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## RESEARCH IN NATIONALIZED INDUSTRIES

IN one of its first studies, the Acton Society Trust expressed the opinion that parliamentary supervision of the nationalized industries in Great Britain is inadequate, and in a later study examined in some detail the use of the Parliamentary question. It is generally agreed that if the Parliamentary question were given free play over the whole field of activity of a nationalized industry, much of the advantage of a public corporation over a government department would be lost. To the extent to which some of the existing weaknesses of the nationalized industries are due to over-centralization, this is important; for Sir Henry Clay has shown convincingly how in practice real decentralization by a government department is impossible—the Minister cannot divest himself of the ultimate responsibility placed upon him by Parliament. The basic feature of the Parliamentary question is that it is answered by the Minister ultimately responsible for the decisions about which he is questioned.

The importance of the subject has been attested by the attention given to its broader aspects in recent books on British government. "British Government since 1918", for example, published in 1950, included a valuable contribution by the late Sir Arthur Street entitled "Quasi-Government Bodies since 1918", in which he sketched very clearly a number of the unsolved problems relating to the organization of public corporations, whether responsible for nationalized industry or not. More recently, in "Parliament: a Survey", Prof. A. L. Goodhart contributed a chapter on parliamentary control over the nationalized industries which, after reviewing recent Parliamentary and other discussions, endorsed much that Sir Arthur Salter wrote in his essay "The Crux of Nationalization", and concluded that up to the present no answer had been found to this major problem of control.

A Select Committee on Nationalized Industries was appointed in December 1951 to consider the present methods by which the House of Commons is informed of the affairs of the nationalized industries and to report what changes, having regard to the provisions laid down by Parliament in the relevant statutes, may be desirable in these methods, and its report is now available*. Whether Parliament has maintained an adequate control of the corporations is important and is also the one to which most attention has been directed. Whether Parliament has devised a method which, while allowing for adequate control, has provided a guarantee for the efficient management of these industries is, as Prof. Goodhardt rightly emphasizes, still more important. Nor do the Acton Society Trust studies suggest we are yet anywhere near finding an answer. It is, as Prof. Goodhardt remarks, a sobering reflexion that a major part of the economic life of Great Britain will soon be placed in the hands of a few comparatively unknown men who will be responsible for the efficient development of the fundamental industries; nor can we say whether it is possible to select men capable of solving the vast problems which attend the concentration of so much power in a few bodies.

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* Report from the Select Committee on Nationalised Industries, together with the Proceedings of the Committee, Minutes of Evidence and Appendices. Pp. xxvi+140. (London: H.M. Stationery Office, 1952.) 6s. 6d. net.

In the April–June issue of 1950 of *The Political Quarterly*, a series of eight essays on aspects of nationalized industries in Great Britain were published. These have now been expanded and issued under the editorship of Prof. W. A. Robson in "Problems of Nationalized Industry"*. Six of the original essays are included in the present volume. That of D. N. Chester on the organization of the nationalized industries has been replaced by one by A. Albu on the same theme, and J. A. G. Griffith's essay "The Voice of the Consumer" is also discarded in favour of chapters by F. Milligan on "The Consumer's Interest" and "Public Relations in the Nationalized Industries". Six new essays include one on "Joint Consultation in Nationalized Industry" by A. M. F. Palmer, and one by Edmund Dews on "Scientific Research and Nationalized Industry". Prof. Robson contributes an introductory essay on the public corporation in Britain and also a comparison of nationalized industries in Britain and France, while the whole of the second part consists of general conclusions which he himself has drawn on the themes of the various essays constituting the first part.

Strong support is lent by these essays to the view that more general publicity regarding the work of the nationalized industries is desirable: some of the annual reports of the boards are severely handled. Generally speaking, however, it is not increased publicity in Parliament that is urged so much as effective use of such devices as the consumers' councils and an adequate system of public relations, both to secure the ventilating and remedying of grievances and the explanation to the public of the policy and operation of the boards.

The place of science and of scientific research in these industries requires closer consideration. Studies made by the Acton Society Trust and others have pointed to the difficulties which the scientist or technologist engaged in nationalized industries encounters and to conditions which may affect adversely the recruitment of men of the desired calibre. The recent Ridley Report, at least by implication, stressed the importance of research and its organization in nationalized industry and, as Mr. Dews reminds us in his chapter on scientific research and nationalized industry, the Advisory Council on Scientific Policy was asked so long ago as April 1947 to consider what should be the respective functions of Government departments, of the research councils and of outside bodies (including the boards of nationalized industries) in carrying out research.

The Advisory Council gave some attention to this problem in its first report and expressed the view that the executive department should be responsible for identifying problems requiring research, settling their order of priority, deciding where the various investigations should be carried out and applying their results. It is clear from the report that the boards of the nationalized industries are for this purpose regarded as executive departments, and to them likewise applies the Advisory Council's further recommendation that such departments require to employ scientific staffs corresponding approximately to the operational research units attached to the Service ministries and commands during the Second World War. The specific recommendation is made that departments should appoint a chief scientific officer to advise generally on the scientific aspects of departmental policy and, particularly, to define the problems calling for research, to arrange for its conduct and to watch the application of its results, and that this officer should be provided with an adequate scientific staff; this is in line with the comment of the Select Committee on Estimates in its third report for the session 1946–47 that a major weakness in the government organization for research and development was the absence of sufficient provision for the identification of scientific problems in day-to-day administration.

The Select Committee itself recommended the appointment of scientific officers or advisers, as the Advisory Council afterwards did, but it also recommended that such scientific advisers should stand high in the departmental hierarchy and should have direct access to the highest policy-forming level. Although it appears, from the review of government scientific organization in the civilian field which the Advisory Council on Scientific Policy issued in 1951, that there is sufficient contact between the chief scientific officers of the National Coal Board, the British Electricity Authority, the Gas Council, the Department of Scientific and Industrial Research and the Ministry of Fuel and Power, there would appear to be some reason to doubt whether this latter recommendation of the Select Committee has really been given effect in the nationalized industries. It is a question of status and the level at which science is able to affect policy.

This broad question of efficiency has not so far received attention from the Select Committee on Nationalized Industries, except from the negative aspect of the effect of the Parliamentary question on the management of these industries, and it would appear that managerial efficiency as such lies rather outside the terms of reference of that Committee. The minutes of evidence taken before the Select Committee scarcely suggest, however, that the Parliamentary question has adversely affected efficiency, though it clearly could do so if abused. Sir Hubert Houldsworth's evidence did not imply that, on the technical side, the danger is very real; but while he clearly recognized that the nation, as well as Parliament, has the right to be fully informed both as to general policy and the results of that policy, he looked to other means of providing such information—notably in the annual reports of the boards and in public debate on such reports.

Sir Hubert here made the important stipulation that such debate and discussion should be objective and constructive, proceeding not along political party lines but inspired by the desire to secure the highest standards of technical efficiency and public service. Prof. Robson, in the essays already mentioned, also recognizes the need for more impartial discussion and, particularly in commenting on Mr. Dews's essay, remarks on the need for a vigorous policy of research and development in the nationalized industries. He does not, however, like Mr. Dews, stress the need for new tests of efficiency and service, nor is it clear that he shares the view that, properly organized, an industrial research programme should be one of the means by which the nationalized industries can be kept under public review. To secure this, Mr. Dews points out, the research organization must be strong and active, in close touch with the industry and on friendly terms with it, yet independent enough to offer public criticism; and he thinks that a modified system of research associations is most likely to answer the purpose.

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* Problems of Nationalized Industry. Edited by Prof. William A. Robson. Pp. 390. (London: George Allen and Unwin, Ltd., 1952.) 25s. net.

The question of the most appropriate organization of research is important—much more important than the exact means by which the necessary financial support is provided, subject to two conditions, both of which seem to escape both Prof. Robson and Mr. Dews. They seem prepared to admit that there is as yet little evidence that nationalization has provided the long-range outlook and the command of resources required for an effective research programme. Prof. Robson concedes also that we should not expect the public corporations to look very far ahead in the scientific sense, and that we should rely on the research associations rather than on the public corporations as sources of new knowledge and improved technology. Nevertheless, the responsibility for deciding expenditure on new ventures must rest with the boards: neither in nationalized nor in private enterprise can it wisely be entrusted to government departments.

Prof. Robson appears to be somewhat over-optimistic—particularly in view of the trend of recent questions in the House of Commons regarding public expenditure on scientific and industrial research—as to the freedom and independence which the research associations enjoy for the continuous and uninterrupted pursuit of long-range projects in fundamental or in applied science. More important, he, like Mr. Dews, has omitted the whole question of outlook to which Sir Henry Tizard directed attention in his Messel Memorial Lecture. Sir Henry Tizard was disturbed at the implications of a situation in which we are coming to rely increasingly on the State to finance developments for civilian purposes which formerly would have been financed by private enterprise.

Whether or not British industry is becoming less adventurous, it has to be admitted that financial conditions and taxation policy tend to discourage enterprise. It must also be admitted that there is little evidence that adventurousness is fostered by State control: quite apart from the high costs of the development stages, it is premature to claim that we have as yet entirely solved the problem of securing the continuous prosecution of long-range research where the financial resources are in the main provided by the State. The reports of the Advisory Council for Scientific and Industrial Research are not reassuring on this point, and it well merits further examination by the Advisory Council for Scientific Policy.

The most efficient and appropriate relations between the research organization in the nationalized industries and the relevant government departments and research associations, however, will fail to yield their full results unless the nationalized industries can attract scientific and technical staff of high quality. Against this possibility Mr. R. Lewis and Mr. A. Maude, in their recent book "Professional People", put a significant question mark. Difficulties do not arise so much from the conditions of service; rather they are inherent in nationalization itself and the consequence for the professional man of finding only one employer available for his talents. Prof. J. W. Cook, in an address to the Royal Institute of Chemistry some two years ago, noted the problem, but few besides Mr. Lewis and Mr. Maude have really faced the issue. Nevertheless, it is one that should figure prominently in discussing the organization of scientific research and development in the nationalized industries, and the wider question of the most appropriate organization of those industries to serve the needs of the day.

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## SIR JOSEPH BANKS: 'THE FATHER OF AUSTRALIA'

### Sir Joseph Banks, K.B., P.R.S., the Autocrat of the Philosophers

By Dr. Hector Charles Cameron. Pp. xx+341+9 plates. (London: Batchworth Press, Ltd., 1952.) 25s. net.

CONSIDERING the immense impression that Sir Joseph Banks made on the science of his own time, he has been treated with singular unfriendliness by biographers and historians. The general conception of him that has come down to our time has been formed by his enemies. It is that of an overbearing tyrant, who ruled the Royal Society with a rod of iron for forty-two years, who blocked all access of scientific men to the Sovereign, who contributed nothing himself to the body of scientific knowledge, who belittled the achievements of those mathematically inclined, and who owed his commanding position mainly to his very great wealth. The well-known picture of him by Thomas Phillips that hangs in the rooms of the Royal Society has done something to reinforce this unfavourable view. It is right to remember that it was done when he was old, ill, gouty and unwieldy. We prefer to think of Sir Joshua Reynolds's picture of the gallant and intelligent young man whose eyes are seeing more clearly the vision of his childhood. Dr. H. C. Cameron's industry has excavated many new facts concerning the manly and not ungentle figure of this great man, and much of what he has to say places Banks in a new and very pleasing perspective.

Banks was little more than a child when he had a vision of what his life should be. It was to be devoted to the study of Nature and to the disposal of the results of that study for the public good. He was but a youth when he became sole controller of an immense fortune; but until the day of his death at seventy-six he never swerved from complete loyalty to his childhood's vision to which all his resources were completely devoted. His scientific writings are very few indeed; but there was scarcely any important scientific venture made in Britain during his adult years in which he did not play some direct or indirect part. He was truly the 'father of Australia', where alone full justice is done to his memory. Of British public institutions, Kew Gardens, the British Museum and the Royal and the Linnean Societies, among others, owe him an incalculable debt. In the "Age of Elegance" he was utterly indifferent to the calls of social gatherings unless science could be furthered thereby. He was as much at his ease in talking to gardeners as to the King, and there is every reason to believe that he and George III were sincerely attached to each other. During periods of George's mental alienation, his medical advisers found that nothing did the King so much good as a talk with Banks about plants, and this we may readily believe. He helped innumerable struggling, distressed and unfortunate men of science and their families and was not infrequently deceived by them. His scientific knowledge was prodigious. His personal courage was unquestioned and his honour was unspotted. If he made no great discoveries—and why should that be said of the man who explored the Pacific with Cook on the *Endeavour*?—he set a standard for all time of single-minded devotion to science.

Dr. Cameron has done a real service by throwing the clear light of documentary evidence on the career, acts and motives of this noble man. On putting down the book one feels that the shade of Banks has handsomely won a libel action which the living Banks would have been far too magnanimous to bring.

Charles Singer

# FORMATION OF SYMBOLS IN THE CHILD'S MIND

## Play, Dreams and Imitation in Childhood

By Prof. Jean Piaget. Translated by C. Gattegno and F. M. Hodgson. Pp. x+296. (London: William Heinemann, Ltd., in association with the New Education Fellowship, 1951.) 21*s*. net.

This translation of Prof. J. Piaget's "La Formation du Symbole chez l'Enfant" is the third of a trilogy devoted to mental development in the first years of life, and is largely based on the detailed study of three children. In the earlier volumes ("La Naissance de l'Intelligence chez l'Enfant" and "La Construction du Réel chez l'Enfant"), which are now being translated, the main theme was the development of sensori-motor intelligence at the pre-verbal level. This third volume deals in the main with the stage of 'representative thinking' which leads to reflective or operational thought proper. In 'representation' the child's mind goes beyond the present moment of time and the immediate space of the perceptual field. This is made possible by previous imitation and play, the former giving rise to images of successful adjustment and the latter to assimilated meanings of the environment. Representation is the union of the centrifugal images of imitation with the centripetal images of play. During the subsequent stage of 'operations', actions may be expressed by signs instead of being actually carried out. 'Operations' are possible actions reduced to anticipatory schemas, at the same time increasing the speed of thought and endowing it with the important characteristic of reversibility.

Each of these three phases, sensori-motor, representative and operational, is interpreted in terms of equilibria between assimilation of the environment and accommodation to it. They are progressive stages of adaptation. In assimilating the environment the organism preserves its cycle of processes, thus exemplifying a feed-back principle. In accommodating to the environment, the movements and positions of external objects act upon the movements and perception of the organism.

The first three chapters trace the development of imitation from reflex and sporadic beginnings through more systematic forms involving new audio-visual models to the stage of deferred imitation to an internal model. At the age of seven or eight there is imitation of detail, consciousness of imitation, and discrimination; but it is only imitation which is relevant to the child's needs.

The second part of the book discusses the beginnings of play and games and criticizes the various theories that have been advanced to explain ludic behaviour generally, though something of value is found in each of them. Prof. Piaget then develops his own theory of games. He distinguishes three aspects: practice games, symbolic games and games with rules. Children's games begin to decline when they are played according to rules. At that stage the transition to adult play begins. Just as symbolic games replace practice games when thought makes its appearance, so the symbol is replaced by the rule as soon as social relationships begin to be formed. Play is the converse and complement of imitation. In imitation there is primacy of accommodation over assimilation, whereas in play there is primacy of assimilation over accommodation.

The third part deals in detail with the development of cognitive representation: through the various stages from the earliest verbal schemas, 'preconcepts', and reasonings from particular to particular, to reversible operations.

The critic may feel that something is missing from Prof. Piaget's account, that something being the child himself in his chameleon-like activities and exuberant loves and hates. The child, it may be said, is more than an apparatus for answering the pointed questions of the investigator. But Prof. Piaget would be the last to claim that he is examining more than the cognitive life of the child. He has placed child development in the very forefront of psychology where it belongs, and his magnificent attempt to trace the emergence of logical structures from psychological ones will doubtless rank as one of the outstanding contributions to contemporary psychology.

The student of the history of scientific ideas will be interested in the resemblances which Prof. Piaget notes between the beginnings of rational thought in the child of seven or eight years and the scientific notions of the early Greek thinkers, who explained certain natural phenomena, for example, the origin of the stars, in terms of the identification of substances—stars being produced by air or clouds. He assumes that the same developmental mechanisms which account for the child's thought were characteristic of pre-Socratic thinking emerging from a mythological and pre-logical epoch.

"In spite of their trivial character, these examples are deserving of careful examination" (p. 218). This remark is in a way the keynote of the book and, indeed, of Prof. Piaget's work generally. Every remark or action of the child, even his first 'mummy' or 'bow-wow', is worthy of the most painstaking examination. It is on the analysis of the same material that Prof. Piaget has erected his imposing axiomatic system as described in his recent "Introduction à l'Épistemologie Génétique" (1950), an English translation of which is very much to be desired since it would provide the necessary stimulus for a wider discussion of this important work.

The translators of the present work deserve commendation for their excellent performance, which has won much praise from the author himself.

John Cohen

## THE PRACTICE OF SCIENTIFIC RESEARCH

### An Introduction to Scientific Research

By Prof. E. Bright Wilson, Jr. Pp. xiii+375. (London: McGraw-Hill Publishing Co., Ltd., 1952.) 51*s*.

THE title of Prof. E. Bright Wilson's book might suggest one of those works which, though they often stimulate discussion, have not been known to influence any actual research. On the contrary, the present book mainly comprises practical advice. After a short chapter more or less about why a scientist undertakes research, the second chapter gives some elements of the technique of an information service, that is, how to find, assemble and store the essentials of relevant prior work. The next chapter, on scientific method, is somewhat metaphysical; but it is sensible, not profound. The chapter on the design of experiments goes into more detail on subjects such as replication, factorial analysis and significance; but it tends to be discursive with brief common-sense observations on a number of topics which have a general connexion with how an experiment is approached. Under the headings of the design of apparatus and the execution of experiments, the author treats the elements of laboratory and workshop practice in scientific work. There are useful suggestions and interesting information; but the mixture is uneven, for the range of topics includes aphorisms about taking records and accessibility in the design of apparatus needing maintenance, fundamental matters such as the limitation of sensitivity by random fluctuation, and technological subjects such as closed control and amplifying systems.

The next four chapters, taking up nearly half the book, comprise a more systematic treatment of statistical principles and techniques, particularly for the assessment of significance. Some topics are included, such as confidence limits and quality control, which are of use more often in industrial studies. On the other hand, there is some formal logic at the beginning of the section, and it closes with the logical basis of probability theory, mentioning symbolic logic in passing. The author clearly attaches great importance to the assessment of the probability that a scientific conclusion is valid, and he explains what he means with care. The last three chapters return to the discursive style of the opening, with one or two notes on mathematical processes, a brief survey of modern aids to computation and hints on writing reports and papers.

The value of a book of this kind depends upon a judicious selection and treatment in the light of the needs of an important enough class of reader. It will not appeal to the experienced man of science, because it is too elementary and because there are too many important omissions in its lists of sources. Indeed, some remarks are so elementary that the student who needed to be told them would seem ill-advised to attempt a scientific career. Nevertheless, we must not forget that the vast expansion in scientific pursuits means that a great and increasing number of young scientific workers will lack the opportunity of acquiring a general knowledge of scientific endeavour and an appreciation of the realities of scientific research by direct contact with leading men of science. To those so placed, this book can be of value. They will realize that the life's work of a man of great ability and industry may be enshrined in a single sentence in a text-book. They will understand that, although a young scientist's research problem may seem very specialized, yet if he is to make a real advance he may have to call on a surprisingly wide range of knowledge and skill. This book can save the young scientific worker much unrewarding toil and inspire him to broaden his studies truly to fit himself for his calling.

S. Whitehead

## A TEXT-BOOK OF PRACTICAL BOTANY

### Textbook of Practical Botany

By Prof. R. C. McLean and Dr. W. R. Ivimey-Cook. Pp. xxiv+476. (London, New York and Toronto: Longmans, Green and Co., Ltd., 1952.) 36*s*. net.

THE authors justify the appearance of this work, a companion volume to their "Textbook of Theoretical Botany", by pointing to the scarcity of practical text-books. It is written for "a general University course", which presumably means General B.Sc. standard, and how far such a book is needed at this stage is controversial. Ideally, at this level, the student should treat each exercise as an independent investigation, and in the main obtain the guidance he needs from standard works. By so doing he will learn his way about the literature and, at the same time, acquire a healthy independence of outlook. To work by this method alone would call for much more time than is normally available.

At the other extreme the student can be issued with schedules and instructions for all his practical work, but such 'cookery book' botany is far from ideal. In practice, some half-way measure seems to be indicated, and this is a part which the present book could fill. Very detailed instructions over the wide field which it covers are clearly out of the question in a book of fewer than five hundred pages, and there has been a good deal of careful selection so that parts of the syllabus which are not likely to be done in practical are omitted. Some of the sections are very short—variation (four pages), evidences for evolution (two pages), hybridization and inheritance (eight pages) and plant ecology, including soil analysis (nineteen pages). The student therefore could scarcely rely on this book alone, and more references to suitable literature might have been desirable. How far the book maintains a good balance must, of course, be a matter of opinion, and it would be unfair to criticize the allocations which the authors have made.

More serious is the criticism which must be made of inaccuracies and misleading or vague statements. A student might well have misgivings when he discovered that Fehling's test on a non-reducing sugar failed, although he had followed the instructions to the letter, for there are no directions that the solution should be neutralized after hydrolysis. The descriptions of *Pandorina*, *Volvox* and *Hæmatococcus* are not entirely accurate, while that of the dehiscence of a fern sporangium scarcely gives a good picture of the course of events. Transfusion tracheids are referred to as parenchyma; laburnum wood is not the happiest choice for tyloses; nor will the student find many chloroplasts in *Nostoc*; and it is surely time that meiosis lost its heterotypic and homotypic divisions. To expect a book of this type to be free from errors or to attain perfect lucidity would be unreasonable; but it does seem reasonable to ask if what might be regarded as a permissible margin—and the examples just noted are only a sample—has not been exceeded.

Nearly all the illustrations are from photographs, and they have been very sparingly used to illustrate material which is difficult to obtain or to prepare. As a whole, they are excellent and form an attractive feature of the book.

F. W. Jane

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# MODERN THEORIES OF INTEGRATION

### The Lebesgue Integral

By J. C. Burkill. (Cambridge Tracts in Mathematics and Mathematical Physics, No. 40.) Pp. viii+87. (Cambridge: At the University Press, 1951.) 12*s.* 6*d.* net.

### The Theory of Functions of a Real Variable

By Prof. R. L. Jeffery. (Mathematical Expositions, No. 6.) Pp. xiii+232. (Toronto: University of Toronto Press; London: Oxford University Press, 1951.) 45*s.* net.

### Lezioni sulla teoria moderna dell' integrazione

Per Prof. Mauro Picone e Tullio Viola. (Manuali Einaudi, Serie di matematica.) Pp. 404. (Torino: Edizioni Scientifiche Einaudi, 1952.) 5,000 lire.

EVERY honours student of mathematics should know why Lebesgue's definition of an integral is preferable to the older definition due to Riemann. One of the easiest ways to acquire this knowledge is to study the clear and concise exposition of the subject by Dr. J. C. Burkill. The preface points out that by adopting Lebesgue's definition we can arrive quickly at results which otherwise require tiresome discussions. This general remark is illustrated by reference to a particular example. There are six chapters, entitled respectively sets of points; measure; the Lebesgue integral; differentiation and integration; further properties of the integral; and the Lebesgue–Stieltjes integral. The tract concludes with hints for the solution of all but the easiest of the fifty-five examples contained in various places, with more detailed solutions of the most important. Perhaps on some pages the virtue of conciseness has been carried to excess. For example, on pp. 7 and 11 there are results without proof, preceded by the statement "the reader will satisfy himself that . . ."; and on p. 10 the proof of a theorem concerning measure ends curtly with the words, "taking the limit, we have the general case". The table of contents is also too concise. For example, it does not reveal that the book contains the inequalities of Holder and Minkowski (pp. 65–66), and there is no index. But these are small defects in an excellent book.

A fuller treatment may be found in the book by Prof. R. L. Jeffery, which seems to consist of two distinct parts. The first part is for beginners in the subject, and starts with an introduction giving a brief account of the real number system. Then follow five chapters which may be described roughly as an amplified treatment of the corresponding chapters in Dr. Burkill's book. One novelty is that the treatment of measure is based upon Lebesgue's outer measure, which Prof. Jeffery prefers to call "metric of a set", and denotes by an unusual symbol. No use is made of inner measure, which he considers to be of purely historical interest. Another novelty is the inclusion of G. D. Birkhoff's ergodic theorem, which arose from problems in dynamics and statistical mechanics but is really a theorem in Lebesgue integration.

The second part of the book, which Prof. Jeffery himself considers of greater importance, consists of Chapters 6 and 7, entitled respectively the inversion of derivates, and derived numbers and derivates. These are written for more advanced students and aim at giving an exhaustive account of a subject to which the author has contributed by his own researches.

The last chapter, dealing with the Stieltjes integral, forms a sort of appendix to both parts. It starts with a simple account of the Riemann–Stieltjes integral and then proceeds to the more difficult topic of linear functionals and the recent ideas on measure and distribution due to L. Schwartz.

The book contains more than a hundred problems, a bibliography of seventy items, an index of subjects and an index of authors. It is carefully written in an attractive style.

The characteristic feature of the Italian book by Profs. M. Picone and T. Viola is the great emphasis on the Stieltjes integral. The introduction deals with two physical problems, the attraction of a body at an external point and the motion produced by an impulse. The first of these problems leads to an integral which involves elements of mass. Such integrals, in the light of modern physical views on the structure of matter, can be understood only as Stieltjes integrals. The authors then develop the whole theory of integration from this point of view, and introduce the term *massa elementare* for an additive function of finite variation. The word *massa* is used continually, roughly as often as the word *measure* in other treatises, but the word *misura* (measure) seems to occur very seldom. The early parts of the book make use of the original work on the theory of limits due to Prof. Picone. These opening chapters are rather different from those of other books, but later on we find the usual theorems, sometimes approached from an unusual angle. The advanced student will find this book interesting and valuable, containing many novelties which would require too much space to specify in detail. It concludes with four indexes, those of notations, of 'examples' (really applications of the theory), of authors, and of subjects. The style is readable, and the printing and paper are very good indeed.

H. T. H. Piaggio

## Lost City of the Incas

The Story of Machu Picchu and its Builders. By Hiram Bingham. Pp. 224+59 plates. (London: Phoenix House, Ltd., 1951.) 21*s*. net.

In the face of great physical difficulties, Dr. Hiram Bingham opened up the magnificent ruins of the late Inca city of Machu Picchu and made them generally known some forty years ago. He published a full account of his work shortly afterwards; but it is now out of print. He recently revisited the site, and this has impelled him to write a shortened popular account of it and of his work there. This is quite pleasant reading, and the photographs are good; but it would be easier to follow if the map had covered the whole of the area described and a plan of the ruins themselves had been provided.

In his original publication, Dr. Bingham put forward the theory that Machu Picchu was Tampu Tocco, the legendary ancestral home of the Incas, and suggested that it was reoccupied in late Inca times after being abandoned for many years. The reasons given for the earlier occupation were flimsy, and the archæological evidence pointed strongly to the late date of the site. No new evidence for an early occupation has come to light since, but Dr. Bingham again advances it in his new book. In general, this book betrays a neglect of recent archæological work in Peru, and a bad fault is the improper use of the term Inca to cover the whole span of ancient Peruvian civilization, which is calculated to give the impression that Machu Picchu is older than it really is.

## Synthesis of Electronic Computing and Control Circuits

By the Staff of the Computation Laboratory. (Annals of the Computation Laboratory of Harvard University, Vol. 27.) Pp. ix+278. (Cambridge, Mass.: Harvard University Press; London: Oxford University Press, 1951.) 52*s*. net.

The first part of this book is concerned with the procedure to be followed in the design of electronic circuits for performing complex binary switching operations such as are required in a digital computer. The principal problem is to arrive at a design which uses the minimum number of components. In 1938 C. E. Shannon showed how Boolean algebra could be applied to the analogous problem of the design of relay switching circuits. The present authors use a closely related method depending on ordinary algebraic manipulation to discuss the design of circuits using diodes, triodes and pentodes.

Tables are given which enable economical designs to be obtained in the case of circuits with up to four binary inputs, and one binary output. Advice is given as to how to proceed in more complicated cases, but, although the authors have clarified the problem to a considerable extent, it cannot be said that the advances they have made are fundamental in character.

The second part of the book contains an interesting chapter on the choice of a binary code to represent the ten decimal digits in a digital computer working in the scale of ten. Later chapters deal with the design of decimal adders, accumulators, multipliers, etc.

The book runs to more than two hundred pages (excluding tables), and the detailed discussion given, together with the large number of examples incorporated in the text, make it difficult on occasion to follow the main trend of the argument. The lack of an index is also a handicap. While everyone concerned with the design of binary switching-circuits should undoubtedly study this book, the reviewer feels that the authors would have made better propaganda for the use of their methods by publishing one or two separate papers in which the important features were explained concisely. The attention of readers may be directed to a group of papers published recently by Kalin, Burkhart and other members of the Harvard Computation Laboratory who were closely associated with the preparation of the book ("Proc. Assoc. for Computing Machinery, Pittsburgh Meeting": Richard Rimbach Associates, Pittsburgh, Pa., 1952). M. V. Wilkes

## Cooperation among Animals

With Human Implications. A revised and amplified edition of "The Social Life of Animals". By Prof. W. C. Allee. Pp. xv+233. (London: Sir Isaac Pitman and Sons, Ltd., 1951.) 21*s*. net.

This is a revised edition of a popular book on biology which is deservedly well known and highly appreciated in the United States. The main section of the work, which is much the same as in previous editions, does not require comment now; but the two last chapters, dealing with some implications of biology for human relations, contain much that is new. Here the author deals with the lessons biology has to teach mankind in connexion with such problems as population growth, food supplies and war. Such applications of biological knowledge to human problems are beset with pitfalls, as so many of the past *ex cathedra* statements of biologists have shown. Prof. W. C. Allee is sufficiently level-headed and critical never to fall into the error of assuming that human beings are just animals or that we can expect studies of *Drosophila*, white rats or chimpanzees to be directly applicable to human societies. His wise humanity and deep understanding of the nature of war and of some of the problems of human population and growth should do much to suppress those wild and muddle-headed theorizings which the less well-read biologist, however technically competent he may be, sometimes tries to convey to the long-suffering public. W. H. Thorpe

## New Biology, 13

Edited by M. L. Johnson and Michael Abercrombie. Pp. 128+19 plates. (Harmondsworth: Penguin Books, Ltd., 1952.) 2*s*.

In the thirteenth issue of "New Biology", which ably maintains the high standard of its forerunners, Prof. R. C. Oldfield contributes an interesting article in which he describes investigations into human skill which have been carried out at Cambridge and elsewhere during the past ten years. Another article, by H. Spurway, suggests that animals in captivity are not really at all representative of the wild populations from which they were originally drawn but are on the road to domestication. In an article on polyploidy and plant breeding, Dr. M. S. Swaminatham discusses some of the means of improving plants by multiplying the number of chromosomes they possess. Prof. E. J. W. Barrington's article on problems of thyroid function in vertebrates is an argument for a broad basis of comparison of different organisms as an aid to the understanding of any one. Dr. C. G. Johnson examines the bed-bug in its ecological relations to human beings.

# STORM DAMAGE TO WOODLANDS IN SCOTLAND ON JANUARY 31, 1953

By Prof. H. M. STEVEN
University of Aberdeen

THE storm on Saturday, January 31, 1953, caused widespread and serious damage to woodlands in the region of Scotland north of the River Tay and east of Inverness. This storm, which the day before had caused the sinking of the *Princess Victoria*, and on the evening of the same day was responsible for the flooding on the east coast of England and in the Low Countries, struck this region of Scotland during Saturday as the storm centre moved eastwards and south-eastwards along its track north of the mainland of Scotland.

## Meteorological Data

Data have been made available by the Meteorological Office for stations at Kinloss on the Moray Firth, Dyce near Aberdeen, and Leuchars in Fifeshire. From midnight on January 30–31, the direction of the wind changed slowly in the two more northerly stations from west-north-west to almost north in the afternoon. At the height of the storm about noon, it was between north-west and north-north-west. At Dyce the average hourly wind speeds increased from 9 m.p.h. for the hour ending 1 a.m. to 38 m.p.h. at 6 a.m., to 63 m.p.h. at noon. There was a slight decline thereafter, but the speeds remained high until evening. Gusts of more than 90 m.p.h. were recorded between 10 a.m. and 4 p.m.; the highest was 101 m.p.h. between 11 a.m. and 12 noon, with several greater than 92 m.p.h. during that period. At Kinloss, the pattern was similar, with higher speeds in the early hours, but the peak at the same period with gusts up to 98 m.p.h. At Leuchars, the speeds were less; the highest gust was 72 m.p.h. at 12.20 p.m. Most of the damage in woodlands took place between 10 a.m. and 2 p.m., when the winds were of hurricane force.

Wind-throw in woodlands often takes place when storms are preceded and accompanied by heavy rain, and the soils are water-logged and spongy. For example, this was so in the storm from the west on November 17, 1893, when a million and a half trees were blown down in Perthshire and Angus alone. The hurricane in New England, United States, on September 21, 1938, was also of this type, when gusts of more than 120 m.p.h. were recorded on the coasts, and in the week previously more than 9 in. of rain had fallen; the woodlands there still bear the mark of that disastrous storm. On this occasion, however, the rainfall in Scotland during January in the region affected had been less than normal at most stations, although the storm was accompanied by showers of rain and sleet.

The north-east of Scotland is less subject to exceptional storms than the western regions and the islands. Nevertheless, the woodlands have to withstand gales. For example, in Gold's records of highest wind gusts for the period 1909–35, speeds of 58 m.p.h. and more were recorded at Aberdeen in every year except 1921 and 1922. There have also been severe gales in recent years, for example on January 15, 1952. Some of these gales did damage to woodlands, particularly that on January 28, 1927, when a gust of 70 m.p.h. was recorded at Aberdeen; but the damage done by that and other gales in living memory was much less severe than in the recent storm.

## Damage to Woodlands

The type of damage caused by the storm of last January varies locally. In some woods the trees have been levelled as if a giant bulldozer had passed over them. From eye-witness accounts, it appears that this was caused by a series of gusts of hurricane force: the first bent the trees over; they rose up again, but succeeding gusts completed their over-throw—thus, in some instances, the trees lie in an unusually orderly way for storm damage. In others the damage is more selective and patchy and the stems may be tangled. In some woods there is little breakage of stems; in others, broken trees stand up among the blown.

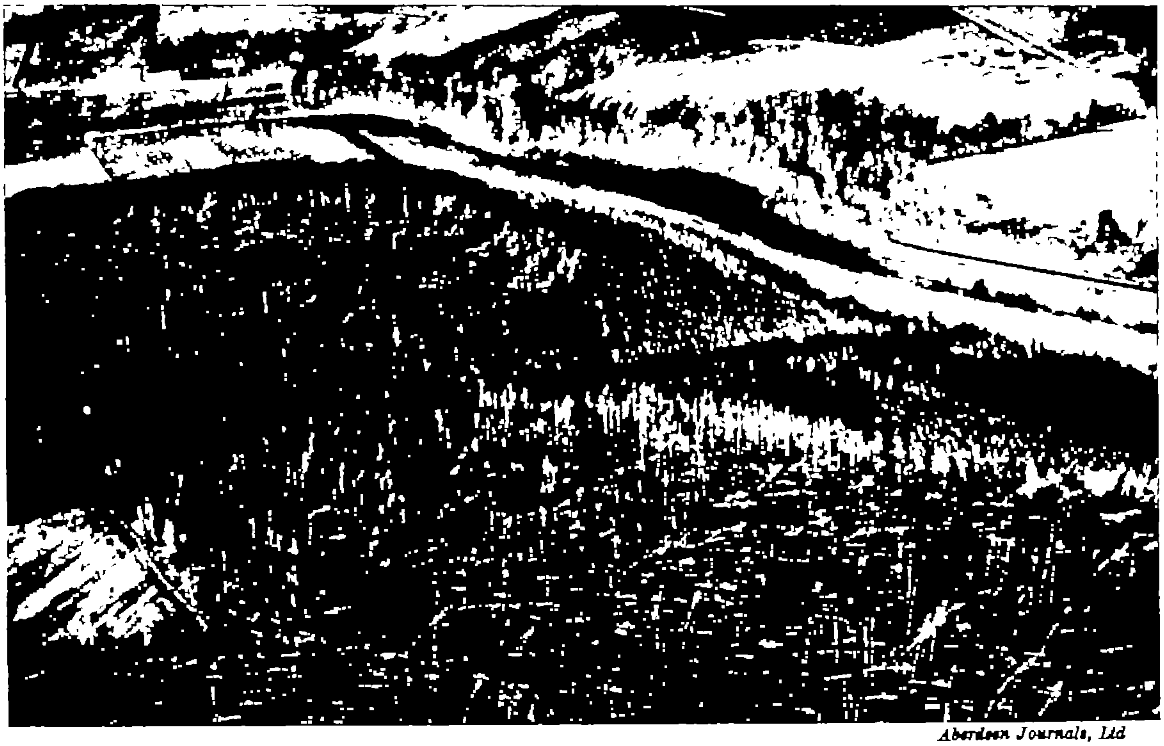
Immediately after the storm, officers of the Forestry Commission made a survey and obtained information from private woodland owners. It is estimated, provisionally, that about 35 million cubic feet of timber (more than one million tons) has been blown. Of this total, about 15 per cent is of broad-leaved species and the balance coniferous, mainly Scots pine. Approximately 90 per cent is on privately owned estates.

The amount of damage varies throughout the region. In the coastal strip north of Inverness, it is not serious. Greater damage has been done in the lowland regions of counties of Nairn, Moray and Banff, and the Spey Valley below Grantown-on-Spey. In the Upper Spey Valley it is somewhat less, particularly where the woodlands were sheltered by the higher land masses. Many of the woodlands in the lowlands of Aberdeenshire, the lower Dee and Don valleys and Kincardineshire have sustained catastrophic damage. In Upper Deeside, where sheltered by the Cairngorms, it is less severe. There is considerable damage to the woods of Angus; but as one proceeds southwards it decreases.

## Influence of Different Factors on the Damage

Where the effect of the storm has been catastrophic, it is not easy to discern the relative resistance of different tree species, the effect of soils, rooting, etc. It so happened that the influence of wind on forest stands was already under study in the Department of Forestry, University of Aberdeen, and a post-graduate worker immediately began a study of the effect of this storm, the Forestry Commission detailed a research officer, and the Macaulay Institute for Soil Research may study the correlation with soils. Until these and other studies are completed, only the broad patterns can be stated, and then only provisionally.

*Age and Height.* The clearest correlation is between the height of the stands and damage. Few woods less than 40 ft. in height have been damaged; it is thus the middle-aged and older woods that have suffered. It is difficult to believe that this is explained entirely by the known gradient of wind-speed with height above ground, and closer investigation is



*Aberdeen Journals, Ltd*

Middle-aged Scots pine in Carlogie Wood, Ballogie Estate, Aberdeenshire, after the storm damage on January 31. Photograph from the air

needed. This correlation is one reason why Forestry Commission woodlands have suffered relatively little damage, and that mainly in woods which they had acquired.

*Species.* Most of the woodlands in the region are coniferous, and Scots pine is the principal species. It is normally deep-rooting and is usually considered wind-firm. It has not proved so in this storm. In some, but not all, Scots pine woods, there is considerable breakage of stems at 6–12 ft. from the ground. European larch has shown greater resistance both to wind-throw and breakage; it has a more elastic stem and the timber is stronger. Both Norway and Sitka spruces have suffered wind-fall; but as they are shallow rooting and not considered wind-firm, one noted with surprise instances of greater resistance relative to pine. The same observation applies to Douglas fir.

Among broad-leaved species, beech is a common species in the lowlands of Angus, Aberdeenshire and the Moray Coast. Many of the trees are mature and over-mature, and the species has been considered, hitherto, as resistant to wind-throw. It has, however, suffered serious damage in this gale. It is even more surprising that the deep-rooting oak has also not proved wind-firm.

*Stocking.* In normal gale damage, there is often a correlation between damage and dense stocking. In woods where thinning has been neglected, the percentage of living crown is low and consequently the centre of gravity is higher than in woods thinned sufficiently early and regularly. This storm does not appear to have left such a pattern; but a closer study may reveal correlations with stocking.

*Physiography.* The factors comprised in this term are taken into account in planning forests and choosing species relative to wind risks. The effect of local shelter can be seen in this instance, but, perhaps, less clearly than usual. One point is noteworthy: many of the woodlands that suffered most severely were growing at low elevations.

*Soil Conditions.* Most of the soils in this region are derived from parent materials of glacial origin. It has been known for a long time that in this region there is often a compacted horizon which may be relatively near the surface, and which may impede the downward penetration of tree roots, either directly or through its influence on soil water relations. The upturned roots in many woods confirm this. Foresters have been aware of this problem. Indeed, more than a century ago, there are records of hand trenching to deal with it, and during the past twenty years, the deep ploughing on heaths carried out by the Forestry Commission and others has been done partly in the hope that depth of rooting would be increased. The opportunity will be taken, therefore, to investigate the connexion between wind-throw and soil conditions.

## Risk of Insect Epidemics

Because most of the blown timber is Scots pine, insect pests attacking this species are the potential menace. The pine weevil, *Hylobius abietis*, breeds in the stumps and roots of pine, and the adults attack young trees. It will be necessary to keep this pest under observation; but as many of the roots are exposed, and will dry quickly, it is not thought that populations will rise steeply. Indeed, at one time on some parts of the Continent 'pan felling', namely, winching the trees over, was practised to reduce the incidence of this pest.

The pine shoot beetles (*Myelophilus piniperda* and *M. minor*) are more likely to be a menace. Both breed under the bark of felled, dead and dying pine, and the adults tunnel into living shoots of the crown. The now abundant breeding material will almost certainly mean a rapid rise in populations, with consequential damage to adjoining crops. The pine, and especially the larger blown pine, should thus be salvaged first.

### Problems of Salvage

The timber blown would have had a value standing of more than £4,000,000. It is essential, therefore, that it should be salvaged before deterioration, alike in the national interest and that of the owners. As already stated, 90 per cent is privately owned, and if a substantial part of its standing value does not accrue to its owners, private forestry and the rehabilitation of private woodlands after the heavy war fellings will be prejudiced seriously in this region.

Largely through the enterprise of the public press, the importance of the problem of salvage is realized widely, and Ministers of the Crown in Parliament and elsewhere have given assurance of help. As soon as the first surveys were completed, the Chairman of the Forestry Commission, accompanied by the Director-General, went to Aberdeen and met the Forestry Commission Regional Advisory Committees for the East and North Conservancies of Scotland, consisting of representatives of private owners, timber merchants and others. The Conservator of the East Conservancy, Forestry Commission, has been put in general charge of the salvage operations, assisted by a small committee of representatives of the regional advisory committees, landowners' organizations and timber trade associations. It has been decided to aim at the completion of salvage within two years. Representatives of the home timber trade in Scotland estimate that there is sufficient sawmill capacity to enable this to be done. The necessary additional logging equipment can be got. Labour is likely to be the limiting factor, and plans are being worked out to obtain what is needed. The Forestry Commission has suspended the licensing of standing softwood timber for clear felling in Scotland, so that the resources of the timber trade can be concentrated on the blown timber.

Of the estimated 35 million cubic feet of timber blown, about 30 million is softwood from coniferous species, and 5 million of hardwoods from broad-leaved species. Of the softwoods, it is estimated that about 12 million will go into pitwood and the balance into sawn goods. The hardwood will produce sawn timber. The National Coal Board should be able to absorb the pitwood. The quantity of sawn softwood, although large, is less than 10 per cent of the annual consumption of this category in the United Kingdom; hence its absorption should not present serious difficulties, although unusually large quantities have been purchased overseas for delivery in 1953. The hardwoods consist principally of beech, and of a quality not suitable for high-grade use, but which could be sawn into railway sleepers and crossings. If the British railways revert temporarily to war-time practice and take this species for this purpose, it would be of assistance. The timber will have to be transported longer distances than normal, both for conversion, and later to consumers. Thus the question of railway-rates will be important in determining the prices obtained by owners of timber.

There are difficult problems still to be solved before the rapid and economic salvage of the blown timber is ensured, but none is insoluble. They must be solved if the effects of this disaster to forestry in the northern half of Scotland are to be mitigated by efficient salvage.

## RÔLE OF VITAMINS IN METABOLIC PROCESSES

THE Nutrition Society held a symposium on "The Rôle of Vitamins in Metabolic Processes" in the Biochemistry Department of the University of Sheffield on December 20, 1952. The conference was attended by more than a hundred and thirty members and guests, a number of whom took part in the discussions that followed the reading of the papers. The latter have been published in full in the *Proceedings of the Nutrition Society*.

In opening the meeting, Prof. H. A. Krebs (Biochemistry Department, Sheffield) said that the subjects of the papers had been chosen with the idea of concentrating attention on the recent advances in this field, and for this reason consideration of thiamine, riboflavin and nicotinamide had been excluded. During the first session, papers were read dealing with pantothenic acid, pyridoxin and vitamin $B_{12}$, substances which are growth factors for micro-organisms as well as for higher animals and which have been shown to have direct connexions with certain metabolic reactions. During the second session, the fat-soluble vitamins and vitamin C were considered; despite the existence of a considerable body of knowledge relating to the effects of their deficiency, comparatively little is known of the nature of their direct participation in metabolic processes.

Mr. D. E. Hughes (Medical Research Council Unit for Research in Cell Metabolism, Sheffield) showed how the bound forms of pantothenic acid, discovered through the use of micro-organisms for the assay of the vitamin, can now be seen to be various stages in the synthesis or breakdown of coenzyme A. The provisional structure assigned to this coenzyme incorporates a phosphorylated adenosine pyrophosphate and pantetheine, which is a peptide-like compound formed from pantothenic acid and mercaptoethylamine. The thiol group of the latter acts as a carrier of acyl groups in a variety of metabolic reactions. The oxidation of pyruvic acid, for example, results in the formation of acetyl coenzyme A, which may then react with oxaloacetate to give citric acid, thus furthering the oxidative metabolism of carbohydrate, or may contribute to the synthesis of a fatty-acid molecule. Succinyl coenzyme A, and probably other acylated forms of the coenzyme, may arise from other oxidative reactions and may serve in other synthetic reactions—for example, the synthesis of porphyrins.

The signs of pantothenic deficiency in the rat include striking changes in the adrenal cortex. Existing evidence might suggest that these arise, first, through an increased demand placed upon this part of the gland and, secondly, from a lack of ability to perform the synthesis of steroids as a consequence of a lack of coenzyme A. Many tissues, including the adrenal cortex, become depleted of coenzyme A when the diet is deficient in pantothenic acid, and the liver, which is the last to suffer depletion, shows a reduced capacity to acetylate sulphonamides. The greying of the fur and the secretion of porphyrin by the lachrymal glands may be secondary effects of the disturbance of adrenal functions.

Dr. H. M. Sinclair (Laboratory of Human Nutrition, Oxford) reviewed the characteristic signs of deficiency of pyridoxin in the rat, and in other animals. These include changes in the skin (erythema and œdema with superficial hyperkeratosis and atrophy of the transitional layers), a microcytic anæmia, and a characteristic gait with, occasionally, epileptiform fits, suggesting changes in the central nervous system. Increased vascularization of the skin in rats is not accompanied by vascularization of the cornea.

As with pantothenic acid, these signs of deficiency bear no simple relation to the known functions of the vitamin as a coenzyme. In the form of pyridoxal phosphate it is apparently concerned with the general metabolism of the amino-acids, as the coenzyme of transamination reactions. It is also required by bacteria for the breakdown of serine and cysteine, and the decarboxylation of certain other amino-acids; and for the synthesis of tryptophane by *Neurospora*. No satisfactory connexion can be established between the effects of deficiency of the vitamin and a lowered histaminase activity, as was suspected at one time.

Consideration of the possible connexions between these coenzyme functions and the changes in various tissues of the rat can go no further than speculation that protein synthesis is impaired, and that lesions appear where the tissues are most subjected to trauma and thus most need repair. This general connexion between the vitamin and protein metabolism is supported by observations on certain aspects of the protein metabolism of deficient animals.

Dr. J. W. G. Porter (National Institute for Research in Dairying, Reading) reviewed the many results suggesting that vitamin $B_{12}$, like folic acid, is concerned with the metabolism of one-carbon fragments, such as formyl and methyl groups, in animals and bacteria. In this case, however, the evidence does not extend to the identification of the vitamin as the coenzyme for a specific reaction. Methionine can partly replace vitamin $B_{12}$ in the nutritional requirements of rats and chicks, and can wholly replace it for certain mutants of *E. coli*. Thymidine has been reported to produce hæmatopoietic responses in man and the pig, and it can replace vitamin $B_{12}$ for the growth of *Lactobacillus leichmannii*. In both cases the explanation could be that the vitamin is required for the methylation of the normal precursors of these substances. These observations connect vitamin $B_{12}$ with protein and nucleic acid synthesis.

A possible clue to the form in which it functions lies in the presence in fæces of several forms of the vitamin, having different activities when tested on various organisms. At least five such forms are now known: of these, all are active towards *E. coli*, but two have little or no activity for *Lb. leichmannii*. All these forms have been found in small amounts in ox liver.

The presence of cobalt in the vitamin has provoked an investigation of its relation to cobalt deficiency in ruminants, and the most recent results indicate that doses of vitamin $B_{12}$ large in relation to those used to treat pernicious anæmia will cure the symptoms of cobalt deficiency in sheep.

Prof. C. P. H. Dam (Afdeling for Biokemi og Ernaering, Danmarks Tekniske Højskole, Copenhagen) was prevented from attending by illness, but his paper, entitled "Recent Studies on Vitamin K", was read for him. He outlined the relationship between vitamin K and blood coagulation, pointing out its complexity. The fact that the plasma from chicks treated with dicoumarol, or with coumachlor (a rodenticide: 3-(α-phenyl-β-acetylethyl)-4-hydroxycoumarin), shortens the prothrombin time of plasma from chicks deficient in vitamin K, and vice versa, shows that more than one coagulation factor is lacking in vitamin K deficiency; but mixing the two plasmas does not bring the prothrombin time to its normal value. There are differences between natural vitamin K and synthetic substitutes for it, such as menaphthone (2-methyl-1,4-naphthoquinone); the latter do not counteract the effects of administration of dicoumarol, and the natural vitamin gives a faster reduction of prothrombin time in chicks deficient in vitamin K. Prof. Dam thought it more likely that dicoumarol displaces vitamin K from an enzyme system than that it inhibits the synthesis of the vitamin. About 10 per cent of a dose of dicoumarol labelled with radioactive carbon was found in the liver after twenty-four hours. Simultaneous administration of a vitamin K substitute increased the rate of disappearance of the dicoumarol from the liver; the longer the dicoumarol was present in the liver the greater its effect on the prothrombin time.

There are natural variations in the clotting time of blood. A very extensive survey in Copenhagen has shown that for three days after birth there is a rise in the prothrombin time, which may be prevented by the administration of vitamin K to the mother *ante partum*, or to the infants. Irrespective of treatment, the (lower) adult level is not reached for six months. That hæmorrhages in the new-born cannot be entirely due to the increased prothrombin-time is indicated by the observation that there is a seasonal variation in the frequency of hæmorrhages, but not in the prothrombin time. Prof. Dam compared the observed decrease in mortality attributable to vitamin K therapy in Copenhagen, one per thousand births, with the extremes of optimism and pessimism attending its first discovery.

In reviewing the other fat-soluble vitamins, Dr. T. Moore (Dunn Nutritional Laboratory, Cambridge) began by pointing out certain differences between vitamins A, D and E. The daily doses for rats are, respectively, 0·025, 0·5 and 50 μgm.; and whereas the precursor of vitamin A, β-carotene, is readily converted to the vitamin in the body, the immediate precursor of vitamin D is formed in the body but cannot be converted to the active form without the aid of ultra-violet light. Vitamin A has a well-defined role in the cyclic formation of rhodopsin in the eye, and in some organisms this may be its sole function. However, in mammals only a minute fraction of the total vitamin A is present in the retina, and in deficiency of the vitamin characteristic changes are seen in the epithelial tissues, possibly due to the replacement of mucoproteins by keratin. In the vaginal epithelium the effects of œstrogens and vitamin A oppose one another, and excess of either may counteract the normal effects of the other. The metabolic reactions underlying these effects are unknown.

No detailed understanding of the action of vitamin D in promoting calcification exists; but some attempts have been made to substantiate the hypothesis that it acts directly on the conversion of phosphate from the organic to the inorganic form.

The observation that methylene blue can cure or prevent some of the symptoms of vitamin E deficiency, in particular the pigmentation of the uterus, suggests that vitamin E may have two functions in metabolism: one to serve as an intracellular anti-oxidant, the other a more specific one connected with reproduction. In vitamin E deficiency there are chemical changes in the muscles, including the depletion of creatine, and there is evidence of interference with protein metabolism. The red blood cells of rats deficient in vitamin E are hæmolysed by dialuric acid.

In the final paper, Dr. L. J. Harris (Dunn Nutritional Laboratory, Cambridge) examined the literature which, despite its bulk, still leaves us without evidence for a specific metabolic role of vitamin C. Among the older hypotheses was one associating ascorbic acid with collagen formation, and also the more general theory that certain formative cells, such as osteoblasts, show reduced activity; in these cells the vitamin has been found to be concentrated in the Golgi apparatus.

Recent studies have established that the metabolism of tyrosine is affected. The intact scorbutic animal (including man) fails to oxidize completely additional tyrosine fed to it, and tissue slices from deficient animals oxidize tyrosine less rapidly than normal.

The extent of conversion of folic acid into folinic acid is reduced in deficiency of the vitamin, a finding which might explain a suspected connexion between scurvy and anæmia.

The adrenal gland, the original source of Szent-Györgyi's 'hexuronic acid', contains high concentrations of the vitamin, and investigations are in progress to see whether any specific relation exists between the activity of the adrenal cortex and the function of the vitamin.

The great majority of animals can synthesize vitamin C, but, although glucose is known to be its precursor, it is still not known whether synthesis is a property of all cells of the body, or whether certain tissues are specialized for this purpose; similarly, the function of the vitamin in plants is still obscure.

J. S. D. Bacon

# ROYAL SOCIETY MOND LABORATORY, CAMBRIDGE

## By Dr. D. SHOENBERG

THE Royal Society Mond Laboratory was formally opened on February 3, 1933, by Mr. Stanley Baldwin, then Chancellor of the University. The twentieth anniversary of this occasion was recently celebrated by a party, preceded by demonstrations of phenomena at very low temperatures. In this brief review of the work of the Laboratory, it is appropriate first to recall how much it owes to the initiative and enthusiasm of Dr. P. Kapitza, who was its first director. Soon after Kapitza came to Cambridge in 1921, he became interested in measuring the curvature of α-ray tracks by magnetic fields, and this led him to think of the possibility of using magnetic fields much larger than those usually available in electromagnets but lasting for only a small fraction of a second. By limiting the duration of flow of a current in a coil to 1/100 sec., much higher currents can be used without producing too much heat, while at the same time 1/100 sec. is usually ample for the full establishment of any magnetic effect to be studied—thus, for example, an α-particle spends only about $10^{-9}$ sec. in the apparatus.

Kapitza first applied this principle in practice by discharging a specially designed accumulator battery through a coil, and breaking the current within a very short time of making by various automatic devices; by this means he studied α-ray curvatures, and later the Zeeman effect. The success of these preliminary experiments, in which fields of order 100,000 gauss were obtained, led him to think of more reliable methods of achieving still greater fields, and eventually he set up a large electric alternator which, during half a cycle of its operation, was connected across a coil to give a field of 300,000 gauss over a volume of several cubic centimetres. The equipment required considerable space, not only because of the large size of the machine and control gear, but also because, in order that the mechanical shock of the discharge should not disturb the delicate recording oscillographs, these had to be placed at a distance of about thirty yards away from the generator—a distance greater than that travelled by the shock wave in 1/100 sec. Space was provided on a site now occupied by the Department of Physical Chemistry, and Kapitza carried out a series of pioneer researches on various magnetic properties of matter—particularly the change of resistance of metals in a magnetic field, and also a study of magnetostriction and susceptibility. Many of the effects studied became much more striking at lower temperatures, and this led Kapitza to construct a hydrogen liquefier and to think of a helium liquefier in order to exploit more fully his high-field technique. It became clear that more laboratory space would be required to house such a complex of magnetic and cryogenic research, and the Royal Society made available funds from a bequest of Ludwig Mond in order to build a new laboratory suitable for the purpose, and at the same time appointed Kapitza to be Messel professor and director of this laboratory.

The special requirements of the Laboratory led to an unorthodox but attractive design of building, the central feature of which is a large hall for the high-field equipment, around which are grouped various smaller rooms for research and for the technical services (liquefiers, workshop and machine room); apart from some office accommodation and a conference room on an upper story at one end, the laboratory is mostly on one floor. The central hall later lost its primary function; but I think everyone who has worked in the Laboratory will agree that it has served a useful secondary function in lessening the isolation of the individual research rooms and providing a spacious atmosphere which is, perhaps, lacking in the more conventional type of laboratory built around narrow corridors.

As soon as the new Royal Society Mond Laboratory had been opened and the various machines installed, Kapitza set to work to build a helium liquefier. In characteristic style he preferred to design an entirely new type of machine rather than copy existing ones, and he was successful in developing a liquefier in which cooling below liquid-nitrogen temperatures was achieved by an expansion engine, and no liquid hydrogen was used (although, of course, liquid hydrogen was available from a separate liquefier if required for investigation at higher temperatures). It is interesting to note that Kapitza's machine was the forerunner of the Collins helium liquefier, which has become commercially available, and has been largely responsible for the enormous development of cryogenic research in the United States in recent years.

Just when it seemed that the Laboratory was ready to carry on full-scale research at low temperatures and high magnetic fields, a serious setback occurred when Kapitza was unable to return to Cambridge from a visit to the U.S.S.R. When it became clear that this situation was likely to continue, it was eventually decided to sell his high-field equipment to the U.S.S.R. so that Kapitza could carry on his work in Moscow, and to develop the Cambridge laboratory primarily as a cryogenic rather than a magnetic laboratory ; J. D. Cockcroft, who had been closely associated with Kapitza in much of his early work, was put in charge of the laboratory. Up to this time, cryogenic research at the temperatures made available by the use of liquid helium had been almost an exclusive monopoly of the Kamerlingh Onnes Laboratory at Leyden, though, on a smaller scale, work had been going on in Toronto, Berlin, one or two centres in the United States, and had just started in Oxford. A number of quite new and unexpected phenomena, such as superconductivity and the λ-transition in liquid helium, had been discovered in Leyden ; but these were, as yet, little understood, and there was still plenty of scope for relatively simple experiments designed to investigate points of principle.

During the next few years work, the policy of carrying out such experiments yielded handsome dividends. J. F. Allen and various collaborators (A. D. Misener, J. Reekie and E. Ganz) took up the study of the properties of liquid helium below the λ-point. Investigation of the anomalously high heat conductivity led to the discovery of the striking 'fountain effect', which showed that the heat flow was intimately associated with material flow. This was followed by the discovery that the liquid could flow in fine channels with an almost complete absence of viscosity, and this led eventually to the concept of a superfluid component of liquid helium. By a curious coincidence, Kapitza, in his new Moscow laboratory, had turned aside from his investigations at high magnetic fields and made the discovery of superfluidity in fine channels independently at the same time. D. Shoenberg took up various questions of the magnetic behaviour of superconductors which, following the discovery of the Meissner effect, were beginning to excite interest ; later, his studies of the magnetic susceptibility of small superconducting particles in mercury colloids, in parallel with experiments by E. T. S. Appleyard and others on superconducting thin films, proved the reality of the small depth of penetration (of order $10^{-5}$ cm.) of a magnetic field into a superconductor, which had been envisaged in the theory of F. and H. London, and demonstrated that this depth of penetration was strongly dependent upon temperature. At the same time, J. Ashmead had designed water-cooled coils to give steady fields of up to 50,000 gauss and used them in the development of the technique of adiabatic demagnetization, which had been recently opened up in Leyden and in Oxford, as a practical method of working at temperatures below 1° K.

All this work was interrupted by the Second World War, and for the next six years the Laboratory was turned over to various researches for the defence ministries. Late in 1945, cryogenic research was started again, first under Allen's direction, and since 1947, when Allen was appointed to the chair of natural philosophy at St. Andrews, under Shoenberg. Perhaps the most striking advance since the War has been the application, by A. B. Pippard, of the radar techniques developed during the War to problems of superconductivity. He has studied the behaviour of superconductors at very high frequencies—where the resistance is no longer zero, but drops only gradually as the temperature is lowered—and has developed methods of studying the depth of penetration which are not only more accurate than the colloid method and other 'static' methods developed in the Laboratory since the War but also lend themselves better to a variation of physical conditions such as crystal orientation and purity. These investigations have reached a stage where the London theory, which provided such a valuable interpretative guide in the past, is beginning to prove inadequate, and Pippard's results are indicating the direction in which the theory needs modification. Other researches on superconductivity by E. R. Andrew, T. E. Faber, J. M. Lock and D. Shoenberg have cleared up some of the puzzles connected with the intermediate state in the transition from the superconducting to the normal phase, and have enabled the magnitude of the surface tension between the phases to be estimated. New data have also been obtained by G. T. Pullan on the behaviour of the thermoelectric power in the transition and by J. K. Hulm and B. B. Goodman on the thermal conductivity of superconductors ; the adiabatic demagnetization technique is being used to extend the latter data into the range below 1° K., which is of particular interest theoretically.

A by-product of Pippard's work on superconductors has been his study of the anomalous skin effect in normal metals, which sets in when the electron mean free path becomes comparable with the skin depth—as occurs at very high frequencies and low temperatures. Pippard's semi-quantitative explanation of the effect was developed in detail by G. E. H. Reuter and E. H. Sondheimer, and comparison with the more detailed experiments later carried out by R. G. Chambers has provided new information about the parameters which enter into the electron theory of normal metals. The de Haas - van Alphen effect (a periodic variation of magnetic susceptibility with field strength) provides somewhat similar information, and during the past few years Shoenberg has discovered this effect in a number of metals. Quite recently he has developed a new method of studying the effect at high fields produced by discharging a large condenser through a coil, thus on a modest scale reviving the Kapitza tradition in the Laboratory.

Work with liquid helium since the War has been carried on by K. R. Atkins (now in charge of the Toronto cryogenic laboratory), D. V. Osborne, A. C. Hollis-Hallett and C. E. Chase. One of the most important researches has been the measurement of the speed of 'second sound' down to about 0·1° K., which proved to show just the rise predicted by Landau's theory. Other work has included studies of the helium film, the hydrodynamic properties of liquid helium and the absorption of sound. Rather as in superconductivity, here too, the further the experiments are pushed the more evident does it become that existing theories are in need of improvement.

In the course of all these researches the essential simplicity of experiments which was characteristic of the early days of the Laboratory has to some extent been lost with the necessity for more accurate measurements of less easily studied properties. More and more complicate devices have had to be accommodated in ever larger liquid-helium 'dewars', while at the same time the number of projects going on simultaneously has also increased. For these reasons the Kapitza liquefier which had rendered such excellent service for many years was abandoned in 1949, when Ashmead built a larger liquefier, working on the more conventional cascade principle, but yielding 3·7 litres per hour instead of the previous 1·8. This gain in yield was achieved by making use of the full capacity of the hydrogen and helium compressors of the Laboratory, and particular attention was paid in the design of the liquefier to ease of servicing. At present, as many as six or seven separate 'helium runs' can be carried on simultaneously on each of the two 'helium days' every week, and it is hoped that the flexibility of experimenting will be still further improved soon, when a large liquid-helium storage vessel is brought into use, so that it will be possible for liquid helium to be used at any time.

In such a brief account as this of twenty years work, it has been scarcely possible to do more than point out the main trends; and inevitably some of the individual researches—such as the experiments on paramagnetism before the War by H. M. Barkla and E. S. Shire, J. Ashmead and J. Reekie and more recently by C. G. B. Garrett—have found no mention. In its main lines of research, on superconductivity and liquid helium, the work of the Laboratory has helped in clarifying many tangled questions; but though in some ways it is now clearer what it is that has to be explained, the underlying fundamental theories are still far from developed. This is an attractive situation for the experimenter in the challenge it offers, and it is hoped that the Laboratory will play a part in the future in reaching the deeper understanding which is still lacking.

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# NEWS and VIEWS

## Wool Textile Engineering at Leeds:
## Dr. Alfred H. Nissan

An interesting development in the Department of Textile Industries of the University of Leeds is the recent appointment of Dr. A. H. Nissan as the first holder of the research chair of wool textile engineering, which was endowed in 1947 by the Wool Industry Surplus Cloth Corporation and the National Wool Textile Export Corporation with donations amounting to £52,500. Dr. Nissan is a graduate in chemical engineering of the University of Birmingham; he was awarded the Sir John Cadman Medal and the Burgess Medal and Prize of the Institute of Petroleum. After carrying out research for the degree of Ph.D., he was appointed to the staff as lecturer in petroleum production engineering in 1939 and proceeded to the degree of D.Sc. in 1943. During the War he worked under the direction of Prof. F. H. Garner on flame-thrower problems, including the hydrodynamics of flow of complex visco-elastic systems and chemical engineering problems connected with the development of a novel flame-thrower fuel. In association with L. Grunberg, he also devised an interesting method of making sea-water potable by removing the chlorine ion with silver oxide and the sodium ion with uranium oxide. After the War, Dr. Nissan's attention was turned to combustion processes in diesel engines and the properties of detergent oils as lubricants, until he was appointed head of the Central Research Laboratories of the Bowater Paper Corporation, Ltd., in 1947. There he has had the interesting and satisfying experience of developing a strong and successful research team from the smallest beginnings; he should find equal opportunities in the work of the new chair to which he has been appointed.

## Imperial College of Tropical Agriculture:
## Dr. G. A. C. Herklots

Dr. G. A. C. Herklots, who is succeeding Mr. H. J. Page as principal of the Imperial College of Tropical Agriculture (see *Nature*, 170, 564; 1952), studied at Leeds and Cambridge under J. H. Priestley, Walter Garstang and F. F. Blackman. In 1928 he went to Hong Kong University to take charge of the new Department of Biology. His first interest in natural history found expression in the ten volumes of the "Hong Kong Naturalist" and in books on trees, orchids, natural history and birds. His interest then extended to economic products; and the *Journal* of the Hong Kong Fisheries Research Station, a book on food fishes, and another on vegetable cultivation, were the practical outcome. The problem of nutrition appealed to him, and he was fortunate in being seconded to Dr. B. S. Platt's nutrition survey unit in Nyasaland for six months in 1939. On his return to Hong Kong his services were lent to the Government, first in connexion with firewood supplies; later, as scientific adviser to the Food Controller, he helped in the establishment of a siege reserve for 1,800,000 people. Following forty-three months internment by the Japanese, when he had practical experience of poverty and malnutrition, he was entrusted with the task of re-organizing the fishing industry and organizing vegetable production on a large scale in Hong Kong. (Hong Kong now sells wholesale 30,000 tons of fish and more than 40,000 tons of locally produced vegetables annually.) As secretary for development he was responsible for the creation of a Department of Agriculture and for the administration of departments of gardens, forestry and of the fish and vegetable marketing organizations. Since 1948 he has been secretary for Colonial agricultural research at the Colonial Office—an appointment which has enabled him to visit most of the Colonies of the British Empire.

## Instruments and Accessories for Use with Radioactive Isotopes

The second edition has been published of "Instruments and Accessories for Radio-Isotope Applications", a useful brochure for the potential users of radioactive isotopes, edited by Dr. Denis Taylor and A. G. Peacock (pp. 20. London: Scientific Instrument Manufacturers' Research Association, 1952; free). Without detailed knowledge, the selection of suitable electronic equipment may be very difficult, and the details given of the various detector elements and associated equipment used for radioactive assay and radiation monitoring, together with the names and addresses of manufacturers, will therefore be of considerable assistance. The brochure is divided into sections, dealing with assay instruments, including Geiger, proportional, and scintillation counters, and ionization chambers; monitoring instruments; geological survey prospecting equipment; special instruments, including material-thicknesses gauges, pulse-amplitude analysers, D.C. amplifiers and oscilloscopes; and accessory equipment, covering isotope containers and handling equipment, laboratory furnishings and dry boxes, mass spectrometers and vacuum equipment. In addition to the Isotope Information Office of the Atomic Energy Research Establishment, from which details of the isotopes available, cost, method of delivery, etc., can be obtained, Isotope Developments, Ltd., (120 Moorgate, London, E.C.2) and Tracer Processes, Ltd., (385 Oxford Street, London, W.1) are listed as consultants on radioactive tracer techniques. Three books are recommended for further information on radioactive isotopes and counting-tubes.

### Physiology of Rubber Tapping

An attempt has been made by J. P. Riches and E. G. B. Gooding (*New Phytol.*, 51, No. 1, 1; 1952), and by E. G. B. Gooding (*ibid.*, 11), on the basis of work done at the Rubber Research Institute, Malaya, to give a more exact account of the forces at work and the processes involved when rubber trees are tapped for latex. The general conclusions of Arisz and Frey-Wyssling are retained in a modified form. When a trunk is first tapped, the latex is of high concentration and high viscosity. As a result of exudation at the cut surface, there is a fall in the internal pressure at the cut ends of the latex vessels; but, because of its resistance to movement, only a small amount of latex is forced out, and the drop in pressure extends over a short length of vessel only. Even though dilution takes place in the affected region, the concentration and viscosity of the latex are still so great as to offer resistance to its exudation. The resistance to movement of the latex has an effect similar to a positive turgor pressure: water is taken in slowly, and pressure release in distant parts of the vessel is delayed. Hence the slow exudation of only slightly diluted latex. These ideas are followed up in their application to subsequent tappings during which flow becomes easier, concentrations become lower, and the region affected by the exudation more extensive. Related aspects are also considered. In a further contribution (*ibid.*, 51, No. 2, 139; 1952), the effect of various factors on the concentration of latex is considered.

### Studies on the Lymnæidæ

In an extensive monograph entitled "Recent Lymnæidæ: their Variation, Morphology, Taxonomy, Nomenclature and Distribution", consisting of 223 pages, illustrated by 369 text-figures and 5 plates (Kungl. Svenska Vetenskab. Hand., Bd. 3, No. 1, 1951. Stockholm: Almquist and Wiksell; London: H. K. Lewis and Co., Ltd.; 25 kr.), Bengt Hubendick has reviewed the taxonomy and nomenclature and discussed critically the distribution of the living Lymnæidæ. As the result of a careful study of many examples of sixty-nine populations from different localities in Scandinavia, the author describes in Part 1 the variations, considered morphometrically, of the important species *Lymnæa peregra*. The range of variation disclosed in the shell and reproductive organs is truly remarkable and no doubt played its part in causing the author to become a 'lumper'. All too frequently collectors, having found a few specimens in a new locality which differ from the actual type in a few or some particulars, have erected a new species without pausing to consider the entire range of variation of the original population even in the type locality; they have also omitted to take into account the possibility or extent of ecophenotypical variations. In Part 2 of the monograph Mr. Hubendick passes on to discuss the value and applicability of morphological characters in the determination of species. In the course of this he has examined a wide specific range of material not only from the shell but also, wherever possible, by dissection and by serial sections of the male copulatory organs. Part 3 is a critical review of the recent Lymnæids considered under biogeographical regions in the light of the preceding mass of information. Finally, a bibliographical list of the previously recorded Lymnæidæ is provided, excluding the specialized Lancinæ, which includes a number of genera and about a thousand specific names. These the author has reduced to three genera and forty species with a number of varieties. This work will remain indispensable to workers in the field for many years.

### Pocket Check List of Malayan Timber Trees

In *Malayan Forest Records*, No. 17, Mr. J. Wyatt-Smith has prepared a "Pocket Check List of Timber Trees" for use by Malayan forest officers (pp. 716: Kuala Lumpur: Forest Department, 1952; 3 Malay dollars or 7*s.* 6*d.*). The list includes all trees which reach timber size, fixed arbitrarily at 4 ft. in girth at breast height. A limited number of common small trees, although they do not reach timber height, are included as being of importance in providing poles and firewood used locally. This publication does not suffer from the disadvantage that attends many other forestry manuals of being too bulky to be taken out into the field. Indeed, this small volume is intended as a book of reference, and its regular use should ensure that only preferred vernacular names are employed and correct symbols used for enumeration surveys and linear sampling. The book is divided into four parts as follows: list of Dipterocarps; list of non-Dipterocarps; alphabetical index to scientific names of all trees included in Parts 1 and 2; keys to groups and species of Dipterocarps. An interesting addition is a translation into Malay of the introductory notes to Parts 1 and 2 for the benefit of the Malay field staff of the Department of Forestry.

### Housing in the Tropics

The problem of low-cost housing in tropical areas is the main topic of the sixth bulletin in the series on Town and Country Planning published by the United Nations Department of Social Affairs. The bulletin states that the great majority of dwellings in the villages, town and cities of the tropics are woefully deficient in the essential physical and social requirements of shelter. Overcrowded, structurally unsound, insanitary and infested with vermin, they lack the simplest arrangements for cooking and storing food or for washing; they are far removed from the most modest concept of standards of legally established minima. The bulletin also presents articles on design and construction for tropical housing, suggestions for improving sanitation in tropical areas and examples of how numerous communities have achieved better housing through 'self-help' projects. International activities in the field of tropical housing are reviewed in a section covering actions taken by the United Nations and several Specialized Agencies, technical assistance given by the United Nations and other organizations, and housing discussions at recent international or regional conferences.

### Manchester Public Libraries: Annual Report for 1951–52

The hundredth annual report of the Manchester Public Libraries Committee, covering the year ended

March 31, 1952 (pp. 55+10 pl.; Manchester: Central Library, 1952), records a slight decrease in the total issue of nearly six million volumes, continuing the trend in the adult lending libraries since the general increase in the cost of books enforced a reduction in the purchase of several copies of a popular book. The photographic reproduction service is in such demand that many requests from beyond the confines of the City have had to be declined. The value of this service has been demonstrated most effectively in the Technical Library, which has its own photographic equipment. The report indicates the way in which this Library is being developed in the closest possible liaison with the various specialist libraries and industrial organizations, and the value of such technical library service is now becoming recognized by industrial firms. Its seating capacity is taxed to the utmost, and although the total issue of items was 186,095 compared with 186,014 in the previous year, the number of books issued on request at the counter again increased in all subjects, especially in technology. The trade catalogue collection now exceeds ten thousand items, nearly six thousand of which were consulted during the year—an increase of 50 per cent. Stress is laid on the assistance given to readers by the staff of both the Technical Library and the Commercial Library and Information Department. In view of the approaching centenary of the Manchester Public Libraries, a chronological table from the purchase of the first building, the Hall of Science, Campfield, on June 10, 1850, is included with the report.

## Large-volume Measuring-Flasks

Messrs. H. J. Elliott, Ltd., E-Mil Works, Treforest Trading Estate, Nr. Pontypridd, Glam., state that from time to time they receive inquiries from laboratories in Great Britain and abroad for measuring-flasks of 3, 5 and 10 litres capacity; the maximum capacity generally available is only 2 litres. Their present information is that the demand would be limited to about a dozen of each size per annum, which would scarcely justify the expense of obtaining the necessary moulds. Scientific workers interested are invited to write to Messrs. H. J. Elliott, to assist the firm in deciding whether to undertake the production of measuring-flasks of large capacity.

## Nuffield Foundation Gerontological Research Fellowship

The Nuffield Foundation, as part of its programme for the care of old people, is offering a research fellowship, of professorial status, for research on the scientific aspects of ageing, or alternatively one or more fellowships of less senior status. The award(s) may be tenable at any university in the United Kingdom and is open to applicants of either sex, usually not more than forty-five years of age. The senior fellowship will normally be made for a period of five years, renewable for five more years, and will be worth not less than £2,000 a year plus superannuation and child allowance; research expenses will be met by the Foundation, including provision for research assistants, apparatus and technicians. If, instead of this appointment, one or more fellowships of a lower category are awarded, they will be for three years in the first instance and worth £1,000–£1,500 a year plus superannuation, child allowance and research expenses. Application forms, to be returned before June 1, and further information can be obtained from the Secretary, Nuffield Foundation, Nuffield Lodge, Regent's Park, London, N.W.1.

## Sixth International Congress of Microbiology

The Sixth International Congress of Microbiology will be held in Rome during September 6–12, 1953, under the presidency of Prof. V. Puntoni, director of the Institute of Hygiene, University of Rome, with Prof. E. Biocca, director of the Institute of Parasitology, University of Rome, as secretary-general. The following is a provisional list of the sections into which the Congress will be divided: general microbiology (morphology, metabolism, growth factors, etc.); growth inhibitors (antibiotics, chemotherapeutics, antiseptics); genetics; pathogenicity (virulence, toxins); microbiological technique and diagnosis (large-scale production of micro-organisms, quantitative microbiology, etc.); general immunology; immunological chemistry; animal viruses; plant viruses; bacteriophages; rickettsiæ; schizomycetes; spirochætes; fungi; protozoa; microbe-transmitting arthropods; microbiology applied to human, veterinary and plant pathology; microbiology applied to agriculture; industrial microbiology and fermentations; microbiology applied to hygiene; and microbiology of milk and foodstuffs. Since the preliminary programme was prepared, the Organizing Committee has decided to establish a sub-section on bacterial taxonomy. All those wishing to read papers must send in titles and abstracts (not exceeding five hundred words) before April 30. In connexion with the Congress the Istituto Superiore di Sanità is planning six symposia, at which the lectures will be by invitation only. The symposia will be on the following subjects: bacterial cytology; microbial metabolism; nutrition and growth factors; growth inhibitors and chemotherapy; morphology, biology and systematics of the Actinomycetales; and host-virus interactions. Further information can be obtained from the VI Congresso Internazionale di Microbiologia, Istituto d'Igiene "G. Sanarelli", Città Universitaria, Roma.

## Faraday Society: Fiftieth Anniversary and Hundredth General Discussion

The fiftieth anniversary celebrations and the one hundredth general discussion of the Faraday Society will be held in the Royal Institution (21 Albemarle Street, London, W.1) during April 16–18 under the presidency of Prof. H. S. Taylor, dean of the Graduate School, Princeton University. The programme for April 16 will consist of addresses by two founder-members, Prof. F. G. Donnan and Sir James Swinburne; an address by Sir Harold Hartley on "Michael Faraday as a Physical Chemist"; the seventh Spiers Memorial Lecture, on "Models and Molecules", by Prof. J. H. Hildebrand (University of California); and a guest-night dinner at the Dorchester Hotel to commemorate the fiftieth anniversary of the Society. During April 17–18 there will be a general discussion on "Equilibrium Properties of Solutions of Non-Electrolytes", in which the equilibrium properties of liquid mixtures (general theory and experimental) and solubility (gaseous mixtures and liquid mixtures) will be considered. Application for attendance at these meetings must be made by March 22. Application forms and further information can be obtained from the Secretary of the Society, 6 Gray's Inn Square, London, W.C.1.

## Third International Biometric Conference

The third international biometric conference, arranged by the Biometric Society, a Section of the International Union of Biological Sciences, will be held at Bellagio, on Lake Como, during September 1–5. There will be ten half-day sessions on the following subjects: training in biometry, mathematical problems in genetics, industrial applications of experimental designs, agricultural designs, public health and social medicine, biological assay with special reference to immunology, biometrical problems in ecology, functional relations in experimentation, methodological problems in biometry, and sequential experimentation. In order to save time, communications from members may be presented in the form of exhibits of mounted charts, photographs, etc. Full information concerning each contributed paper or exhibit, including a summary in English of not more than two hundred words, should reach the secretary of the conference (Dr. L. L. Cavalli-Sforza, Istituto Sieroterapico Milanese, Via Darwin 20, Milano) before April 30, from whom all further particulars can be obtained.

### Ionization Phenomena in Discharges: Conference in Oxford

The Clarendon Laboratory, Oxford, in co-operation with the Institute of Physics, the Physical Society and the British Electrical and Allied Industries Research Association, will be holding a conference on "Ionization Phenomena in Discharges" during July 18–23. Visits to laboratories, social meetings and excursions have been arranged for July 18–19, and then the main subjects will be discussed as follows: July 20–21, the mechanisms of glow discharges, sparks and arcs, and electrodeless discharges; July 22–23, Geiger counters, photo-ionization processes and ionization by electron collision in gases. A session will be reserved for questions of general interest. Further particulars can be obtained from the secretary of the Conference, Dr. G. Francis, Clarendon Laboratory, Oxford.

### British Sociological Association

The first conference of the British Sociological Association, to be preceded by the annual general meeting, will be held at Queen Elizabeth College, Campden Hill Road, London, W.8, during March 27–29. The topic of the conference will be "Social Policy and the Social Sciences". The address at the first session will be given by Prof. Gunnar Myrdal, executive secretary of the Economic Commission for Europe. The conference will divide into three groups to discuss: (1) health; (2) design and planning; (3) needs and standards in the social sciences. Reports from the groups will be presented and then summed up by Prof. T. H. Marshall. Further information can be obtained from the honorary general secretary, R. J. Goodman, British Sociological Association, Skepper House, 13 Endsleigh Street, London, W.C.1.

### Radio Industry Council Awards for Technical Writing

The Radio Industry Council has awarded six premiums for technical writing in the field of radio, the articles being published during 1952. These premiums, of which the first four are for twenty-five guineas and the other two for ten guineas, have been awarded to the following, the name of the journal and subject of the article being shown in brackets: P. H. Parkin and J. H. Taylor (*Wireless World*: speech reinforcement in St. Paul's Cathedral); T. Somerville and C. L. S. Gilford (*B.B.C. Quarterly*: composite cathode-ray oscillograph displays of acoustic phenomena and their interpretation); J. A. Jenkins and R. A. Chippendale (*Electronic Engineering*: some new image-converter tubes); W. R. Stamp (*Discovery*: underwater television); T. W. Bennington (*Wireless World*: propagation of very high frequency radiation via sporadic E); and Dr. G. N. Patchett (*Wireless World*: faulty interlacing). The awards will be presented at a luncheon of the public relations committee of the Council at the Café Royal, Regent Street, London, W.1, on April 9.

### Announcements

Mr. Walter English, director and general manager of Messrs. Brough, Nicholson and Hall, Ltd., Leek, has been awarded the Textile Institute Medal, in recognition of his distinguished services to the textile industry in general and to the Institute in particular.

A symposium on some present problems in virology, to be conducted in French and English, will be held in Lausanne by the Centre de Collections de Types Microbiens de l'Institut d'Hygiène et de Bactériologie during May 22–23. The fee for the meeting is 15 Swiss francs. Enrolment forms and further information can be obtained from Prof. P. Hauduroy, 19 rue César Roux, Lausanne.

A symposium on cortisone and the suprarenal cortex, organized by the University of Milan and sponsored by the Società Italiana di Reumatologia, will be held in Milan during August 31–September 2. Short papers, lasting not more than twenty minutes, on the biological and clinical aspects of the topic will be read, the permitted languages being Italian, French and English. Further information can be obtained from the secretary of the symposium, Prof. C. B. Ballabio, Clinica Medica dell'Università di Milano, via F. Sforza 35, Milano.

The seventh annual conference of the Stress Analysis Group of the Institute of Physics will be held in the Engineering Laboratory, University of Cambridge, during March 25–27. Further information can be obtained from the honorary secretary of the Group, E. K. Frankl, Engineering Laboratory, Trumpington Street, Cambridge.

The laboratories of the British Non-Ferrous Metals Research Association (81–91 Euston Street, London, N.W.1) will be open for inspection, by invitation only, on March 23 at 3 p.m.

A special exhibition, entitled "Navigation To-day", will be opened by Lord Waverley at the Science Museum (South Kensington, London, S.W.7) on March 31 at 3 p.m. The exhibition will be open to the public until the middle of September; during the course of this time six special evening lectures on various aspects of navigation will be given. Features of the exhibition will be full-size models of a ship's bridge and of the flight deck of an aircraft.

The fifth technical trade exhibition of raw materials and equipment used in the paint, varnish and printing-ink industries, organized by the London Section of the Oil and Colour Chemists' Association, will be held at Borough Polytechnic, Borough Road, London, S.E.1, during March 30–April 1 (2.30–8.30 p.m. each day). Further information can be obtained from the honorary secretary, H. C. Worsdall, c/o Plastanol, Ltd., Crabtree Manor Way, Belvedere, Kent.

Referring to the review of the "Proceedings of the Second Berkeley Symposium on Mathematical Statistics and Probability", published in *Nature* of March 7, p. 410, the Cambridge University Press states that the English price is £4 2*s.* 6*d.*

# HÆMOGLOBIN METABOLISM

A SYMPOSIUM on hæmoglobin metabolism, under the chairmanship of Prof. G. Payling Wright, was held in London on the evening of February 17 by the Section of Pathology of the Royal Society of Medicine. Dr. A. Neuberger was prevented by illness from giving the opening paper, which was on hæm biosynthesis, and his place was therefore taken by Mr. John Scott. Mr. Scott referred to the important work of Shemin and Rittenburg, who were the first to show that glycine is the specific precursor of porphyrin nitrogen. They also showed that the incorporation of nitrogen-15 into hæmoglobin after feeding such nitrogen-labelled glycine to a man revealed that the hæmoglobin of red cells is not continuously degraded and synthesized like other proteins, but has a life-span of about a hundred and thirty days. Certain limitations, inherent in isotope experiments, together with the delay in the delivery into the circulation of hæmoglobin after synthesis of the porphyrin in man, render difficult the interpretation of the persistence of small quantities of isotope in the red cells even two hundred and fifty days after the feeding of glycine. In contrast, the Ashby agglutination technique appears to show that no appreciable number of red cells survive for more than a hundred and thirty days. While this might be due to the synthesis of porphyrin from glycine retaining a low but definite isotope-content for as long as a hundred days, it is not impossible that there is some re-utilization of hæmoglobin or hæm from the cells breaking down. Experiments by Shemin *et al.*, and by Muir and Neuberger, using glycine and acetate labelled in various ways by nitrogen-15 and carbon-14, have shown that all the atoms of the protoporphyrin molecule can be accounted for in terms of glycine and a four-carbon compound, such as succinic acid, derived from acetate by the Krebs tricarboxylic acid cycle. The experimental evidence is in accord with the initial synthesis of a monopyrrolic unit bearing a carboxyethyl and a carboxymethyl group in the β positions. Condensation of four of these units under the restricted conditions postulated by Neuberger, Muir and Gray would lead to the formation of uroporphyrins I and III, the latter in excess. Decarboxylation of the carboxymethyl group of these would lead to coproporphyrins I and III; an oxidative decarboxylation of two of the carbethoxy groups of this last porphyrin would lead to protoporphyrin IX.

Prof. C. Rimington emphasized the enormous synthetic capacity of the hæmopoietic system. Whipple has stressed the great importance of the liver and labile protein reserve in meeting emergencies for the production of fresh red cells and hæmoglobin by the hæmopoietic organs. Reference was made to the stimulating effect of amino-acids in hæmoglobin regeneration after hæmorrhage. Borsook has observed that the incorporation of some amino-acids labelled with carbon-14 into the hæmoglobin and stroma of reticulocytes from phenylhydrazine-treated rabbits is always greater when the maturation is studied in a plasma medium rather than in saline. This effect is in part due to some unidentified factor present in plasma. Thorell has shown that the total protein in bone marrow cells has reached a maximum, and the ribonucleic acid content, which is always correlated with protein synthesis, has fallen to a very low level by the time hæm production is occurring. Although this suggests that globin is formed before the hæm, the microspectrographic method used does not discriminate between globin and other proteins. *In vivo* and *in vitro* exposure to X-rays affects the synthesis of hæm and globin to a different extent, and also suggests that the two processes are independent. Muir, Neuberger and Peronne have shown that, when glycine labelled with carbon-14 is fed to the rabbit, the glycine of the globin and of the hæm are of comparable radioactivity only after twenty-four hours. Before this time, more activity was in the globin glycine. This could be due to globin formation preceding hæm formation or to the relative sizes of the globin and porphyrin pools and other factors. Hæmoglobin synthesis may also be studied in hæmolysates of avian nucleated red cells, and much valuable information may in future be obtained from such a system.

Dr. W. M. Davidson described the structure of the red cell with its preferential barrier to diffusion, and was of the opinion that, at the end of its life-span, certain enzymes become used up so that the cells are destroyed by the reticulo-endothelial system. Lytic processes play a major part in certain disorders, but probably not in normal red cell destruction. Lysis can be effected by certain chemicals, antibodies, hypotonic solutions, heat, freezing, buffeting, alteration in *p*H and the effects of light especially in the presence of photosensitizing agents, such as porphyrins, Rose Bengal, etc. Cells which have been partly damaged by some lysins or are congenitally fragile lyse in slightly hypotonic solution. Ionic surface-active lysins penetrate monolayers of cholesterol and lecithin, substances known to be important constituents of the cell structure, and raise the surface pressure until collapse occurs. The relationship of non-ionic agents to hæmolysis is less clear. Sphering appears to be an important but not essential preliminary to lysis, and the process, though reversible in its early stage, soon becomes irreversible. Serial estimations of the diameters of red cells show the process of development and disappearance of the spherocytes. Lysis is sometimes preceded by agglutination, the formation of siderocytes, Heinz bodies or basophil stippling. It is probable that the hæmolytic activity of bile salts, which are present in circulating blood, is normally prevented by certain inhibitors. In most immune hæmolytic reactions, a factor sensitizes the red cells for the lytic agent which is usually complement. Some hæmolysins cause only agglutination *in vitro*, but hæmolysis *in vivo*; and some incomplete antibodies have no apparent effect on red cells *in vitro*, but cause hæmolysis *in vivo*. Human hæmolytic disorders are classified according to whether the cells of the affected person have, or have not, a shortened life after transfer into normal individuals. There is a definite difference between *in vitro* and *in vivo* effects of the immune hæmolysins; *in vivo*, some factor, possibly a tissue lysin, greatly exaggerates the reaction.

According to Prof. C. H. Gray, the mechanism of breakdown of hæmoglobin to bile pigment is obscure. The original view was that the globin is split from the hæmoglobin molecule to give hæmatin, which is then broken down through protoporphyrin to bile pigment. Earlier workers who attempted to demonstrate the conversion of hæmatin to bile pigment obtained discordant results, but in 1950 London showed by isotope experiments that at least 20 per cent of administered hæmatin is rapidly metabolized to bile pigment. Although the experiments of Grinstein and his colleagues indicate that part of the fæcal protoporphyrin in the dog may be formed from breakdown of hæmoglobin, in man porphyrin excretion can contribute no more than an insignificant amount to the total breakdown products of hæmoglobin. Lemberg has shown that hæmoglobin is oxidized by oxygen in the presence of ascorbic acid to choleglobin, a complex of globin and the iron derivative of a bile pigment. The proportion of the total hæmoglobin broken down by intra-corpuscular degradation of this kind is quite unknown. It seems likely that the dipyrrolic compounds, such as propentdyopents and bilifuscins, are derived from bile pigments subsequent to their excretion by the liver. Isotope experiments have shown that bile pigment can arise not only from cells at the end of a normal life-span, but also by a very rapid mechanism as well as by a slower mechanism not from cells at the end of a normal life-span. In the small intestine, the bilirubin excreted in the bile is reduced to 'fæcal urobilinogen', a mixture of colourless precursors of the pigments stercobilin, urobilin IXα and *d*-urobilin. Baumgartel believes that mesobilirubinogen, the precursor of the optically inactive urobilin IXα, is formed only in the liver, but Watson has contested this view. The determination of fæcal urobilinogen has been much used as a rough measure of hæmoglobin breakdown. Interpretation of the results obtained must, however, always take into account certain limitations: urobilin and urobilinogen are converted into other substances not estimated by the Ehrlich reaction; and hæmoglobin may break down directly into dipyrrolic compounds, or other unknown substances. The very high proportion of bile pigment not formed from old red cells may occur in other diseases as well as in pernicious anæmia and congenital porphyria.

Dr. J. C. Houston outlined the view that the body is unable to excrete iron, and that the amount of this element within the body is normally regulated by its absorption, which is strictly limited, according to the needs of the tissues. Apoferritin of the duodenal and intestinal mucosa appears to act as an acceptor. When all the apoferritin has combined with iron to give ferritin, no more iron can be absorbed until some has been given up to the plasma. The factors controlling the rate of release of iron from the mucosal ferritin into the plasma are obscure. The total iron-binding capacity of plasma is normally only about one-third saturated. In hæmochromatosis, serum iron is always above normal, and there is complete or almost complete saturation. The serum iron of hæmochromatosis patients does not increase after oral ferrous sulphate as does that of a normal person. Attempts using radioactive iron to determine the absorption of iron and the amount laid down in the tissue stores have given discordant results, either because of technical difficulties in measuring fæcal radioactivity or because patients have been investigated at different stages of the disease. Very little isotope passed into the blood, presumably because of dilution by a pool of physiologically available iron that is larger than normal. That some of these enormous deposits of iron in hæmochromatosis are available for regeneration of hæmoglobin has been shown by the failure of these patients to become anæmic even after repeated large bleedings. Patients with hæmochromatosis can thus regenerate hæmoglobin at a great rate, and it seems likely that it is the small reserve of available iron which limits the rate of hæmoglobin regeneration after hæmorrhage.

In the subsequent discussion, Dr. W. W. Payne emphasized the importance of the mucosal block in the absorption of iron by reporting a case of fersolate poisoning in which the serum iron concentration reached 20 mgm./100 ml., consequent to the destruction of the intestinal mucosa. In reply to a question from Prof. N. F. Maclagan, Prof. Gray observed that 'fæcal urobilinogen' determinations are of some value in the diagnosis of hæmolytic disease. Prof. H. Munro Fox described how hæmoglobin synthesis in the crustacean *Daphnia* is greatly stimulated by oxygen lack and how, on re-oxygenation, the extra hæmoglobin rapidly disappears, apparently without bile pigment formation. Dr. J. C. White referred to the observation of Haurowitz, that the oxidation of fatty acids is coupled with the breakdown of hæmoglobin to colourless products. Dr. T. With remarked that in the horse the serum bilirubin is much greater than in man, yet in the horse the bile contains very little bilirubin. Dr. M. G. Good was of the opinion that the thyroid influences hæmopoiesis.

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# EDUCATION IN CHEMISTRY

A DISCUSSION on education in chemistry was held on February 18, under the joint auspices of the London Sections of the British Association of Chemists and the Royal Institute of Chemistry. This attracted an audience of about two hundred people, not only from the London area, but also from various other parts of Britain. Introductory talks were followed by an animated discussion, and altogether twenty-one people spoke in the course of just under three hours. They were representative of the University of London, the Royal Institute of Chemistry, technical colleges, technical schools, the Ministry of Education and industry.

The five introductory speakers dealt with distinct facets of the subject. Prof. C. K. Ingold (University College, London) spoke about the aim of the revised regulations for the Special degree in chemistry of the University of London. A specialist in chemistry, he said, should reach a standard at which he has studied some aspects in sufficient detail, in order to have the right to form an independent judgment. At the same time, the conventional barriers between chemistry and other sciences are breaking down, and it is necessary for chemistry specialists to have a broad background in other sciences. Prof. Ingold thought that sufficient experience has been gained with the Internal degree of the University to be sure that the students trained under the revised regulations are better developed than those trained under the old regulations.

Dr. J. H. Skellon (Acton Technical College) spoke about External degrees in chemistry of the University of London, mainly from the point of view of the technical colleges. He described ways in which these colleges are adjusting their arrangements to fulfil the additional requirements of the new regulations, and thought that there is a danger of the main subject being neglected in the first years of the course. He felt that the new regulations for the External degree should be reconsidered at the end of an experimental period of, say, five years. A point of serious concern is that a student has to decide at the Intermediate science stage whether he will work for the General degree or for a Special degree, and he felt that this is too early a stage for a specialist to be selected. The old arrangement, whereby a man could take the General degree and, one year later, a Special degree, had a distinct advantage.

Prof. Harold Burton (Queen Elizabeth College, London) said that the only professional qualification in chemistry, apart from the Special B.Sc. degree and the associateship of certain technical colleges, is the associateship of the Royal Institute of Chemistry. The Institute had 3,174 registered students at the end of 1952. Approximately three hundred have entered for the examinations in April, and the normal percentages of passes is of the order of 25 per cent. This qualification places more emphasis on practical work than the University of London degree. He pointed out that many candidates are found to be weak in physical chemistry.

Mr. R. W. Blount (Ministry of Education) discussed National Certificates in chemistry, which are qualifications below the professional level. This scheme has been in operation since 1921, and he felt that, apart from providing an indication of the level of training of chemical assistants, it has a distinct value in encouraging organized part-time courses, in raising the standard of accommodation and equipment at many technical colleges, and in bringing students into early contact with their professional institution. He said that the numbers of candidates for the Ordinary National Certificate in chemistry has risen from 358, with 245 passes, in 1946 to 1,285, with 729 passes, in 1952. For Higher National Certificate the increase has been from 112, with 83 passes, to 593 with 364 passes. Further increase is probable, particularly as opportunities for part-time day-study increase.

Dr. Norman Booth (British Oxygen Co., Ltd.) talked about the requirements of industry, in which two out of every three qualified chemists are employed. He stressed that only about one-third of the qualified chemists in industry are engaged on research work, and that more than 8 per cent are engaged on administrative work of various types, including departmental management and membership of boards of companies. This is a growing tendency which should be taken into account when considering the education of chemists. A man with only scientific and technical knowledge will have a limited scope in industry, and the universities should foster other qualities essential both for senior technical and for administrative posts. Dr. Booth also referred to the value to industry of integration of the respective courses for the National Certificate and for the associateship of the Royal Institute of Chemistry.

The discussion which followed covered a wide range of subjects and is not easily summarized. Some purely factual matters raised were answered by the opening speakers. A number of contributors considered that the Special degree in chemistry, although perhaps suitable for those who will become outstanding academic workers, covers too much detail for most chemists' needs. It was believed that a course which pays particular attention to the principles of chemistry and puts more emphasis on practical training would be more valuable generally. Some desirable features are difficult to achieve; for example, a practical examination in physical chemistry cannot be adopted because of lack of examination facilities.

Many speakers referred to the question of flexibility and integration of courses, the object being to enable a person to change from one type of course to another without necessarily having to start at the bottom of the new course. It was generally felt that there could be improvements in the present system. It was suggested that bursaries should be made available to enable promising persons with Higher National Certificate in chemistry to study as full-time students for a degree, either in pure science or a technology.

It was pointed out that the University of London has taken distinct steps to ease the way for admission of students from technical secondary schools, which for some young people might provide the best approach to the chemical profession. Thus, for example, people of mature years are no longer required to have passed a preliminary examination in a foreign language. The ordinary National Certificate in chemistry is regarded as part-fulfilment of the entrance qualification. Further, in the General Certificate of Education, it is not necessary to take all the subjects at once, as was the case with the old matriculation examination.

Mr. L. E. Ball said that the University of London is revising many of the degree courses; but it has not been possible to bring them all into operation at once. He referred particularly to revised General degree regulations which will require the student to take three subjects in his first post-intermediate year and two subjects for a further two years.

Dr. H. B. Nisbet thought it might be possible to arrange a system so that at about General degree standard a person could decide to proceed either to take a technological course or, if he intended to go into research, to take the Special chemistry course. In this way industry would be able to recruit men with training more appropriate to the type of work they are going to do than is the case at present.

It was noted that there is a class of worker in industry, namely, the process worker or plant operator, who would benefit from instruction in the chemical principles underlying the processes he is operating. Although some industrial concerns themselves provide this training, co-operation with the local technical colleges might well be extended.

Other points which arose in the discussion were the continued shortage of teachers of chemistry in schools and its future effect on higher education in chemistry; the necessity for teaching students to express themselves in simple and unambiguous language; the desirability of industry revising its recruiting standards, for example, by taking more people with a General degree and placing less emphasis on a degree with honours in Special chemistry; and how far attempts should be made to educate chemistry students in the humanities.

It is probable that no single point raised during the discussion would have met with unqualified agreement. It was clear, however, that there is no smug satisfaction with the present system of education, and that there are many constructive ideas for improvement. The education of chemists is evidently receiving serious attention by all sections of the chemical community, and perhaps the one thing on which all would agree is that methods of teaching, the content of courses and the regulations must all be adjusted at suitable intervals of time in the light of new knowledge and new demands.

NORMAN BOOTH

# ROYAL COMMISSION ON AWARDS TO INVENTORS

THE Royal Commission on Awards to Inventors, under the chairmanship of Lord Cohen, which was appointed in 1946, has now submitted a third report containing a general survey of the principles which have guided its decisions and some particulars of the more important claims dealt with up to November 8, 1952.

Since hearings started in February 1947, the Commission has sat in public on 278 days and disposed of 325 cases. Many of the claims have presented features of great complexity and have involved hearings extending over several days. About 255 cases were withdrawn after being referred to the Commission. This large number of withdrawals indicates that the procedure adopted by the Commission for enabling the claimant and the government department concerned to set out their case in writing in the first instance has been useful in clarifying and leading to the settlement of many difficult cases without recourse to a hearing.

The Commission, under its terms of reference, can only deal with those cases referred to it by the Treasury or the government department concerned. To assist the department in determining which cases should be referred, the chairman, at the request of the Treasury, set up an Investigating Committee consisting of two or three members of the Commission who carefully examine all claims submitted to it. This Committee has dealt with about 280 claims. Many of the claims comprised several inventions which had to be considered separately.

Sums totalling approximately £616,770 have been awarded since the Commission began its work. By far the largest number of claims has been on an *ex gratia* basis—that is, where the claimant has no legal right to payment but relies upon the bounty of the Crown. Under this heading, for example, the Commission has awarded a total of £94,600 to the inventors of radar installations, including £50,000 to Sir Robert Watson-Watt. A further series of claims for which a total of £23,300 was recommended concerned the inventions (generally known as 'degaussing') used on ships to counteract the German magnetic mine. Other claims concerned the 'Fido' project for dispersing fog from airfields, the 'Leigh' light for aircraft used in anti-submarine warfare and the 'Morrison' table shelter for air-raid protection.

The Commission has also dealt with several legal claims based on the use of patents, in these cases acting in lieu of the High Court. One of these inventions concerned stabilizing gear for reducing the rolling of ships, and the Commission awarded the claimants £27,500.

The Commission has continued the shortened procedure for dealing with claims, for this procedure provides a claimant with a more expeditious and less expensive means of bringing his claim to a hearing.

Although there is still a considerable number of claims outstanding, which the Commission will deal with as and when it is ready for hearing, it can now be claimed that the major part of the task allotted to the Commission has been accomplished.

# COMMONWEALTH FUND

## ANNUAL REPORT FOR 1951–52

THE thirty-fourth annual report of the Commonwealth Fund*, founded on October 17, 1918, by Mr. Stephen V. Harkness (whose residence, Harkness House, New York, was bequeathed to the Fund and is occupied as its headquarters), covers the year ended June 30, 1952. Of the 2·7 million dollars appropriated during the year, 39 per cent was for medical education, 16 per cent for experimental health services, 15 per cent for medical research and 8 per cent for fellowships, including advanced fellowships in medicine and allied fields, particularly for work involving the crossing and re-crossing of interdisciplinary frontiers, and thirty-one British fellowships and nine Salzburg fellowships. The report lists the thirty research projects currently aided by the Fund; and, of the nine which were new or renewed during the year, six relate to integrative processes in man or to crucial factors in the adjustment of man to this environment.

The major interest of the report, however, lies in its account of the experimental work in medical education and in health services supported by the Fund and of the ideas which are guiding these experiments. In medical education, the experiments turn on the assumption, still to be verified, that medical teaching organized around the student's need to learn and the patient's need for care, will prepare students to meet the responsibilities of medicine as a social institution more effectively than medical teaching organized around the preoccupation of teachers with what they as specialists think they ought to teach. To the five-year grant made in 1950 for the reorganization of the curriculum at the Western Reserve School of Medicine, a further grant of 276,428 dollars has been added. This will facilitate a reorganization in which the initial two phases will occupy about two and a half years; first, the student is oriented to medicine and to the patient, presenting the fundamental principles of man's structure, function, growth, behaviour, and relation to his environment; and then, during the second phase, dealing with disease (by general principles and afterwards by organ and site), the teaching will be done by inter-departmental teams on which each man will teach what he is best fitted for; the third and final phase of the reorganization will take a further eighteen months and will deal with the care of sick people.

The second group of experiments embraces grants to the University of Colorado School of Medicine and to the Cornell University Medical College for studies relating to teaching and learning by contact with patients in the clinical years of the medical course, conducted in a new kind of clinic which will put a premium on continuity and comprehensiveness in medical care. If the experiments succeed, they should assist in providing answers to some of the outstanding questions regarding the relation of generalized to specialized medicine, the responsibility for insight into the patient's total problem and the like. The Fund has also made a new grant for the support of the "family general practice" clinic begun at the University of Tennessee College of Medicine in the autumn of 1951, and one of 200,000 dollars for the expenses of a working-party for three years to devise an integrated programme in human biology and ecology at Yale University based on the joint contributions which Yale College and the School of Medicine might make. The Fund has also provided 96,500 dollars towards a study of the state of the resources of the University of Florida which can, and should, be woven into the pattern of medical education.

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* Commonwealth Fund. Thirty-fourth Annual Report for the Year ending June 30, 1952. Pp. xiii+42 (New York: Commonwealth Fund, 1952.)

In the field of Experimental Health Services the Fund has been most interested in integrating health care, and its main grant has been a further 158,100 dollars in support of the large experiment in integrated health care at the Hunterdon Medical Centre, New Jersey, which a sound and ably led rural community is building, with a further 250,000 dollars to meet the emergency arising from the sharp increase in building costs. In effect, the plan adds a general staff to existing health services of the United States, and also seeks to encourage a keener understanding of people in need of help by stimulating the community to discover and practise mental hygiene. Comprehensive efforts are also being made to obtain a complete picture of the nature and extent of the need for the treatment of chronic illness and disabling conditions and the rehabilitation of their victims.

# THE BOSE INSTITUTE, CALCUTTA

## THIRTY-FIFTH ANNIVERSARY

THE director, Dr. R. C. Mazumdar, before presenting his report on the working of the Bose Institute for the past year, took the opportunity to refer to the fiftieth anniversary of the publication in 1902 of Sir Jagadish Chandra Bose's book "Response in the Living and the Non-living", which had at the time of its publication evoked a great deal of interest. He also announced the receipt of a legacy of £5,000 from the executors of the late Miss Edith Keating, of London. A fellowship is to be created in the Bose Institute, which will be known as the Edith and Richard Keating Research Fellowship.

Satisfactory progress has been made during the past year in the investigations carried out at the Mayapuri Research Station, Darjeeling, on plant virus and microbiological investigations. The different virus strains in seed potatoes, collected from the Seed Potato Farm at Rungbull, have been isolated and identified. Attempts are being made to produce hybrid strains, which will be immune to many of the virus infections, by crossing local commercial strains of potato with different wild South American species. The work planned is a long-range one and cannot be successful without the financial aid and co-operation of the State Department of Agriculture, West Bengal. A scheme for continuation of this work has been submitted to the Government. At Mayapuri other applied investigations of importance to the Darjeeling District, like the introduction of white and red clover from seeds imported from Britain, are being taken up.

The Institute has been selected by the Indian Council for Agricultural Research for carrying out a five-year scheme of investigation on chemical eradication of weeds which infest fields growing rice and other economic crops.

Some aspects of photosynthesis, on which the nutrition of plants and animals are ultimately based, have been studied in the Institute for some time. At present, radioactive carbon imported from Harwell is being employed in the Institute to elucidate as tracer certain problems of assimilation of carbon during photosynthesis.

Successful X-ray irradiation of seeds of economic plants like jute, cotton and oil seeds with the view of evolving new economic types of mutants are being continued. With jute, a tall mutant has been stabilized; chemical examination of the fibre constituents, tensile strength and anatomical studies of the fibres have been started, as well as a method of impregnating with artificial resins bleached jute fibre, for increasing its wet tensile strength.

Nitrogen fixation by soil and nodule bacteria is being studied. Mention was also made in the report of various plant physiological investigations, including cultures of plant tissue in artificial media, and the study of the conditions for producing neoplastic growth in plant cells, similar to the development of cancer cells in animal tissues. The effect of antibiotic substances on plant nuclei is being studied.

The director also reported on the different schemes for providing additional building accommodation for library and workshop, and for the acquisition of a large plot of good agricultural land to the north of Calcutta where the whole agricultural experimental work of the Institute can be centralized. At present considerable difficulty is being met with in maintaining the agricultural experiment stations of the Institute at two different places, one seventeen miles north of Calcutta at Bamangachi, and the other thirty-two miles south of Calcutta at Falta.

Dr. Mazumdar then delivered the fourteenth Acharya Jagadish Chandra Bose Memorial Lecture entitled "Growth of Scientific Spirit in Ancient India".

# RESEARCH IN THE SOCIAL SCIENCES

THE latest issue of that valuable publication, the "Register of Research in the Social Sciences"*, makes it possible to examine the trends of development that have become apparent in social research in recent years. The most important factor underlying these trends is, of course, the 'Clapham' grant given to the universities to make expansions possible in teaching and research in a number of the social sciences, and the effects are evident in the current issue of the "Register". In addition, the Government has taken action in a number of ways to expand social research, notably by direct grants to such bodies as the National Foundation for Educational Research, the British Institute of Management, and the Colonial Social Science Research Council. The provision made in this way has also been supplemented by generous benefactions from private agencies, the most important of which is the Nuffield Foundation.

The immediate impression which a quick survey of the "Register" makes on the mind is that social research is steadily expanding, that advances are, however, in a number of more-or-less disconnected areas rather than along a general line; and that, though an increasing amount of work of fundamental importance is being undertaken, much 'research' is still very superficial, directed too often to mere trivialities, or to objectives which only possess a temporary importance in an administrative context. The truth is, perhaps, that the social sciences are still unable to ask the really important questions with sufficient clarity and simplicity to make it possible to devise effective methods of answering them. The economists have had most success in this endeavour, and this is perhaps why roughly a quarter of the whole of the research work summarized in the "Register" is in the field of economic analysis of one kind or another.

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* Register of Research in the Social Sciences in Progress and in Plan: No. 9, 1951–52, with a Directory of Research Institutions. Prepared at the National Institute of Economic and Social Research. Edited by Feodora Stone. Pp. 188. (London: Cambridge University Press, 1952.) 15s.

Development appears to be slowest in the exceedingly important area of social behaviour. The need for relating the study of psychology to that of social organization is obviously great, for this is one of the central problems of the social sciences ; yet the whole psychology section devoted to "General Social Problems" only runs to three pages, or about the same length as that of the agricultural economics section. Modern psychiatry only appears in the outlines of researches on rare occasions, as, for example, in those of the Medical Research Council, the Tavistock Institute of Human Relations, and the Institute for the Study and Treatment of Delinquency. The various university research organizations appear for the most part to have been deterred from entering the more adventurous fields of research, and to have been led to attach too high a value to the safe and respectable. Nevertheless, the wastage-rate among Ph.D. students in the social sciences still remains notoriously high. It is probable that the phase of 'settling-down' in social science research will have to go on for some time yet, and that bolder experiments will have to be encouraged, before substantial advances can be made otherwise than on one or two rather narrow fronts.

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# RHODOPSIN AND INDICATOR YELLOW

By Dr F. D. COLLINS

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MUCH is now known[1,2] concerning the biochemistry of scotopic vision ; but the chemical nature of the chromophore of rhodopsin (visual purple) is still obscure. When rhodopsin is exposed to light, various changes can be detected. Wald[3] showed that a substance, which he called retinene, could be extracted from retinæ exposed to light, or treated with a polar solvent such as chloroform. Retinene had an absorption maximum at 385 mμ in chloroform, and at 664 mμ in the presence of antimony trichloride dissolved in chloroform. Work in this laboratory[4,5] showed that vitamin A aldehyde was spectroscopically indistinguishable from retinene. This conclusion has been fully confirmed by subsequent investigations[2,6]. This research on retinene demonstrated that the most promising and practicable method of elucidating the chemical nature of rhodopsin and its breakdown products was by comparing their absorption spectra with those of materials prepared in the laboratory. The naturally occurring pigments are present in very small quantities (for example, 3 μgm. of chromophore per ox retina) and all are unstable. However, the fact that rhodopsin is known to give vitamin A aldehyde provides a starting-point for the preparation of compounds for spectroscopic comparison with the naturally occurring pigments.

The position of indicator yellow in the visual cycle has been uncertain ever since it was first described by Lythgoe[7]. He found that a rhodopsin solution after irradiation formed a substance which exhibited variations in spectral absorption with changing *p*H. In alkaline aqueous digitonin the absorption maximum was at 365 mμ while in acid it was changed to 440 mμ. Work in this laboratory[8-10] showed that vitamin A aldehyde would combine, in alkaline solutions only, with aliphatic amines (in excess) to form a substance with an absorption maximum at 365 mμ (solvent, aqueous ethanol). On the addition of one drop of concentrated hydrochloric acid, the maximum shifted to 440 mμ. It was thus clear that indicator yellow must be a compound of retinene and a free amino-group, perhaps attached to a protein.

Two alternative conclusions are possible. (1) Retinene (in this case the first stable product of the bleaching of rhodopsin) would combine with any free amino-groups (for example, amino-acids or proteins) which might be present. "In this case indicator yellow would be a fortuitous artefact having no direct relevance to visual chemistry"[8]. Although retinene will only combine with amino-groups at an alkaline *p*H, indicator yellow is none the less formed in irradiated rhodopsin solutions buffered at an acid *p*H[10]. This objection can be met by assuming that retinene, when first formed as a result of the irradiation of rhodopsin, is in an 'activated' form and that this 'activated' form combines rapidly with any free amino-groups. (2) The alternative conclusion is that the carbon-to-nitrogen bond present in indicator yellow is also present in rhodopsin.

On the basis of the first proposition, it might be expected that formation of indicator yellow would be totally prevented by 'blocking' the free amino-groups. A well-established means of doing this is by the use of formaldehyde[11-13], as exemplified by the formol titration of amino-acids and proteins. A number of experiments have been carried out to test the validity of the above line of thought.

From the work of Levy[11,12] and his co-workers the reaction between an amino-acid and formaldehyde can be formulated as follows :

$$R\text{—}\overset{+}{\mathrm{N}}\mathrm{H}_3 \rightleftharpoons R\text{—}\mathrm{NH}_2 + \mathrm{H}^+$$
$$R\text{—}\mathrm{NH}_2 + \mathrm{HCHO} \rightleftharpoons R\text{—}\mathrm{NH}\text{—}\mathrm{CH}_2\mathrm{OH}$$
$$R\text{—}\mathrm{NH}\text{—}\mathrm{CH}_2\mathrm{OH} + \mathrm{HCHO} \rightleftharpoons R\text{—}\mathrm{N}(\mathrm{CH}_2\mathrm{OH})_2$$

From the data[11,12] it is possible to calculate the proportion of these forms which will be present in a given set of conditions (see table). The amount of free amino-nitrogen in a rhodopsin solution is small, and an upper limit was established as follows. Two solutions (each 1 ml.) of rhodopsin ($13 \times 10^{-6}$ *M* in respect to retinene) gave readings in a manometric Van Slyke apparatus which did not differ from the blank reading by more than 1·7 mm. of mercury, a difference which corresponds to 3 μgm. amino-nitrogen per ml. : to be quite certain, an upper limit of 5 μgm. amino-nitrogen per ml. was assumed, which is equivalent to $360 \times 10^{-6}$ *M*. Assuming that the amino-groups are all present in the form of tyrosine (the amino-acid with the least affinity for formaldehyde) and that the 'activated' retinene reacts equally well with the two forms of the free amino-group

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Extent of the reaction between amino-acids and formaldehyde, as calculated from the data of Levy and Silberman (ref. 11), at $p$H 9. Total concentration of amino-acid put equal to 1·00

| Amino-acid | Tyrosine | | Leucine | | Lysine | |
|---|---|---|---|---|---|---|
| Formaldehyde conc. | 2·67 *M* | 10 *M* | 2·67 *M* | 10 *M* | 2·67 *M* | 10 *M* |
| $R$—$\overset{+}{\mathrm{N}}\mathrm{H}_3$ | 0·018 | 0·0019 | 0·0107 | 0·00086 | 0·013 | 0·00109 |
| $R$—$\mathrm{NH}_2$ | 0·015 | 0·0017 | 0·0084 | 0·00027 | 0·00035 | 0·000030 |
| $R$—$\mathrm{NH(CH_2OH)}$ | 0·415 | 0·17 | 0·145 | 0·044 | 0·22 | 0·072 |
| $R$—$\mathrm{N(CH_2OH)_2}$ | 0·552 | 0·83 | 0·840 | 0·954 | 0·76 | 0·926 |

($R$—$\overset{+}{\mathrm{N}}\mathrm{H}_3$ and $R$—$\mathrm{NH}_2$), which is unlikely, then the concentration of amino-nitrogen available for reacting with the retinene will be $12 \times 10^{-6}$ *M* for 2·67 *M* formaldehyde and $1 \cdot 3 \times 10^{-6}$ *M* for 10 *M* formaldehyde, both at $p$H 9. These two figures are 92 per cent and 10 per cent of the available retinene and are the maximum amounts of free amino-nitrogen that could be present. From these figures it is apparent that, if a $p$H of 9 and a formaldehyde concentration of 10 *M* are used, the amount of free amino-nitrogen will be less than one-tenth of the retinene present (molar concentrations). These conditions would allow the two hypotheses to be distinguished: if the first alternative is correct, not more than 10 per cent of the retinene will be present as indicator yellow. If the second alternative is the correct one, then the amount of indicator yellow will approach 100 per cent.

On the second hypothesis, some retinene is to be expected, as the following evidence demonstrates. Retinene combines with methylamine to form a Schiff's base[14] ($R$.CH=NCH$_3$) which has nearly the same absorption maximum as alkaline indicator yellow and which on acidification gives a compound with an absorption band at 440 mμ. If the Schiff's base is dissolved in water (0·15 *M* borate buffer $p$H 9·3) with the aid of 'Tween 80', the absorption maximum changes from 363 mμ (characteristic of alkaline indicator yellow) to 383 mμ (characteristic of retinene) (see Fig. 1). This change is unimolecular with a half period of 25 min. at room temperature (about 18° C.). Therefore, if indicator yellow is formed directly from rhodopsin on irradiation, some retinene will be formed by hydrolysis even before the absorption spectrum can be measured. With the above considerations in mind, the following experiment was carried out (other similar experiments have given the same results). A rhodopsin solution was prepared from cattle rod outer segments as described by Collins, Love and Morton[15]. The rhodopsin was extracted with 2 per cent aqueous digitonin, and 1 ml. of this solution was mixed with 3 ml. of 40 per cent formaldehyde which had been adjusted to a $p$H of 9. The extinction at 500 mμ was recorded and the solution bleached with a photoflood lamp. The absorption curve was then measured at intervals up to 60 min. (see Fig. 2). Finally the extinction at 500 mμ was measured, as was the $p$H. The difference before and after irradiation in the extinction at 500 mμ (0·760 − 0·032 = 0·728) was a measure of the amount of rhodopsin present. Using the figure for the molecular extinction coefficient (in terms of a $C_{20}$ molecule) of 48,000[15], the total concentration of retinene in the final solution would be $15 \cdot 2 \times 10^{-6}$ *M*.

The curves shown in Fig. 2 have a well-defined isosbestic point, from which it follows that one material is being transformed into one other substance. The final absorption curve corresponds closely to that of retinene, while the initial curve differs comparatively little from that of alkaline indicator yellow. As the irrelevant absorption does not alter during the change of indicator yellow to retinene (because of the isosbestic point), the difference in the extinction between that at any particular time and the final reading is a direct measure of the indicator yellow present at that time.

If $x$ be concentration of retinene at time $t$ after irradiation of the rhodopsin solution, and $y$ the concentration of alkaline indicator yellow when the concentration of retinene is $x$, then the final concentration of retinene will be $x + y$. The molecular extinction coefficient of retinene at 360 mμ (aqueous) is 28,200, while that of alkaline indicator yellow is 50,000[13,14]. Hence, using the points on Fig. 2 at 360 mμ, the following equation will hold:

initially $28{,}200\ x + 50{,}000\ y + i = 0 \cdot 676$, where $i$ = irrelevant absorption;

finally $28{,}200\ (x + y) + i = 0 \cdot 543$;

subtracting, $y\ (50{,}000 - 28{,}200) = 0 \cdot 133$;

and hence $y = 6 \cdot 1 \times 10^{-6}$ *M* or 40 per cent of the total retinene.

In another experiment at the same $p$H and strength of formaldehyde, the indicator yellow represented 49 per cent of the total retinene. In both cases the lower limit of the indicator yellow concentration was at least four times the upper limit of the free amino-nitrogen. That the first is a lower limit is evident from the fact that the reading at 360 mμ, after irradiation of the rhodopsin solution, was falling rapidly and that the true initial concentration was certainly higher. The time between the beginning of irradiation and the measurement of the extinction

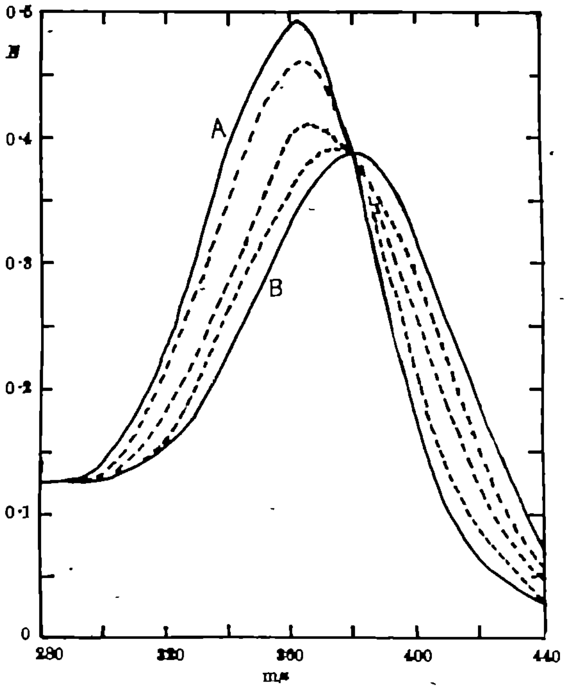

Fig. 1. Retinene methylimine dissolved in aqueous 0·15 *M* borate buffer ($p$H 9·3) with the aid of 'Tween 80'. The first absorption curve *A* was measured as soon as possible after solution had been effected. Curve *B* was measured after 170 min. The absorption curves were measured at frequent intervals between these two extremes, three of which are shown. The rate of change was unimolecular with a half-period of 25 min.

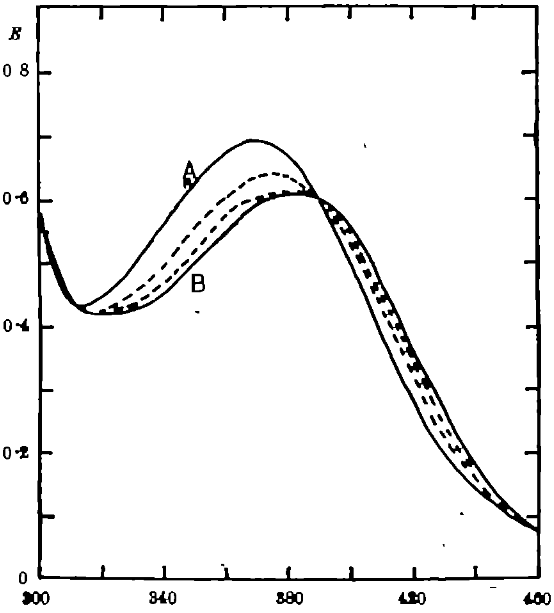

Fig. 2. A rhodopsin solution (in 0·5 per cent (w/v) aqueous digitonin, 10 *M* formaldehyde and enough alkali to bring the *p*H to 9·0) was irradiated and the absorption spectrum measured (*A*). The absorption spectra were measured at frequent intervals (two being shown) and finally after 60 min. (*B*). The rate of change was unimolecular with a half-period of 9·0 min.

at 360 mμ was five to ten minutes, and in this time the concentration of indicator yellow would have fallen rapidly. In the two experiments just described, the difference between the extinction at 360 mμ and the final reading at this wave-length fell off at a unimolecular rate. The values of the rate-constant were − 0·031 and − 0·037, corresponding to a half-life of 9·8 and 8·3 min., respectively, the mean half-life being about 9 min. It is thus evident that all the retinene could have been in the form of indicator yellow immediately after bleaching.

Two differences are apparent between the alkaline form of indicator yellow and the compound between retinene and methylamine. First, the isosbestic points (the wave-length at which indicator yellow or its analogue and retinene have the same value of the molecular extinction coefficients) are different—380 mμ for retinene methylimine, and 389 mμ for indicator yellow. However, retinene in combination with proteins and compounds such as β-alanine and glycine has an isosbestic point with retinene at 386–390 mμ. The second difference is that indicator yellow is hydrolysed by water more rapidly (half-life, 9 min.) than is retinene methylimine (half-life, 25 min.). This difference in the rate of hydrolysis and in the isosbestic point indicates that, although retinene methylimine is an analogue of indicator yellow, it is not an exact one. This is most probably because a methyl group is unlikely to simulate exactly an amino-acid radical or other large group.

These experiments demonstrate that indicator yellow is not a fortuitous artefact, and it thus follows that an understanding of the chemistry of indicator yellow and its analogues is essential to the elucidation of the chemical nature of rhodopsin. Retinene combines with methylamine to yield a crystalline material with an absorption maximum at 365 mμ in ethanol (melting point 73° C.; per cent nitrogen 4·82; molecular weight (rast-camphene) 290). This corresponds to a simple Schiff's base (retinene methylimine). On acidification, a substance with an absorption maximum at 440 mμ in ethanol is obtained. The purest preparation of this analogue of acid indicator yellow had $E$(1 per cent, 1 cm.) (465 mμ in chloroform) = 1,200, melting point 140° C. and 3·9 per cent nitrogen; this material was unstable and to date has not been obtained as a pure crystalline material. The hydrochloride of retinene methylimine would not differ in its absorption maximum greatly from the free imine, and an absorption maximum at 440 mμ would imply a doubled molecule. Collins and Morton[10] put forward provisional formulæ for acid and alkaline indicator yellow, which they claimed were the simplest explanations of the facts. Their conclusions were in principle correct; alkaline indicator yellow is now known to be a Schiff's base, but the acid form may well be a more complicated molecule than that proposed by Collins and Morton. Until the structure of acid indicator yellow is known, it is not possible to say more except that a carbon-to-nitrogen bond must be present in rhodopsin.

Workers in the field of visual chemistry have been divided in their assessment of the role of indicator yellow. Some[7,16,17] have always accepted indicator yellow, although on mainly circumstantial evidence, whereas others (notably Wald and his co-workers[6]) have minimized its importance. The present work demonstrates that indicator yellow is a key substance in visual chemistry and represents a close approach to rhodopsin. How close is demonstrated by the following experiment.

Retinene methylimine was dissolved in chloroform and treated with a solution of antimony trichloride in chloroform. The resulting solution had an absorption maximum at 505 mμ, changing to 497 mμ within ten minutes. Like rhodopsin (which has its absorption maximum varying from 503 to 496 mμ, according to the species from which it is obtained), the band is broad (half-width 110 mμ, rhodopsin 100 mμ). Although this product differs from rhodopsin in several respects (that is, it is relatively thermostable, is photostable and is produced under unphysiological conditions), this result is none the less a clear indication of the potentiality of retinene imines.

Thanks are due to Prof. R. A. Morton, without whose help and encouragement this work would not have been possible. Thanks are also due to Dr. H. K. King for the amino-nitrogen estimations, and to Dr. A. L. J. Buckle, of the Organic Chemistry Department, University of Liverpool, for the determinations of nitrogen (micro-Dumas) and of molecular weight.

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# CYTOPLASMIC LOCALIZATION OF NUCLEIC ACIDS IN PLANT CELLS

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It is generally conceded that the nucleic acids are of major importance in the cell. Thus, protein synthesis is almost invariably associated with a high concentration of ribose, or pentose, nucleic acid[1]; and the consistent occurrence of deoxyribose nucleic acid on the chromosomes, even in interphase nuclei, and on the bands of the salivary gland chromosomes of *Drosophila* has led Muller[2], among others, to consider that the gene may be composed of deoxyribonucleoprotein. This conclusion has gained support from the work of Vendrely and of Mirsky, who have used biochemical procedures, and of many others who, by using staining and photometric methods, have shown that diploid nuclei apparently contain twice the amount of deoxyribose nucleic acid present in sperm and approximately half that found in nuclei believed to be tetraploid.

The method most commonly utilized for demonstrating the localization of deoxyribose nucleic acid in cells is the Feulgen reaction. There has been considerable controversy concerning how far this test is specific[3] and whether deoxyribose nucleic acid, with or without the recolorized leuco-basic fuchsin, could diffuse about the cell. Moreover, cytologists have felt that the hydrolysis involved in this reaction, namely, heating the tissue in normal hydrochloric acid for 6 min. at 60° C., was an undesirable part of the procedure.

More recently, Kurnick[4] has developed a method by which polymerized nucleic acid can be stained by a stoichiometric reaction with purified methyl green. It is generally assumed that whereas deoxyribose nucleic acid occurs as a very highly polymerized molecule, ribose nucleic acid is present in cells as a relatively small molecule and hence does not give this stoichiometric reaction with methyl green. While this assumption may be true of aged and differentiated cells, it is not entirely correct for plant meristematic cells, in which some of the ribose nucleic acid may also be polymerized sufficiently to give this reaction; for this reason we have used Kurnick's methyl green method in conjunction with treatment with deoxyribonuclease, acting in the presence of a protease inhibitor[5], to locate deoxyribose nucleic acid. It should be noted that many popular fixatives and treatments apparently depolymerize the ribose nucleic acid, thus removing from it this property of binding methyl green.

A third method of studying the cellular distribution of nucleic acids is by ultra-violet absorption microscopy. Maximal absorption at about 2600 A., the absorption maximum of both the nucleic acids, does not allow differentiation between ribose nucleic acid and deoxyribose nucleic acid, and, if not supported by other evidence, must be interpreted with considerable caution[6].

In our study of the distribution of nucleic acids in cells of plant root meristems, and in particular in the roots of *Vicia faba*, we have been unable to use the Feulgen reaction because the cytoplasmic particles of these cells are readily destroyed by the acid hydrolysis, and clearly it would have been absurd to discuss the localization of substances in cells in which important structures have been destroyed. It has also been found that the cytoplasmic granules are easily disintegrated by other treatments which might have been considered much less drastic than hydrolysis with hot acid. Thus, in cells fixed in neutral formalin, these organelles are lost when the *p*H is lowered to about *p*H 5, so that after such fixation Kurnick's methyl green reaction had to be performed in acetate buffer at *p*H 6 instead of the customary *p*H 4·2.

We have found a constant correlation in the root meristem cells of the broad bean, treated with various techniques, between preservation of cytoplasmic granules and paucity of nuclear absorption at 2650 A., and of nuclear basophilia. Techniques which have been found suitable for demonstrating this include living preparations[7,8], the polyvinyl alcohol–pectinase method[9], neutral 'Formalin–aquax'[10], the Newcomer–Zirkle procedure[10,11], and freeze-drying. In the first two procedures the cells are studied whole in squash or smear types of preparation, whereas in the last three they are examined in sections. On the other hand, when the cytoplasmic granules are destroyed, the nucleus becomes strongly absorbing at 2650 A. and intensely basophilic. This effect may be produced by destroying the granules (for example, by treatment with hot acid) in preparations made by any of the above methods, by fixation in acetic alcohol and either embedding in paraffin or separating the cells in hot hydrochloric acid, or by fixing the roots in hot 45 per cent acetic acid.

When cells containing well-preserved cytoplasmic granules are stained overnight with purified methyl green at *p*H 6 and then washed in buffer at the same *p*H for several hours, only the granules and nucleoli retain the stain appreciably, suggesting that these sites alone contain polymerized nucleic acid. Thus the resting nucleus, apart from the nucleolus, does not retain the stain. The colour of the stained structures is blue-green, quite unlike the vivid green usually produced by the reaction of this dye with cellulosic or lignified structures. If, however, the granules are destroyed by gentle treatment which should have less effect on the polymerization of nucleic acid than hydrolysis in hot acid (for example, by changing the *p*H to 4), it is the nucleus and nucleolus which retain the stain, indicating that the polymerized nucleic acid has become attached to these structures. If the intact cytoplasmic granules are treated with deoxyribonuclease in the presence of a protease inhibitor, they lose all or most of their ability to retain methyl green. Furthermore, nucleolar basophilia and absorption at 2650 A. are lost after the cells have been treated with normal hydrochloric acid at 60° C. for 6 min., which removes ribose nucleic acid from root meristem cells.

It has been shown[9] that if living cells are treated overlong with commercial pectinase, the granules are reduced in number while the nucleus becomes more refractile and increases in density when viewed with stopped-down green illumination, indicating that material has diffused into the nucleus. We have checked that this change of refractivity is not due to light being lost from the system by scatter, etc. (for example, apparent absorption at 3100 A. remains small). A similar effect has often been observed by us when living cells, separated by the pectinase technique, are mounted in Tyrode solution which has been diluted four times with distilled water. Samples of nuclei photographed at 2650 A. after such diffusion has taken place, when compared with samples photographed before the change, suggest a three- to five-fold increase in absorption at this wave-length. A similar result has also been seen in cells prepared in other ways.

We have now followed this change while it occurred in one cell. The bean root had been treated by the pectinase method for separating living cells[8], macerated in distilled water, and photographed immediately at 2650 A. Diluted Tyrode solution was added to the side of the coverslip and almost immediately the interphase nucleus, viewed in green light, began to darken. Serial photographs taken at 2650 A. at three intervals after the addition of dilute Tyrode solution showed a progressive increase of nuclear absorption at this wave-length. This has been confirmed by microphotometry. Of particular interest, however, is the fact that while the nucleolar absorption at 2650 A. in the first photograph is considerably higher than that of the rest of the nucleus and of the cytoplasm, it becomes progressively masked by the rising absorption of the rest of the nucleus although the nucleolus neither lost absorption nor altered in size.

Thus a transfer of absorbing material has been recorded in one cell in which the cytoplasmic granules were disintegrating, the interphase nucleus having been seen to change from a poorly absorbing body to one which absorbed very strongly at 2650 A. To this observation may be added the results with methyl green which suggest that at least much of the deoxyribose nucleic acid is cytoplasmic when the cytoplasmic organization is intact, but nuclear when these granules are disturbed. It has been shown previously[12] that the destruction of these granules does not necessarily cause the absorbing material to shift from the cytoplasm to the nucleus. Thus suitable treatment with acetic alcohol leaves the interphase nucleus weakly absorbing, although when such cells are heated at 60° C. in normal hydrochloric acid for 6 min. the absorption of the nucleus increases several-fold. It is for this reason that the cytoplasmic localization of deoxyribose nucleic acid cannot be demonstrated by the Feulgen reaction which not only destroys the granules but also, as in this case, causes a shift of the freed deoxyribose nucleic acid (or deoxyribose nucleic acid-protein) into the nucleus. It is important to note, however, that this change of cytoplasmic to nuclear localization is observed only in these plant root meristem cells; it is not found in other proliferating cells such as those of the staminal hairs of *Tradescantia*, in which there are no large cytoplasmic granules of the type found in the root meristem cells. Since these granules comprise the mitochondria and similar organelles, it seems reasonable to assume that the cells which contain such bodies are capable of considerable synthetic activity, whereas those which do not possess these structures are less active metabolically and also show a different localization of all or most of the deoxyribose nucleic acid.

At first sight these findings seem to contradict many well-established ideas concerning the chemical nature of the gene and the nucleic acid cycle in mitosis, but this is not necessarily so. For example, no evidence has been presented to show that there is no deoxyribose nucleic acid in the interphase nucleus; absolute measurement is made difficult by the over- and under-lying cytoplasm and by the apparent accumulation of ultra-violet-absorbing cytoplasmic bodies close to the nuclear-cytoplasm boundary. Furthermore, Darlington[13] has stated clearly that although maximum attachment of the deoxyribose nucleic acid to the chromosomes corresponds to maximal spiralization, that is, at metaphase, "At the other extreme, within the resting nucleus, they [the chromosomes] are uncoiled and relatively free from nucleic acid". The present investigation provides no information about the attachment of the nucleic acid to the mitotic chromosomes. Furthermore, since the evidence offered in the present communication depends on cytochemical results, the possibility cannot be excluded of the presence on the granules of some basophilic, ultra-violet-absorbing substance which is removed by deoxyribonuclease but which is yet distinct from deoxyribose nucleic acid. This could be examined by biochemical procedures only if they could be shown not to disturb the delicate cytoplasmic structures, so causing the same artefacts as are discussed above.

The results described above, however, emphasize certain points. First, in actively synthesizing cells it is possible that some, if not most, of the deoxyribose nucleic acid is cytoplasmic, even if it is only partly synthesized or stored there[14]; at least it should not be treated as axiomatic that all deoxyribose nucleic acid must be in the nucleus. Secondly, it follows from this that the Feulgen reaction, in plants if not in other organisms, is of little cytochemical value unless the final preparation compares favourably with living cells; this is likely to be true only if there are no structures present in the cell which both contain deoxyribose nucleic acid and are destroyed at a pH below about pH 5. Thirdly, it may be as well to accept with caution the assumption that the gene is necessarily composed of deoxyribonucleoprotein. At least it may be argued that other evidence of the gene-nature of this complex is required before the gene is actually defined in terms of deoxyribonucleoprotein. Similar conclusions, based largely on other observations, have been discussed previously[12]. The present communication is a summary of experiments conducted during the past four years and a full account of the results will be published elsewhere.

This work owes much to the specialized advice on the various facets of the problem and the encouragement which we have received. In particular, we wish to acknowledge our gratitude to Prof. J. T. Randall, who has made this research possible and whose encouragement has greatly assisted us, and to Dr. H. B. Fell, for her frequent kind and valuable advice. We are grateful to Prof. J. F. Danielli, Dr. C. D. Darlington and Prof. J. Brachet for helpful discussions and for advising us with regard to the manuscript, and to Sir Rudolph Peters for his encouragement in the work. We wish to express our gratitude to Dr. M. H. F. Wilkins for his advice on biophysical problems, and to various of our colleagues at King's College for their help and friendly discussions. We are indebted to the British Empire Cancer Campaign (J. C.) and the Rockefeller Foundation (K. P. N.) for grants which have enabled this work to be done.

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# LETTERS TO THE EDITORS

*The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications*

## A New Procedure for Correlating the Structure of Glycosides

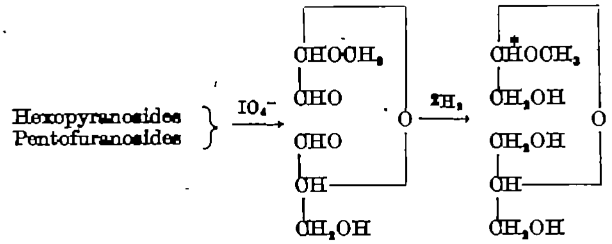
WHEN a sugar glycoside is oxidized with periodate, the ring is severed and a dialdehyde is formed[1]. In the case of pyranosides, cleavage is accompanied by the elimination of the $-CH(OH)-$ group at $C_3$ as formic acid, whereas in the cleavage of pentofuranosides no formic acid is formed. The elucidation of this reaction by recognition of the dialdehydic character of the periodate oxidation product[1] and an extensive study of the corresponding dibasic acids and their salts have enabled the ring structure of glycosides to be determined and have provided a simple method for correlating the structure of the various glycosides[2].

We wish to report another procedure for correlating the structure of glycosides, which consists of the reduction, either catalytically (in alcohol at 100° C. with 1,500 p.s.i. hydrogen and Raney nickel) or with sodium borohydride (in aqueous solution at 25° C.), of the dialdehydes formed by periodate oxidation and an examination of the corresponding alcohols so formed. The dialdehydes (I) from the hexopyranosides and pentofuranosides give the alcohol (II), while the dialdehydes (III) from the pentopyranosides furnish the alcohol (IV). Similarly, the dialdehydes (V) from the 6-deoxy-hexopyranosides yield the alcohol (VI).

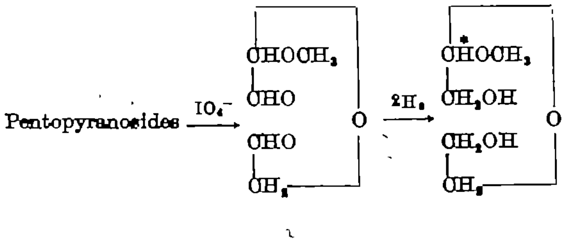
When the dialdehyde (I) is hydrogenated under pressure in the presence of a palladium-charcoal catalyst at room temperature, only the aldehydic group at $C_4$ of the original glycoside is reduced.

There is only one centre of asymmetry in the alcohols II and IV. Consequently, all the α-methyl-D-hexopyranosides and all the β-methyl-L-hexopyranosides should give the same optically active alcohol (*A*). Similarly, all the β-methyl-D-hexopyranosides and all the α-methyl-L-hexopyranosides should furnish the same optically active alcohol (*B*) which is the enantiomorph of *A*. The same relationship should exist among the alcohols (IV) produced from the α- and the β-methyl-D- and L-pentopyranosides. Experiments carried out on the glycosides of D-glucose, D-mannose, D-galactose, D-xylose and L-arabinose have shown that these relationships do actually hold true.

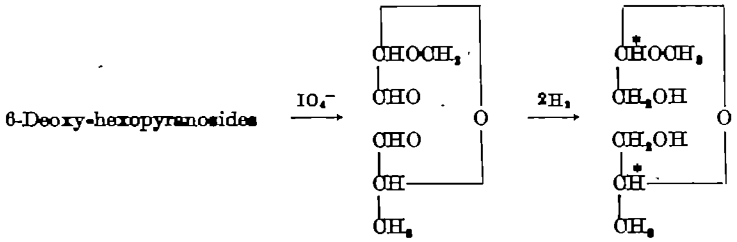
The alcohols represented by the general formulæ II, IV and VI, which can be produced in almost quantitative yield, are colourless fairly mobile liquids and they can be distilled *in vacuo* without decomposition. The enantiomorphic alcohols (II) obtainable from the hexopyranosides and pentofuranosides give the corresponding enantiomorphic tribenzoates, melting point 66°, $[\alpha]_D^{20}$ + 21° and − 21° (ethanol), and the *tris-p*-nitrobenzoates, melting point 110°, $[\alpha]_D^{20}$ + 24° and − 24° (chloroform). The enantiomorphic alcohols (IV) from the dialdehydes (III) furnished by the pentopyranosides yield the enantiomorphic *bis p*-nitrobenzoates, melting point 113°, $[\alpha]_D^{20}$ + 10° and − 10° (chloroform). The diasteroisomeric alcohols corresponding to (VI) from the aldehydes (V) provided by the 6-deoxy-hexopyranosides have been characterized as *bis p*-nitrobenzoates. The structures of the alcohols represented



(I) (II)

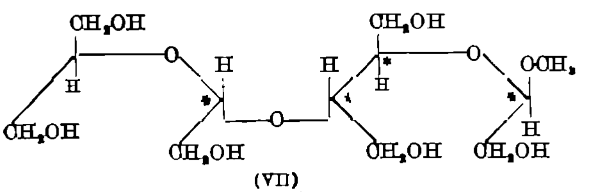


(III) (IV)

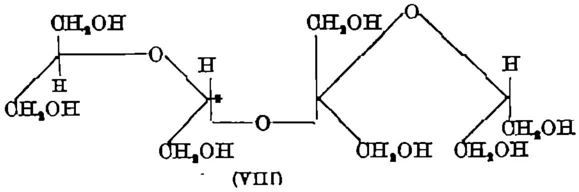


(V) (VI)

* Denotes an asymmetric carbon atom.



(VII)



(VIII)

by the formulæ II and IV have been established by acid hydrolysis and identification of the fragments, namely, glycerol (from II), ethylene glycol (from IV) and glycollic aldehyde (from II and IV). Confirmation of these results has been obtained from experiments carried out with the benzoyl and *p*-nitrobenzoyl derivatives of the alcohols.

Proof of the structure of the alcohols represented by VI may be illustrated by reference to that obtained from α-methyl-L-rhamnopyranoside. This particular alcohol affords upon hydrolysis glycollic aldehyde (2,4-dinitrophenylhydrazone, melting point 86°) and an optically active 1,2-propanediol (*bis p*-nitrobenzoate, melting point 109°, $[\alpha]_D^{23} + 48 \cdot 5°$ (acetone) ), which proved to be identical with that obtained from L (dextro)-lactic acid and its methyl ester by reduction with lithium aluminium hydride.

We have also found that reduction of aldehydes, formed by periodate oxidation of glycosides, is also applicable to oligosaccharides. Thus β-methyl maltoside has given VII whereas sucrose has afforded VIII.

Furthermore, the fact that the latter, which contains only one asymmetric carbon atom ($C_1$ of the original D-glucose moiety), has a negative rotation shows that in sucrose the anomeric linkage at the glucose residue is of the α-type, inasmuch as all alcohols of the type represented by II (an analogue of VIII) derived from α-alkyl-D-glucopyranosides have a negative rotation, whereas all those derived from β-alkyl-D-glucopyranosides have a positive rotation.

Further details of this work will be published later.

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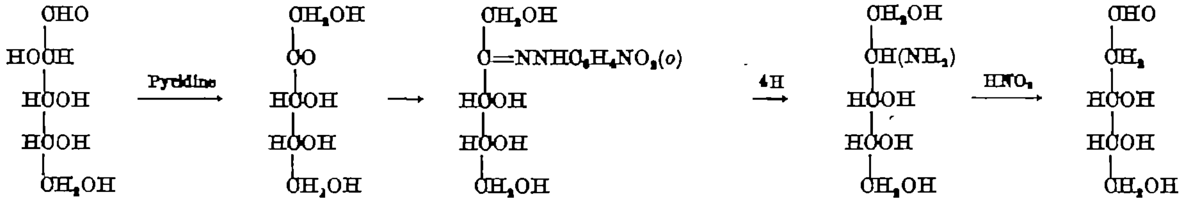
## A New Synthesis of 2-Deoxy-D-ribose

It has long been a matter of interest to synthesize 2-deoxy-D-ribose, a component sugar of deoxyribonucleic acid, and several methods have been reported[1]. We wish to communicate some results which we obtained recently.

D-Arabinose was converted into ribulose by heating it in pyridine[2]. Ribulose isolated as its *o*-nitrophenyl hydrazone was reduced as such with Raney's nickel catalyst to the 2-deoxy-2-amino-pentitols, the crystallization of which failed. The amino-alcohols were converted into deoxy-pentose by treatment with nitrous acid. The course of the reaction may be interpreted as a sort of 'semipinacolinic deamination'[3]. 2-Deoxy-D-ribose was isolated as its benzylphenyl hydrazone melting at 125·5–126·5° C., $[\alpha]_D^{11}$ being − 15·25°. The overall yield was about 3 per cent. The whole course of the reaction is represented as follows :



We are indebted to Prof. K. Makino and Mr. K. Ohta, of the College of Medicine, Kumamoto University, for an authentic specimen of deoxyribose, and we are grateful to Prof. S. Akabori, of the College of Science, Osaka University, for his suggestions and encouragement.

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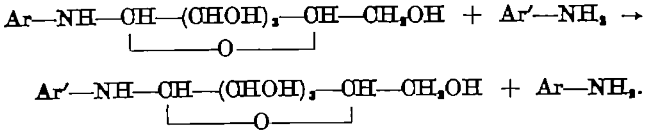
## Transglucosylation of Aromatic N-Glucosides

Although the transglucosylation of O-glucosides is not very practicable and has been described hitherto only in isolated cases[1], the same mechanism appears in the case of N-glucosides of primary aromatic amines and seems to be fairly easy and to proceed according to the reaction :



$$\mathrm{Ar{-}NH{-}\underbrace{CH{-}(CHOH)_2{-}CH}_{O}{-}CH_2OH + Ar'{-}NH_2 \rightarrow Ar'{-}NH{-}\underbrace{CH{-}(CHOH)_2{-}CH}_{O}{-}CH_2OH + Ar{-}NH_2.}$$

The first example of this reaction was given in 1936 by R. Kuhn and A. Dansi[2], who in this way prepared nitroxylidine-glucoside from *p*-toluidine-glucoside, but the yield was very low. In 1948, J. Inoue and K. Onodera described two further reactions, namely, the preparation of aniline-glucoside and *m*- or *p*-nitraniline-glucoside from *p*-toluidine-glucoside ; however, the description of the latter seems to me doubtful ("white tabular crystals (?), m.p. 120–122°, of aniline N-D-glucoside"[3]).

Since this process appears to be of significance both from the chemical and biochemical points of view, we have made detailed investigations of the conditions and mechanism of the reaction. Our conclusions can be summarized as follows :

(1) The reaction is dependent upon *p*H.

(2) It is in certain circumstances reversible (see examples 4–5, 6–7 and 8–9 in the accompanying table).

(3) The reaction will proceed to completion in solvents such as methyl alcohol and ethyl alcohol in a few minutes at low temperature with very satisfactory yields ; Inoue and Onodera heated the reaction mixtures for eight hours. We find that application of heat serves only to speed up the solution of the starting reactants.

(4) The reactions in absolute alcohols leave little doubt that the process is really transglucosylation rather than hydrolysis followed by redistributive reglucosylation. This conclusion is confirmed by the

| Reactants | Product | Solvent | Catalyst | Yield (per cent) |
|---|---|---|---|---|
| (1) Aniline-glucoside + sulphanilamide (1 mol.) | Sulphanilamide-N⁴-glucoside | abs. ethyl alcohol<br>" " " | abs. HCl<br>conc. HCl | 70<br>69 |
| (2) Aniline-glucoside + *p*-nitraniline (1·1 mol.) | *p*-Nitraniline-glucoside | abs. ethyl alcohol<br>80% methyl alcohol | abs HCl<br>conc. HCl | 41<br>43 |
| (3) *o*-Nitraniline-glucoside + *p*-nitraniline (1·1 mol.) | *p*-Nitraniline-glucoside | 87% methyl alcohol | conc. HCl | 57 |
| (4) *m*-Nitraniline-glucoside + *p*-nitraniline (1·1 and 1·5 mol.) | *p*-Nitraniline-glucoside | abs. methyl alcohol<br>" " " | abs. HCl<br>conc. HCl | 68<br>65 |
| (5) *p*-Nitraniline-glucoside + *m*-nitraniline (1·5 mol.) | *m*-Nitraniline-glucoside | abs. ethyl alcohol | abs. HCl | 58 |
| (6) *m*-Nitraniline-glucoside + sulphanilamide (1·1 mol.) | Sulphanilamide-N⁴-glucoside | abs ethyl alcohol<br>96% " " | abs. HCl<br>conc. HCl | 85<br>60 |
| (7) Sulphanilamide-N⁴-glucoside + *m*-nitraniline (2 mol.) | *m*-Nitraniline-glucoside | 85% ethyl alcohol | conc. HCl | 79 |
| (8) *p*-Nitraniline-glucoside + sulphanilamide (1 mol.) | Sulphanilamide-N⁴-glucoside | abs. ethyl alcohol<br>96% " " | abs. HCl<br>conc. HCl | 97<br>72 |
| (9) Sulphanilamide-N⁴-glucoside + *p*-nitraniline (2 mol.) | *p*-Nitraniline-glucoside | 83% methyl alcohol | conc. HCl | 92 |
| (10) *p*-Bromaniline-glucoside + *p*-nitraniline (1·15 mol.) | *p*-Nitraniline-glucoside | 83% methyl alcohol | conc. HCl | 67 |
| (11) *o*-Bromaniline-glucoside + sulphanilamide (1 mol.) | Sulphanilamide-N⁴-glucoside | abs. ethyl alcohol<br>" " " | abs. HCl<br>conc. HCl | 84<br>71 |
| (12) *p*-Aminosalicylic acid-N-glucoside + *p*-nitraniline (1·5 and 2 mol.) | *p*-Nitraniline-glucoside | abs. methyl alcohol<br>" " " | abs. HCl<br>conc. HCl | 81<br>96 |
| (13) *p*-Aminosalicylic acid-N-glucoside + sulphanilamide (2 and 1 mol.) | Sulphanilamide-N⁴-glucoside | 96% ethyl alcohol<br>" " " | conc. HCl<br>$NH_4Cl$ | 89<br>83 |
| (14) α-Aniline tetra-acetyl-glucoside + sulphanilamide (1·2 mol.) | Sulphanilamide-N⁴-tetra-acetyl glucoside (isomeric mixture) | abs. ethyl alcohol | abs. HCl | 56 |
| (15) β-Aniline tetra-acetyl-glucoside + sulphanilamide (1 mol.) | Sulphanilamide-N⁴-tetra-acetyl-glucoside (isomeric mixture) | abs. ethyl alcohol | abs. HCl | 60 |

fact that the transformation of *p*-aminosalicylic acid-N-glucoside into sulphanilamide-N⁴-glucoside will proceed at a considerably higher velocity than the formation of the corresponding glucoside from a mixture of *p*-amino salicylic acid, sulphanilamide and glucose under the same conditions. It should be noted, however, that water at a concentration of less than 5 per cent will not, in most cases, influence formation and yield of the product and the velocity of transglucosylation. However, in special cases the presence of water is advantageous on account of the crystallization and separation of the products from the mixture. The solubilities of the components evidently play a very important part in these reactions.

(5) In the examples described in the table, the amines were used in about 1 or 2 mol. excess. In the reversible reactions, we never used more than 2 moles of amines.

(6) We find that not only the free glucosides but also the tetra-acetylglucosyl derivatives can be subjected to transglucosylation. Sulphanilamide-N⁴-tetra-acetylglucoside could be prepared from aniline-tetra-acetyl-glucoside both from a mixture of the α,β-isomers and from the pure α- or β-isomer. An isomeric mixture was obtained which was almost identical with that obtained from sulphanilamide and tetra-acetylglucose or acetobromglucose respectively[4].

The transglucosylations indicated in the table have been accomplished.

Detailed description of the experiments will appear elsewhere. We thank the Hungarian Academy of Science for assistance in this investigation.

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## Demonstration of Transaminase Systems in the Alga *Chlorella*

As part of a programme of study of the nitrogenous metabolism of the alga *Chlorella* being undertaken in this department, it was considered desirable to obtain evidence for the presence or absence of transaminase systems within the organism, and to evaluate the relative activities of any such systems found to be present. The organism used was a strain of *Chlorella vulgaris* identical with that used in the experiments described by Syrett and Fowden[1].

Preliminary experiments had shown that large amounts of material are often required to demonstrate metabolic processes in *Chlorella*, even though micromethods may be used for their investigation. For this reason the alga was grown in a 10-lit. 'Pyrex' aspirator, containing 8 lit. of medium similar to that used by Syrett and Fowden and illuminated by four vertical, equally spaced 40-watt fluorescent tubes. The temperature was that of the laboratory, varying in the range 15–22° during the course of the experiment. The medium was aerated with air plus 0·5 per cent carbon dioxide, the total gas flow being approximately 100 lit./hr. This vigorously stirred the large volume of liquid, ensuring that all the cells were intermittently exposed to the light at the edges of the culture, even when penetration of light into the bulk of the culture was reduced to a very low level at the later stages of growth. The medium was inoculated with 20 ml. of an actively growing *Chlorella* suspension growing in the same medium but containing in addition 1·0 per cent glucose. Growth was continued for six to seven days after inoculation.

The alga was harvested by centrifuging at 950 *g* for 5 min. The centrifuged cells were then washed by repeated centrifuging from distilled water and finally resuspended in 30–40 ml. of *M*/15 phosphate buffer (*p*H 7·5). This two-hundredfold concentration ensured a thick active suspension of cells. Their density was approximately 4 million/mm.[2].

*Preparation of a concentrated, cell-free extract.* The concentrated suspension of cells was subjected[3] to a shearing strain of 20,000 lb./sq. in. This disrupted most of the cells, and a cell-free extract was obtained by removing unbroken cells and cell debris by centrifuging at 1,100 *g* for 30 min. The dark green, slightly turbid supernatant liquid was decanted and stored while the separated solid matter was discarded. In order to remove the free amino-acids already present in the extract, it was dialysed for 24 hr. at 4° C. in a collodion bag against a slow stream of *M*/15 phosphate buffer (*p*H 7·5).

The presence of transaminase systems in the extract remaining in the dialysis sac was then demonstrated as follows. The transamination systems investigated were those catalysing the transfer of amino-groups from various amino-acids to either pyruvic or α-keto glutaric acid. Eight amino-acids were used, including those that might be expected to be most active in transamination systems. The limited amount of extract available precluded the use of all the naturally occurring amino-acids. Oxalacetic acid was not used as an amino-group acceptor for this same reason, together with the fact that under the experimental conditions used it rapidly undergoes conversion to pyruvic acid, so giving anomalous results.

The *p*H at which the extract was buffered (7·5) has been demonstrated to be optimum for several transaminase systems in *Neurospora crassa*[3]. Transaminations catalysed by the *Chlorella* extract were demonstrated by following the production of glutamic acid or alanine formed from α-keto glutarate or pyruvate respectively, by means of chromatography. 0·5 ml. of the extract was pipetted into each of sixteen tubes. To each of eight of these, 0·25 ml. of *M*/10 sodium pyruvate was added, while 0·25 ml. of sodium α-keto glutarate was added to each of the other eight. Finally, 0·25 ml. of an *M*/10 *l*-amino-acid was added to each tube. Glutamic acid was not added to α-keto glutarate, nor was alanine used with pyruvate. Instead, 0·25 ml. of buffer was added, and these tubes then constituted the controls upon which the changes in the concentrations of glutamic acid and alanine could be based. A duplicate set of sixteen tubes was also prepared, one set being incubated at 25° C. for 3 hr. and the other for 24 hr. At the end of the incubation periods the reactions were stopped by the addition of 2 ml. of absolute alcohol to each tube, followed by slight warming. This precipitated the proteins and stopped all enzyme action.

After settling of the precipitates, 60 µl. of the clear supernatant was withdrawn from each tube in turn and applied as a spot to a sheet of Whatman No. 4 filter paper in the normal way. The chromatogram was developed for 24 hr. in phenol-ammonia, and, after drying, the amino-acids were located by the usual ninhydrin treatment. The relative amounts of glutamic acid and alanine formed from the respective keto-acid from different amino-acids were estimated by comparison of spot sizes and intensities. The accompanying table summarizes the results obtained; the maximum amount of transamination found for any amino-acid was not considered to represent more than 20 per cent of the *l*-amino-acid originally added.

| α-Amino-acid added | α-Keto glutarate added | | Pyruvate added | |
|---|---|---|---|---|
| | Glutamate formed at 3 hr. | Glutamate formed at 24 hr. | Alanine formed at 3 hr. | Alanine formed at 24 hr. |
| Aspartic acid | +++ | ++++ | — | +++ |
| Glutamic acid | | | ++ | ++++ |
| Alanine | ++ | +++ | | |
| Leucine | + ? | ++ | — | ++ |
| Valine | — | — | — | — |
| Arginine | — | + ? | — | — |
| Serine | — | + ? | — | + |
| Glycine | * | * | — | + |

* Glycine was not added to α-keto glutarate.

From an inspection of the table it is seen that in *Chlorella* those transamination systems involving either aspartic acid, glutamic acid, or alanine are the most active. These conclusions agree very well with those obtained in other work using higher plants or animal tissues.

Thanks are due to Dr. L. Fowden and Mr. P. J. Syrett for their helpful advice and criticism, and to Prof. W. H. Pearsall for his interest in the work. The work was carried out with the aid of a grant from the Department of Scientific and Industrial Research.

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## Controlling Effect of Salts on the Activity of the Cytochrome Oxidase

ACCORDING to the theory of anion respiration[1], the activity of the cytochrome system is controlled by the activity (concentration) of movable salt anions in the surroundings. With the aid of a new spectrophotometric technique it has been shown that in living wheat roots the oxidation reduction balance of the cytochromes *a* (oxidase), *c* and *b* is moved towards a higher state of oxidation by a change of the medium from distilled water to salt solutions (potassium chloride or nitrate, calcium nitrate, etc.). On removal of the salts the cytochromes revert to a more reduced state. From the automatic recording of the time-course of the phenomena, it was clearly shown that the change in the oxidation-reduction balance of the cytochromes starts simultaneously with the absorption of the salt ions. The fundamental fact that the coenzymatic effect is exerted by salt anions was established by earlier investigations on the effect of salts on the cyanide-sensitive part of respiration[2]. It was shown that this part of respiration is enhanced only if anions are absorbed; absorption of cations only had no effect on it.

Measurement of the reaction kinetics of the cytochrome system of wheat roots shows an electron transference from a dehydrogenase system (*DH* = succinic dehydrogenase) to oxygen along the potential ladder $DH \rightarrow b \rightarrow c \rightarrow a \rightarrow O_2$. According to the theory, an electron cannot be transferred from one molecule to another unless the same quantity of electricity is moved in the opposite direction in the form of a movable anion. As regards roots, oxygen and anions are provided from the medium. The cytochrome oxidase is most probably present in the surface of the protoplasm[1] and catches anions simultaneously with the delivery of electrons to the oxygen molecules. By a similar exchange between anions and electrons the former are successively forwarded to the end of the potential ladder. As each step of the chain requires the presence of anions as coenzymes, it will be theoretically possible to demonstrate this activity factor at any of the isolated steps. Technically, the sequence cytochrome *c* → cytochrome oxidase → oxygen is quite simple, because in homogenized roots the normal anion respiration is rapidly brought to a standstill, whereas the oxidase remains active as shown from its rapid oxidation of added reduced cytochrome *c*. The following experiment may serve as an illustration.

100 mgm. dry weight of wheat roots from desalted seedlings three weeks old was ground in a porcelain mortar after adding 10 c.c. distilled water. 1·5 c.c. of this preparation was added to a solution of 0·02 per cent cytochrome *c* ('Sigma'), reduced with some dithionite and afterwards aerated. The oxidation was followed spectrophotometrically by observing the decrease of the difference in extinction between the wavelengths 550 and 560 mμ. After 5 min., 41 per cent of the cytochrome was oxidized. If 0·1 *M* potassium chloride was added to the preparation, 73 per cent of the cytochrome was oxidized in 5 min. Controls with 0·001 *M* hydrogen cyanide showed no oxidation. The figures correspond to an oxidation of 1 07 μgm. iron per hr. per 10 mgm. in the desalted material and an oxidation of 1·70 μgm. iron after addition of potassium chloride; thus there was an increase of 64 per cent due to the salt effect. Similar results were obtained with potassium nitrate. Desalting can also be brought about by treatment with anion-absorbing resin.

Simultaneous spectroscopic measurements on living roots showed a quantity of $3 \times 10^{-5}$ μmol. cytochrome oxidase per 10 mgm. dry weight. In the presence of salts, this quantity oxidized 1·7 μmol. iron in 1 hr., corresponding to a turnover number of *c.* 1,000 per min. In the absence of salts this number decreases to *c.* 600; but this is, of course, not a minimum value because salts are always to some extent still present in 'desalted roots' (cf. ref. 2). In other experiments the activity of the preparations nearly equalled the normal activity of living roots, showing[1] a turnover number of *c.* 1,700 per min. at 19° C. The roots used for these experiments showed an active salt absorption from 0·0005 *M* potassium chloride of 0·82 μmol. chlorine per hr. per 10 mgm., corresponding to $Q_{an}/Q_{O_2}$ = *c.* 0·9 if calculated from the directly determined oxidase activity. This value is quite in accord with determinations of the anion respiration of living roots (see ref. 2).

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## Acetic Acid in Fresh Grass

EXPERIMENTS carried out in these laboratories[1] on the formation of volatile fatty acids in grass/water slurries showed that, whereas butyric and propionic acids were formed after the primary production of lactic acid had been stabilized, acetic acid was produced even before the lactic fermentation began. It is, of course, well known that acetic acid is formed during the silage fermentation, but it seemed surprising that it should be formed so speedily.

An examination of a slurry which had been standing for two hours showed that appreciable amounts of acetic acid were even then present, although tests for lactic acid by the *p*-hydroxy diphenyl test[1-3] gave negative results.

It was decided to experiment with fresh grass juice; for this purpose, samples of grass obtained from a plot adjoining the laboratory were immediately minced and the product squeezed through a linen cloth which had been washed in hot water and then dried. The grass juice was subjected to steam distillation according to the procedure of Scarisbrick[4] to isolate the total volatile fatty acids, and the distillate was submitted to gas chromatography according to the technique of James and Martin[5]. A definite yield (about 8 mgm. per cent of the grass dry matter) was obtained on each occasion, but no other lower fatty acid in the $C_1$–$C_{12}$ range was isolated.

So far as we are aware, such a finding has not previously been reported in the literature, and all that may be concluded at this stage is that acetic acid is present, either free or in a state of loose combination, in the grass. It is possible that it forms an intermediate in the tricarboxylic acid cycle.

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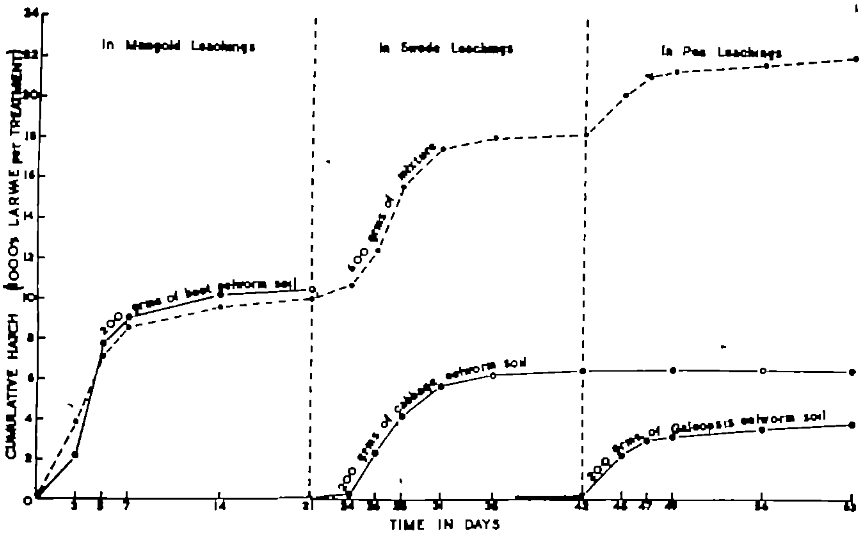
## Hatching Responses in Root Eelworms (*Heterodera* spp.)

RESULTS of recent investigations on larval emergence from cysts of root eelworms (*Heterodera* spp.) when exposed to plant root diffusates (using the methods evolved by Fenwick for potato root eelworm[1,2,4]) are summarized below.

Beet, potato and carrot root eelworms behaved normally in that they responded only in diffusates from hosts and from invaded plants. Cabbage root eelworm responded well in diffusates from hosts belonging to the genus *Brassica*, but did not respond to other cruciferous hosts or to non-hosts. *Galeopsis* and clover eelworms gave little or no response in diffusates from typical hosts, but responded readily to pea root diffusate. Hop eelworm responded to diffusates from three hosts, hop, hemp and small nettle (*Urtica urens*), and from the related plant *Parietaria diffusa*. Negligible responses in host and non-host diffusates were obtained with pea and oat root eelworms.

From the above findings, it seemed that a measure of success might be obtained in quantitative estimation of mixed populations of *Heterodera* species by exposing the cysts to a succession of plant root diffusates. In preliminary experiments of this nature reliable estimates (in terms of 'hatchable' larvæ) were obtained for a mixed soil population of beet, cabbage and *Galeopsis* eelworm cysts (see graph). A limitation of the method is that it is not applicable to those species which do not respond to root diffusates, for example, pea and oat root eelworms.

Applying Fenwick's technique for determining the shape of the hatching curve[3] to some of the above-mentioned species, it has been found that in all cases investigated (those of beet, cabbage, *Galeopsis* and



Hatching responses in a mixture of equal parts (by weight) of beet, cabbage and *Galeopsis* eelworm soils Method 1

hop eelworms) the curve is very similar to that found by Fenwick for potato root eelworm.

Certain of the plants investigated appear to have interesting possibilities for the biological control of root eelworms. Thus the root diffusate of the common weed swinecress (*Coronopus squamatus*) stimulates larval emergence from beet eelworm cysts and the roots are invaded by the larvæ, but apparently cysts are not formed[5]. The same is true of *Solanum nigrum* and potato root eelworm[6,7]. Diffusate from the urticaceous plant *Parietaria diffusa* stimulates emergence from hop eelworm cysts, but so far cysts have not been found on this plant when grown in infected soil. Pea diffusate causes a marked hatch of larvæ from *Galeopsis* and clover eelworm cysts, but the pea plant can scarcely be regarded as an efficient host of either eelworm. Similarity in the behaviour of these two eelworms suggests that they may be one and the same species.

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## Toxicity of Chlorinated Phenyl Benzenesulphonates to Winter Eggs of the Fruit Tree Red Spider Mite, *Metatetranychus ulmi* (Koch)

The mite ovicidal activity of a number of substituted phenyl benzenesulphonates toward the eggs of the two-spotted spider mite, *Tetranychus bimaculatus* Harvey, was examined by Kenaga and Hummer[1], who found that substitution by bromine or, better, chlorine in the *para*-position in both phenyl rings led to compounds of considerable activity. By far the most active was 4-chlorphenyl 4-chlorbenzenesulphonate, and this has now been developed commercially in the United States. Afterwards, Kirby and McKinlay[2], using summer eggs of the fruit tree red spider mite *Metatetranychus ulmi* (Koch), and Read and Smith[3], using eggs of the glasshouse red spider mite *Tetranychus telarius* L., found that 4-chlorphenyl benzenesulphonate (CPBS) was at least as potent as 4-chlorphenyl 4-chlorbenzenesulphonate (CPCBS) toward both these eggs. Field experience in 1952 has shown that the former, especially when applied in conjunction with an acaricide, can give remarkably persistent control of the fruit tree red spider mite under English conditions, but considerable damage may occur in a year like 1952 to fruits of certain apple varieties, notably Worcester Pearmain.

Apart from dinitrophenols such as DNC and dinex, few chemicals so far tested have proved highly toxic to both the summer and winter eggs of the fruit tree red spider mite. Eaton and Davies[4] found both types of egg susceptible to *n*-dodecyl thiocyanate, azoxybenzene and the di*cyclo*hexylamine salt of dinex, but azobenzene was much less toxic to the winter than to the summer egg, and diphenyl sulphone showed an even greater disparity in the same direction. It is therefore of interest to record that the toxicities of a number of chlorinated phenyl benzenesulphonates are very similar toward both summer and winter eggs of this mite. In 1951, we tested 4-chlorphenyl 4-chlorbenzenesulphonate at 0·1 per cent, formulated with acetone (2 per cent), *cyclo*hexylamine dodecyl sulphate (0·05 per cent) and sodium di-octyl sulphosuccinate (0·02 per cent), using the rearing and dipping techniques described by Eaton and Davies[5], and found hatching to be almost completely prevented, even fewer eggs hatching than among those treated with 0·09 per cent diethanolamine salt of dinoseb.

Laboratory tests on March 12, 1952, were extended to phenyl benzenesulphonate and eight chlorinated derivatives (several of which appear to be new compounds), using the same techniques and formulation, except that the wetting agent was reduced from 0·02 to 0·01 per cent. The compounds used and their melting points are listed in the accompanying table, with the concentrations (which were equimolar), and the percentage mortalities corrected by Abbott's formula using the formulation control mortality as base-line. 4-Chlorphenyl 4-chlorbenzenesulphonate was also tested at three lower concentrations, and the results are included in the table.

It will be seen that four of the nine compounds tested possess considerable activity, and that the order of toxicity among the first four esters listed is similar to that established by Kirby and McKinlay[2] against the summer egg. This possession of winter ovicidal activity by promising summer ovicides may

| Chemical | Melting point (° C) | Percentage concentration | Percentage mortality ($c = 0$) |
|---|---|---|---|
| Phenyl benzenesulphonate | 34·5–35·5 | 0·1 | 5 7 |
| 4-Chlorphenyl benzenesulphonate | 59·5–61 | 0·115 | 100·0 |
| Phenyl 4-chlorbenzenesulphonate | 91–92 | 0·115 | 71·8 |
| 4-Chlorphenyl 4-chlorbenzenesulphonate | 83–84 5 | 0·13 | 99 9 |
| | | 0·065 | 78·5 |
| | | 0·016 | 17·0 |
| | | 0·008 | 14·6 |
| 2,4-Dichlorphenyl benzenesulphonate | 46·5–47* | 0·13 | 80·3 |
| Phenyl 2,4-dichlorbenzenesulphonate | 76 5–77* | 0·18 | 12 5 |
| 2,4-Dichlorphenyl 4-chlorbenzenesulphonate | 117–117 5* | 0·145 | 18·7 |
| 4-Chlorphenyl 2,4-dichlorbenzenesulphonate | 80–80·5* | 0·145 | 11·6 |
| 2,4-Dichlorphenyl 2,4-dichlorbenzenesulphonate | 89·5–90* | 0·16 | 4 3 |

* Not previously recorded.

well prove to be of considerable practical significance as regards the time at which they are applied in the orchard. In the past, the first application of summer acaricides and ovicides has been delayed until the hatching of the more resistant winter eggs is complete, a procedure which involves extremely careful timing for maximum effectiveness. It is conceivable that, using compounds possessing such well-developed activity to both types of egg, an earlier and more effective application might be possible. At the same time the undesirable effects on developing fruit which have been encountered might be avoided.

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## Effects of Different Water-regimes on the Growth of Tomatoes under Glass

The relationship between the growth of glasshouse crop plants and the level of their water supplies is still uncertain. In order to investigate possible effects of soil moisture on the rate of growth and yield of tomatoes (varieties of *Lycopersicum esculentum* Mill.) under glass, tomato plants have been subjected to four different water-regimes for a continuous period of about five months with interesting results. During that time, the soil moisture in each treatment has been allowed to fluctuate only between field capacity and a predetermined level of dryness as indicated by the moisture tension at a depth of 15 cm. below the surface.

A glasshouse was subdivided into twenty-four plots by water-proofed brick walls which penetrated into the subsoil. Each plot was approximately 210 cm. × 180 cm. and contained a bed of about 20 cm. of coarse sandy loam top soil, overlying about 40 cm. of slightly heavier, well-drained, cultivated subsoil, which in turn rested on massive, well-structured but undisturbed Keuper marl. Plots were equipped with apparatus for the measurement of soil moisture, including laboratory and commercial models of soil tensiometers, the bulbs of which were buried variously at 15 and 45 cm. below the surface.

Early in March 1952 the beds were thoroughly flooded with water, allowed to drain and given a normal commercial dressing of base fertilizer. On March 31 they were planted up with uniform plants of the tomato varieties Ailsa Craig and Single Cross, ten plants of each variety being planted in each bed. During the next twenty-five days all plants were treated similarly and watered individually, until each had a well-developed root system.

On April 25, four different water-regimes were introduced and applied consistently for the rest of the season, each of the four treatments being replicated in six randomized blocks. In each treatment one plot, chosen at random, was used as the key plot to control the watering throughout the season of that treatment, that is, all six plots were watered when the tensiometer bulb embedded at 15 cm. depth in the key plot recorded a predetermined reading. The tensions, chosen arbitrarily, at which it was decided to apply water were 7, 15, 30 and 60 cm. of mercury for the four treatments respectively.

The approximate water deficit of each key plot at the selected tension was assessed by a rough calculation, and on each occasion when a plot was watered, sufficient water was applied to make good this deficit with the view of wetting the whole bed of soil approximately to field capacity. The volume of water applied per plot at each watering naturally varied at different times and from treatment to treatment, ranging from as little as 14 litres per plot on the wettest treatment early in the season when most of the roots were confined to a relatively shallow layer of soil, to as much as 318 litres per plot (8·4 cm. of water) in the driest plots towards the end of the season when the tomato roots had ramified through the whole bed of soil. Similarly, frequency of application of water varied widely, from almost daily watering of the wettest plots to approximately monthly applications to the driest plots.

With regard to other environmental factors, the plants were treated according to the rules of good husbandry throughout the season. All plots received the same total amount of nutrient, which was applied in solid form prior to watering and washed in. Treatments continued until early October, and it may thus be claimed that the plants were grown for about five months under four different and definable water-regimes.

Data regarding watering and yields are given in the accompanying table, in which all the figures refer

| Treatment | Irrigation data | | | Average yield per plant* | | | |
|---|---|---|---|---|---|---|---|
| | Tension at which water applied (cm. Hg) | Number of times water applied | Total amount of water applied (cm.) | Ripe fruit | | Total yield (incl. green fruit picked Oct. 4) | |
| | | | | Ailsa Craig (kgm.) | Single Cross (kgm.) | Ailsa Craig (kgm.) | Single Cross (kgm.) |
| *A* (Wet) | 7 | 136 | 53 3 | 3·4 | 2·6 | 4·2† | 3·2 |
| *B* | 15 | 17 | 37·8 | 3·2 | 2·2 | 3 8 | 2·6 |
| *C* | 30 | 9 | 32 0 | 3·1 | 2·2 | 3 5 | 2·5 |
| *D* (Dry) | 60 | 5 | 31 0 | 2·6 | 1·8 | 3 0 | 2·1 |

* Average of sixty plants for each variety in each treatment.
† Equivalent to a yield of 86 tons per acre at the spacing of plants in this experiment, excluding the space taken by the path down the centre of the house.

Significance at 2 per cent level ($P = 0·02$) :—
Ailsa Craig : *A* and *C* are significantly greater than *C* and *D* respectively. Single Cross : *A* and *C* are significantly greater than *B* and *D* respectively.

to the period from April 25, 1952 (when differential watering commenced), to October 4, 1952.

Since the level of watering was the main variable environmental factor under the conditions of this experiment, the results suggest that there was a strong correlation between the type of water-regime under which the plants were grown and the yield of ripe fruit produced, the wetter treatments tending to produce the higher yields. Other observations point to a similar positive correlation between the vigour of vegetative growth and the level of water applied. The distribution of roots in the soil was also affected by the water-regimes, the zone of greatest root development becoming progressively deeper in the drier treatments.

The results are of great interest when compared with those of other workers in this field. Martin[1] (working with *Helianthus annuus*), Heck[2] (working in Hawaii on sugar cane) and others have found that vegetative growth is retarded as moisture tensions rise, which is in accord with our own results on tomatoes. On the other hand, Singh and Joon, in India[3], and Molenaar and Vincent, in Washington[4], have shown that excessive application of water to tomatoes (growing out-of-doors) may reduce the yield of fruit. There may thus be an optimum moisture regime, in the region of field capacity, for the growth of tomatoes under glass.

We wish to express our appreciation of the help given by Mr. D. V. Crawford, of the Department of Agricultural Sciences, in connexion with determinations of soil moisture, pore space, etc.

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## Use of the Warburg Respirometer to study Microbial Activity in Soils

THE respiratory activity of the micro-organisms in samples of soil, determined by estimating the evolution of carbon dioxide, has long been considered by soil microbiologists to be related to soil fertility[1,2]. Lees has recently described a modified Haldane respirometer for measuring oxygen uptake as the criterion for that activity[3]. Along somewhat similar lines, our own studies suggest that the Warburg constant-volume respirometer may prove a valuable tool with which to examine the activities of soil organisms in the breakdown of soil organic matter, or to determine the effect of various treatments in modifying the behaviour of soil organisms.

We have noted that, when air-dried soil is placed in Warburg vessels and moistened to 80–90 per cent of saturation, the daily rates of oxygen uptake may be related to time by the equation:

$$Y = F'/t^{m'},$$

where $Y$ represents oxygen uptake expressed in µl. per gm. of soil per hr., $F'$ and $m'$ are constants, and $t$ is time in days. This equation is derived from earlier forms reported by other workers[4,5]. $F'$ and $m'$ are derived by converting the equation to its logarithmic form:

$$\log Y = \log F' - m' \log t.$$

When $\log Y$ is plotted against $\log t$, a close fit to a straight line has, as a rule, been obtained for periods of two to three weeks; and it appears that observations taken for five or six days (the result for the first day usually being omitted) establish the line reasonably well. We are of the opinion that the Warburg method, combined either with graphs or regression-line values, makes possible a considerable reduction in the time required for determining respiratory activity in a soil.

By these procedures it was found that two soils, differing widely in their organic content (one being a 'muck' and the other a loam), gave $m'$ values which did not differ significantly, though their $F'$ values were quite distinct. Lees's results from an experiment with a tropical soil[3] yielded a regression line having a value of $m'$ similar to those obtained from our own soils, but a value of $F'$ much higher than any we have found.

Results of experiments using agents (disinfectants and heat) detrimental to the soil organisms suggest that our method may prove useful in determining the degree and duration of the interference of such agents with the biological equilibrium, since such treatments cause a marked deviation from the normal straight line; the latter reappears if and when adaptation to the treatment occurs.

A hypothesis seeking to explain the peculiar log rate – log time linear function is proposed. It is based upon the premise that the energy-yielding components of soil organic matter may be composed of two fractions, one being readily decomposable and the other less readily decomposable, and that the breakdown of each portion proceeds simultaneously according to first-order reaction rates. It is suggested that the apparent log rate – log time function arises because two superimposed first-order reaction rates tend to dominate the processes of decomposition. A more detailed account of our results is planned for a later paper.

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## Influence of the Blood Glucose-Level on the Secretion of Adrenalin and Noradrenalin from the Suprarenal Medulla

CONSIDERABLE evidence has accumulated to show that hypoglycæmia, for example after insulin, leads to an increased liberation of adrenalin from the suprarenal medulla[1]. This effect may be regarded as a regulating mechanism for the blood sugar homœostasis.

In order to study this possible mechanism, the secretion of adrenalin and noradrenalin has been determined quantitatively in the venous blood after injections of glucose into cats anæsthetized with 'Nembutal'. The venous blood from the left suprarenal was collected by means of a polyethylene tube in the lumbar vein. The amounts of adrenalin and noradrenalin were determined by comparative tests on cat's blood pressure and hen's rectal cæcum[2]. The blood sugar was controlled regularly during the experiment.

On an average, the secretion of noradrenalin and adrenalin was 75 mμgm./min./kgm. (16 per cent adrenalin) at the beginning of the experiments. Glucose was infused in quantities from 0·1 to 0 8 gm./kgm. body-weight. The infusion of 0·1 gm./kgm. brought the secretion of adrenalin down to about 50 per cent, and 0·8 gm./kgm. to 7 per cent, of the secretion at the beginning. As the blood sugar decreased, the adrenalin secretion was found to increase proportionally. The noradrenalin secretion also decreased, but not to the same extent. Similar experiments were carried out on animals with a denervated suprarenal gland. The denervation brought the secretion down to about 25 mμgm./min./kgm. and this level remained unaffected by glucose. The blood glucose-level therefore causes a graded activation of the medullary secretion which is controlled by a nervous mechanism.

An attempt to localize the origin of the effect of glucose was made in the following way. The head of one cat (*A*) was cross-connected with the body of another (*B*). Glucose infused in *B* increased the blood sugar in the head of *A* and led to a decrease of the secretion from its suprarenal in spite of low blood sugar-level in this body. It therefore seems possible that glucose affects the secretion from the suprarenal medulla via some kind of chemoreceptor located centrally.

A further attempt to localize these supposed chemoreceptors was made by local injections of glucose in the hypothalamic region after injection of 0·05 ml. of a 5·5 per cent (isotonic) glucose solution. A marked decrease in the adrenalin secretion was noted in some of these experiments, while control injections of saline failed to produce this effect.

A full account of this work will be published in *Acta Physiol. Scand.*

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## Development of *Ostertagia circumcincta* in the Abomasal Mucosa of the Sheep

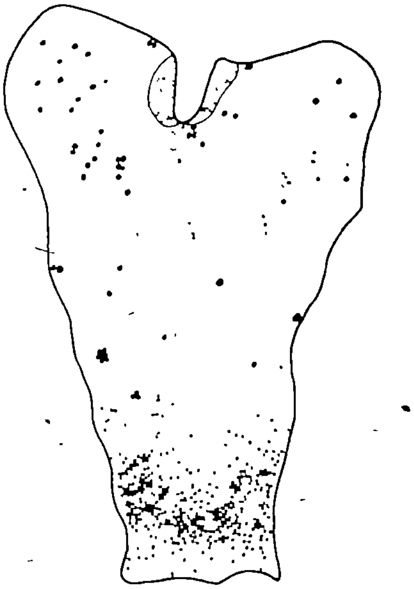
In the course of studies on *O. circumcincta* made at this laboratory, I have found that the phenomena of inhibited development and extended pre-patent period, described in *Nature* by Taylor and Michel[1] with reference to the lungworm *Dictyocaulus viviparus*, are also evident in the development of *O. circumcincta* in the abomasal mucosa of the sheep.

The literature on the 'histotropic phase'[2] of *O. circumcincta* is controversial. Threlkeld[3] found fourth stage larvæ in the mucosa four days after infection, and at eight days found adults and larvæ, both on the surface and within the mucosa. However, on the seventh day the presence of larvæ "for the most part unattached to the mucosa" suggested that larvæ may leave the mucosa, and afterwards repenetrate it. Contrary to this, Dickmans and Andrews[4] state that larvæ develop to maturity without leaving the shelter of the mucosa. The duration of the histotropic phase is not known, but Morgan, Parnell and Rayski[5] failed to find any evidence that it would extend over winter, and concluded that it was unlikely to be of importance in the epidemiology of ostertagiosis.

At this laboratory, worm-free sheep, housed under conditions which prevented accidental infestation, were dosed with 20,000 *O. circumcincta* larvæ each, and killed at intervals from three to eighty-four days later. Examination of the abomasal mucosa suggested that third stage larvæ penetrate the gastric pits on the third and fourth days. Thereafter larvæ may develop in one of several ways. Some may leave the mucosa after the third ecdysis and live on the surface. Others may grow within the mucosa but are able to leave it at any stage of development, although some may remain in the mucosa for a short time when mature. Yet other larvæ may fail to develop, and remain in the gastric pits and glands where they were found in sheep killed three months after the administration of infective larvæ.

The distribution of larvæ in the mucosa is shown in the accompanying drawing. The majority were found, singly or in pairs, in small nodules in the pyloric region, and on the valvulæ terminales around the cardiac orifice. In some sheep larvæ were found in the peptic region in groups of four to ten, usually in large flattened nodules which lie chiefly towards the edges of the spiral folds.

The extended histotropic phase may influence the effects of anthelmintics on *O. circumcincta*, since it is probable that parasites in the gastric pits and glands are protected. Preliminary observations suggest that phenothiazine is less effective against



Distribution of *Ostertagia* in the mucosa of the sheep's abomasum. Small dots represent one or two worms; large dots from four to ten worms

*O. circumcincta* than against *Trichostrongylus* spp.[6]. The extended pre-patent period observed in many of the sheep may be significant in the epidemiology of *O. circumcincta*. Larvæ acquired in any one month may not contribute to the contamination phase, as recorded by worm-egg counts, until several months later, but meanwhile may damage the mucosa.

The observations recorded here concern sheep which were given a single dose of larvæ. Whether a similar picture will be presented by sheep receiving repeated doses (as is assumed to occur in the field) is to be the subject of further investigation. Immunological phenomena may modify the pattern of development and may account for the findings of Morgan *et al.* that the number of larvæ occurring in the mucous membrane of the abomasum and small intestine were always surprisingly low.

A more detailed account of this work will be published elsewhere. The help of my colleague, H. McL. Gordon, is gratefully acknowledged.

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Dec. 2.

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## Differences in the Vitamin $B_{12}$ Content of Cow's Milk during the Last Month Indoors and the First Week at Pasture

THERE is not much information available regarding the amount of vitamin $B_{12}$ in the milk of individual cows[1]. The present work was undertaken to obtain a quantitative idea of the vitamin $B_{12}$ activity in cow's milk during the period of indoor feeding, and during the first week at pasture.

For assaying the vitamin $B_{12}$ potency of the milk, samples were taken twice a week from ten healthy animals of Friesian breed. The cows were milked twice a day, in the morning and in the evening. The morning and evening milk of each cow were analysed separately.

The determination is carried out by the microbiological method using the strain *Lactobacillus leichmannii* A.T.C.C. 4797. The response of the organism to vitamin $B_{12}$ activity was measured in terms of titratable acidity, and the experimental conditions necessary for obtaining consistent results were standardized. The results are shown in the accompanying table.

AVERAGE VITAMIN $B_{12}$ CONTENT OF MILK IN $\mu$GM. PER LITRE

| Cows | Morning milk | Evening milk | Daily production |
|---|---|---|---|
| Indoors | 5·96 | 6·65 | 6·31 |
| At pasture | 10·52 | 12·00 | 11·10 |

The vitamin $B_{12}$ level in the morning milk is in all cases evidently lower than that of evening milk. Indoors, the average production of milk in the morning was 10·98 lit., and in the evening 9·37 lit.; for animals at pasture, it was 9·53 and 6·90 lit. respectively for the first week. In the second week, the average production was the same as indoors. The morning milk showed an average vitamin $B_{12}$ content of 5·96 μgm. per lit. for cows indoors and 10·52 μgm. per lit. for cows at pasture, while the highest values observed were respectively 7·60 and 20·40 μgm. per lit. and the lowest 4·10 and 6·8 μgm. per lit. for morning milk indoors and at pasture.

The average vitamin $B_{12}$ activity in evening milk of cows indoors is 6·65 μgm. per lit. and of cows at pasture 12·00 μgm. per lit. Indoors, the maximum and minimum values found were 9·6 and 5·2 μgm. per lit. respectively, and at pasture 15·50 and 8·50 μgm. per lit. respectively. The daily production showed an average value of 6·31 μgm. vitamin $B_{12}$ per lit. for cows indoors and 11·10 μgm. per lit. for cows at pasture.

In agreement with the observation of de Heus[2], the increase in vitamin $B_{12}$ activity of milk of cows on grass is approximately twice that of cows indoors. All animals showed this increase in the first week on grass. It may be suggested that the micro flora of the rumen of cows at pasture changes to the advantage of the micro-organism producing vitamin $B_{12}$.

A detailed account of this work will be published elsewhere.

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[1] Sreenivasamurthy, V., *et al.*, *Ind. J. Dairy Sci.*, 3, 179 (1950). Collins, R. A., *et al.*, *Fed. Proc.*, 9, 356 (1950). *J. Nutrition*, **43**, 313 (1951). Anthony, W. B., *et al.*, *J. Dairy Sci.*, **34**, 749 (1951).

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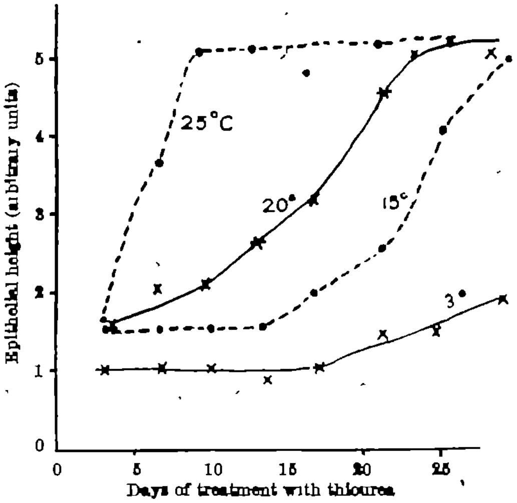
## Thyroid Activity in Teleosts

THE available evidence suggests that a calorogenic effect of the thyroid is doubtful in Teleosts. There has been a failure to modify the oxygen consumption, and therefore the heat production, by increasing or decreasing the amount of thyroid hormone available. Furthermore, the gland, as demonstrated in *Phoxinus lævis* and *Lebistes reticulatus*, unlike that of the higher animals, shows a regression with low external temperatures, and an increase of activity with high. This is emphasized by treatment with thiourea, for immersion of the fish in 0·05 per cent thiourea (changed twice weekly) results in an increase in epithelial height and a decrease in the amount of colloid present. These changes are more rapid when the treatment is applied at a constant high temperature. In this instance the activity has been measured arbitrarily by the epithelial height. For example, in October 1951, the gland of *Phoxinus lævis* showed a maximal structural effect after ten days at 25° C., whereas at 3° C. there was only a slight rise after three weeks (see graph).

It is unlikely, therefore, that the Teleost thyroid is functioning as a thermo-regulator, and it would not be expected to exert a calorogenic effect.

Terrestrial animals live in an environment of low thermal capacity and are exposed to great changes of external temperature; in addition, if the internal temperature becomes too great, there is a danger of death by desiccation, so that animals with a thyroidean type of thermo-regulator would have a selective advantage. The Teleost, in an environment of high thermal capacity, would not be subjected to such selection and so provides an example of physiological evolution.



This raises the question of the function of the thyroid in Teleosts. Some light may be thrown on this by the fact that thiourea-treated Teleosts can withstand much higher temperatures than usual. *Phoxinus laevis*, which, under conditions used, generally dies at 23° C., appears normal at 33° C., and *Lebistes reticulatus* shows a similar effect.

This fact, in addition to demonstrating a physiological effect of thiourea on Teleosts, suggests that there is yet another manner in which the thyroid can act as a mediator between the organism (in this case the fish) and its environment. Barrington and Matty[1] have recently shown a correlation between the thyroid and the reproductive organs; but it is possible that the thyroid exerts a more widespread influence, and treatment with thiourea may disturb the entire endocrine balance in the Teleosts in a manner unlike that in the higher vertebrates.

Further details of these experiments will be published elsewhere.

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[1] Barrington and Matty, *Nature*, 170, 105 (1952).

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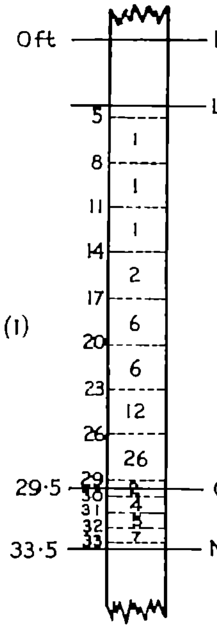
## Vertical Distribution of *Teredo norvegica*

THE literature dealing with the wood-boring bivalve, *Teredo*, is extensive. The majority of investigations, however, have dealt with floating structures and little attention has been paid to the problem of vertical distribution. During a recent investigation into an attack of *T. norvegica* on wooden structures at Loch Ryan, Scotland, information was obtained regarding the vertical distribution of this species.

In order to estimate the extent of the infection a wooden pile, 62 ft. long, was removed from a jetty and examined. This member of the structure had been in service for ten years but had been disturbed, with a resultant rise to 4 ft. above its original position, approximately three years before being pulled. The distribution of entry holes over the seaward face of this pile is shown in Fig. 1. There is an obvious increase with increase in depth down to the original mud-line at 29·5 ft. below M.T.L. This is followed by a sharp decrease at the original mud-line and a second increase down to the new mud-line at 33·5 ft. The number of *Teredo* holes in cross-sections of the pile shows a similar distribution. At 23·5 ft. there were 14, at 26·5 ft. 28 and at 29·5 ft. 52. Thus, within the vertical range covered by this pile, that is, down to 33·5 ft. below M.T.L., there is an increase in the intensity of infection with increase in depth.

There is little in the literature to explain this very marked distribution of *Teredo*. The larvae of *Teredo* tend to sink passively downwards whenever ciliary activity ceases. This tendency may possibly explain the distribution of *T. norvegica* observed at Loch Ryan. Observations on *T. pedicellata*, however, do not support this explanation. Doochin *et al.*[1] have suggested that the presence of a layer of silt near the mud-line would offer immediate protection from the mechanical effects of current. Unlike the cyprids of barnacles, the larvae of shipworms are not affected by the presence of a layer of silt. They are able to burrow through it. Isham *et al.*[2] have recently investigated the effect of light upon larvae of *T. pedicellata*. The results do not allow of any but tentative conclusions. It would appear from their experiments that settlement and subsequent boring may be expected to occur at a maximum under conditions of illumination of 160 ft.-candles. Illumination at the surface of open water on a bright day is of the order of 20,000 ft.-candles[3]. Thus, the figure of 160 ft.-candles represents deep shade.

The conclusions that light and the presence of a layer of silt may affect the vertical distribution of shipworm larvae would appear to agree with the distribution of *T. norvegica* observed at Loch Ryan. It is interesting to note, however, that the under-surfaces of horizontal structures suffered from a much heavier infection than did vertical surfaces at the same level. Similarly, an underwater survey by divers revealed that the raker piles, which are inclined at an angle to the vertical, were most heavily infected in the region shown in Fig. 2. This is the region of maximum shade.



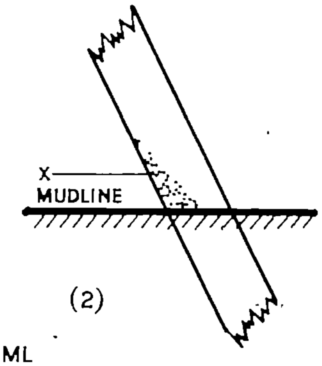


Fig. 1. Vertical distribution of entry holes of *T. norvegica* over the seaward face of a wooden pile. The measurements are given in feet below M.T.L. *NML*, new mud-line; *OML*, original mud-line

Fig. 2. Diagram of a raker pile near the mud-line to indicate the region most heavily attacked by *T. norvegica*. *X*, region of greatest attack

These observations suggest that the larvæ of *T. norvegica* tend to settle in increased numbers in dimly lit regions and that the presence or absence of a layer of silt is of little importance. More information is required, however, before the importance of light as a factor in determining the vertical distribution of *Teredo* can be accurately assessed.

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## Life-history of *Gorgoderina vitelliloba* (Olsson)

AMERICAN species of the subfamily Gorgoderinæ (Trematoda) exhibit life-histories which appear to fall into two distinct groups. In the genus *Phyllodistomum*, the host into which the miracidium penetrates is a freshwater cockle of the family Sphæriidæ, and the cercaria passively enters a dragonfly nymph, where the metacercarial cyst is formed. Life-cycles of this nature have been determined by Goodchild[1] and others. In the second type of life-history, as exemplified by that of members of the genera *Gorgodera* and *Gorgoderina*, while the miracidial host is again a freshwater cockle, the metacercarial host is usually a tadpole. Goodchild[2], Krull[3] and Rankin[4] have determined experimentally life-histories of this type.

Ssinitsin[5] described the life-cycle of *Gorgoderina vitelliloba*, the only European species of its genus, and recorded the metacercarial host as being a dragonfly nymph. If dragonfly nymphs are the usual metacercarial host for this species, it would appear that the European species of *Gorgoderina* has a life-cycle similar to those of American species of *Phyllodistomum* and different from American species of its own genus. Joyeux and Baer[6], however, have described a cercaria, liberated from sporocysts developing in *Sphærium corneum*, which they believe to be the cercaria of *Gorgoderina vitelliloba*. These cercariæ when fed to tadpoles produced metacercariæ.

The purpose of this communication is to place on record the fact that in England I have found tadpoles of *Rana temporaria* to contain metacercarial cysts, which when fed to frogs and toads known to be free from *G. vitelliloba* gave rise to infestations with this parasite. In addition, I have completely determined the life-cycle of *G. vitelliloba* in the laboratory and found the miracidia to enter both *Sphærium* spp. and *Pisidium* spp., but more frequently the latter. Cercariæ, when fed to tadpoles of *Rana temporaria*, produced metacercariæ which were used for infecting the definitive hosts. It would appear, therefore, that *G. vitelliloba* in England has a life-cycle similar to that of American species of the genus.

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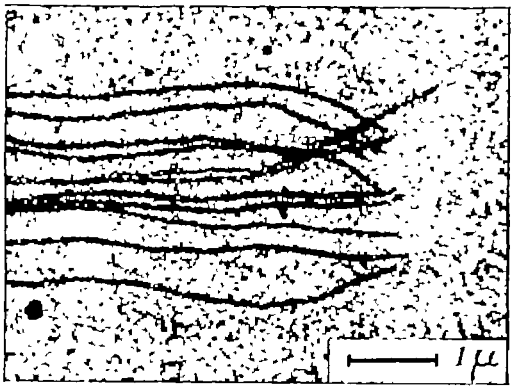
## Number of Fibrils in the Cilia of the Green Algæ

READERS of *Nature* who may have noticed the simultaneous appearance in the issue of February 14 of two independent communications[1,2] on plant cilia, one of them an abstract[2] of a paper of our own, could be misled by the accidents of context and wording into the belief that we are trying to use the internal structure of cilia as a basis for phyletic conclusions and that there is a fundamental difference between the green algæ in which Astbury and Saha[1] have found nine strands and all other plants in which there are eleven. To prevent such a mistake, it will perhaps be helpful to point out that the structure of the ciliary axis in all groups of plants and animals in which accurate work has been done appears to be identical. There is a precise and predetermined fibrillar structure composed of nine peripheral strands and a central pair (making eleven strands in all); there is also a superficial skin, some other components within the fibrils, and in certain cases at least there is a spiral winding between the peripheral fibrils and the core.

These facts are not controversial. Photographic evidence for all the more important plant groups possessing ciliated cells has been published by us in the *Journal of Experimental Botany* in a series of papers[3] during the past two years. Much of this is summarized in the report[4] of the 1951 Symposium of the Society of Experimental Biology, which also contains an electron micrograph showing the eleven strands in the green alga *Ulothrix*. Our most recent publication[5], on the moss *Sphagnum*, contains a diagrammatic reconstruction of the micro-anatomy of a cilium, the correctness of which as a generalized statement applicable to other groups, at least as regards the essentials of the transverse section, has been powerfully confirmed by the very beautiful thin sections prepared by Fawcett and Porter[6] of Harvard Medical School, who have communicated to us original prints of micrographs of transversely cut cilia in a frog, a mollusc and man, all of which show the same arrangement and number of strands. The eleven strands in animals have also been very clearly demonstrated among others by Jakus and Hall[7] in the cilia of *Paramecium* and by Grigg and Hodge[8] in the sperm tails of the fowl.

Where other numbers have been reported this is sometimes, and possibly always, due to imperfect observation or to imperfect material. Thus the two central strands often decompose more readily than the others or they may fall out, leaving only the peripheral nine. We have a paper passing through the press now[9] correcting an earlier mistake of our own (in the hind flagellum of *Fucus*) due to this cause. Astbury and Saha's figured specimen of *Polytomella*[1] (a colourless member of the Volvocales) is undoubtedly in the same condition. We append a micrograph of the green alga *Chætomorpha* which shows unequivocally that in a complete specimen the normal complement of eleven strands can quite easily be found in this group as in others.

No phyletic significance can, of course, be attributed to a character as widespread as this, and the only possible interpretation is in terms of functional or structural mechanics. Some aspects of these are discussed in our paper on *Sphagnum*[5] and others in a new paper[9] on the brown algæ which is in the press. The phyletic conclusions mentioned in the summary in *Nature* of Manton, Clarke, Greenwood



Electron micrograph of the distal end of a dismembered cilium of the green alga, *Chaetomorpha melagonium*, stained to show the number of fibrils without other details, and stripped from glass as described in Manton, Clarke, Greenwood and Flint (ref. 2). Philips electron microscope, 60 kV., unshadowed, magnification × 12,000

and Flint[2] depend on the characters provided by external appendages which in a limited number of plant groups (but not in animals, land plants or green algæ) are borne upon the cilia. This will be obvious to anyone familiar with our work as published, though the cross-reference to Astbury and Saha's article in the summary of our paper might otherwise be misleading.

The specimen figured was from a preparation made by A. D. Greenwood and B. Clarke from fresh material collected at Cullercoats by Dr. E. Nicolai in January 1952.

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Feb. 20.

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[2] *Nature*, 171, 289, abstracting Manton, I., Clarke, B., Greenwood, A. D., and Flint, E. A., *J. Exp. Bot.*, 3, 204 (1952).

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[8] Grigg, G. W., and Hodge, A. J., *Aust. J. Sci. Res.*, 2, 271 (1949).

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## Growth and Optical Properties of Stearic Acid Crystals

We have applied optical and interferometric techniques to stearic acid crystals ($CH_3(CH_2)_{16}COOH$) which were grown from a dilute solution in benzene of the compound. Tabular crystals were produced by slow evaporation of a drop of this solution placed upon a clean, cooled microscope slide. Many spiral features have been observed upon the basal planes by examining the silvered crystals under phase-contrast illumination. These are growth spirals in accordance with the dislocation theory of Burton, Cabrera and Frank[1].

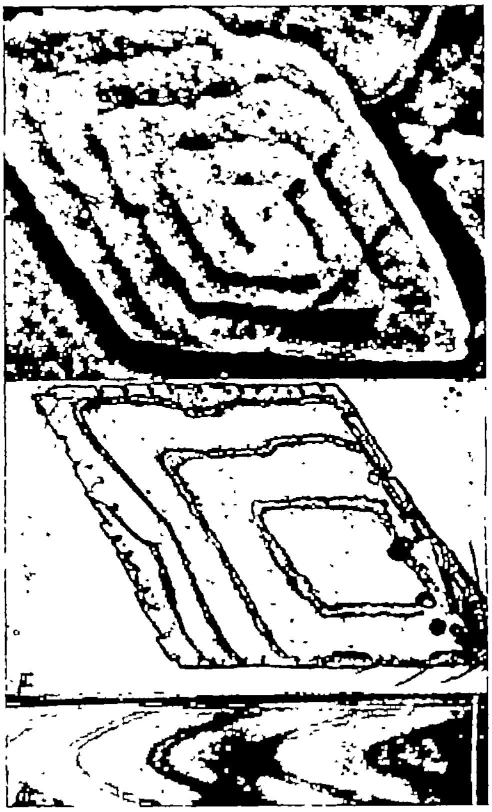
Fig. 1 (top) shows a growth spiral and a terminated line which can be interpreted as a ledge between the point of emergence of the screw dislocation on the underside of the crystal and the crystal boundary.

In addition, by the rapid evaporation of a drop of solution upon a warmed glass plate, circular spiral patterns have been obtained. These 'evaporation figures' have not been identified as growth spirals. The existence of oriented overgrowth has also been established.

Stearic acid is a monoclinic crystal with lattice parameters[2] $c = 48 \cdot 84$ A.; $\beta = 63° 38'$. Since the crystals were small (approximately 200 μ), the multiple-beam surface topography interference fringes generally obtained by matching the silvered crystal against a silvered optical flat could not easily be employed to determine the spiral step-height. It was found satisfactory to use the interferometric techniques formerly used with thin sheets of mica. The multiple-beam interference fringes produced by the internal reflexion between the two silvered surfaces of the crystal were thus found more convenient and accurate for the measurement of step-heights. We have made a large number of measurements and found that most of the step-heights are small integral multiples of 45 ± 5 A., which within experimental errors agree with the predicted X-ray repeat unit.

Fig. 2 (middle) illustrates the multiple-beam reflexion Fizeau fringes given by a doubly silvered crystal plate. The fringes are contouring a spiral so that they are parallel to the growth edges and, being very sharp, appear double owing to the birefringence of stearic acid. The two components are polarized at right-angles to each other. In Fig. 3 (bottom), the fringes of equal chromatic order[3] for a line section across the peak of this growth spiral are shown; the birefringence of the crystal is again obvious. These fringe patterns permit an accurate determination of the birefringence and also other optical properties of the crystal, in a manner already established.

A more detailed account of these investigations has been communicated elsewhere[4]. We thank Prof.



S. Tolansky for his interest and encouragement in this work. One of us (A. R. V.) wishes to express his thanks for the Imperial Chemical Industries Fellowship of the University of London, and to the University of Delhi for an extension of study leave.

*Note added in proof.* Since then, in addition to a step of unit height equal to 46·3 ± 0·8 A., we have measured steps which are odd-half integral multiples of the X-ray repeat unit.

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[1] Burton, W. K., Cabrera, N., and Frank, F. C., *Phil. Trans. Roy. Soc.*, A, 243, 299 (1951).

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## Radiation Induced by Alpha-Particles in Thin Films

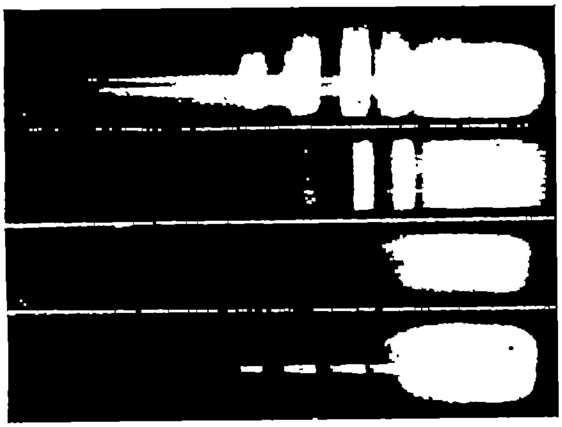
We have examined spectrographically the light emitted by thin films bombarded by α-particles[1]. The films were built up by evaporation on quartz slides to a thickness small compared with the range of the α-particles. The slides were mounted in front of the slit of a Hilger $f/4$ quartz spectrograph and exposed to a 25-mC. polonium source. Representative spectra, photographed on Eastman Kodak type II-0 spectroscopic plates, are shown in the accompanying photograph.

Spectrum (*a*) shows the continuum emitted by collodion extending, left to right, from about 230 mμ to about 470 mμ. The wave-length limits are set by the sensitivity of the photographic plate and not by the spectral energy distribution of the emitted light. Superimposed on the continuum are a number of bands which come from air molecules and from oxygen bound to the polonium[2]. At a slit-width of 0·2 mm. these bands are resolved into a series of lines listed in the accompanying table.

LIGHT FROM POLONIUM IN AIR

| Wave-length (mμ) | Rel. intensity | Wave-length (mμ) | Rel. intensity |
|---|---|---|---|
| 298 | 5 | 355 | 4 |
| 300 | 5 | 359 | 2 |
| 313 | 5 | 376 | 4 |
| 314 | 4 | 382 | 4 |
| 326 | 3 | 392 | 4 |
| 330 | 5 | 402 | 6 |
| 336 | 5 | 408 | 6 |
| 338 | 1 | 430 | 6 |

Spectrum (*b*) is obtained from a film of deoxyribonucleic acid of thickness corresponding to approximately 2 mgm./cm.$^2$. The film is transparent to the light from the polonium source, which again gives the characteristic superimposed bands. Spectrum (*c*) is from aluminium. Spectrum (*d*) comes from a thin film of gold (above) and a thin film of copper (below) separated by a narrow gap. Light from the polonium source can be seen through the gap on the quartz slide. It is clear, therefore, that films of collodion, deoxyribonucleic acid, aluminium, gold and copper, when bombarded by α-particles, emit radiation in a continuum from 230 to 470 mμ, the region of observation.



(*a*) Collodion; (*b*) deoxyribonucleic acid; (*c*) aluminium; (*d*) gold (above) and copper (below), separated by a narrow gap. Slit width, 2·5 mm. Exposure times, about 60 hr. for (*a*), (*b*) and (*d*), and 20 hr. for (*c*)

Dee and Richards[3] irradiated thin films of water on a quartz slide and found that chemical reactions were induced in solutions placed beneath the quartz. The chemical reactions were ascribed to quanta emitted from the bombarded water. To investigate the nature of these quanta we immersed the polonium source in water and made an eleven-day exposure. No radiation other than the lines listed in the table was observed. The failure to find such additional radiation from the water implies that any quanta emitted by the water must lie at wave-lengths shorter than 230 mμ, and hence beyond the limits of detection of our system.

We are indebted to Dr. R. E. Nusbaum, Mr. G. V. Alexander and Mr. F. W. Bishop for technical assistance.

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Paul M. Kratz

Department of Radiology,
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Sept. 3.

[1] Richards, H. W. T., and Cole, J. F. L., *Nature*, 167, 286 (1951).

[2] Ortner, G., and Salim, S., *Nature*, 169, 1060 (1952).

[3] Dee, P. I., and Richards, H. W. T., *Nature*, 168, 736 (1951).

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## Structural Skeleton in a Bituminous Coal

Our previous experiments on the rheological properties of coal, determining Young's modulus by a resonant frequency method[1], internal viscosity by measuring the vibrational decrement at audio-frequencies[2], and breaking-strength by measuring the stress applied for rupture for various durations of load[3], have shown that variations of these properties with ash concentration in coal expressed by volume parts are linear.

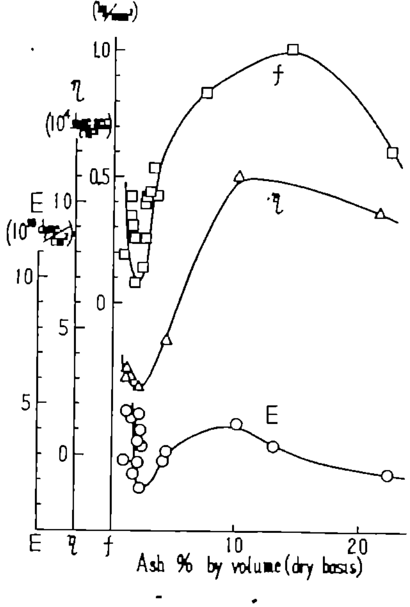
I have therefore suggested that in the caking coals ash particles 'solvate' coal molecules and form a micellar structure, as in the rubber–carbon black system. Although the proposed micellar structure is fundamentally different from that used by D. H.

Bangham *et al.*[4], it is believed that the physical picture presented can be used for interpreting the rheological properties and especially the caking phenomena. The state of ash in caking coal as an active 'filler' is not specified; but it is inferred that the active filler in general has strong affinity for the matrix molecules and is finely dispersed, so that the 'active' ash is likely to correspond to the inherent ash of coal.

Recently, we recognized interesting anomalies in these values for a Japanese bituminous caking coal, Takashima, with an average volatile matter of 38 per cent (dry ash-free), as illustrated in the graph; minima were shown in the range of 2 per cent of ash-volume concentration, and maxima in the 8–10 per cent range. These results seem to support the theory that the inorganic matter plays a significant part in the structure of coal and its properties. The linear relationship between the values and ash content is considered to be in the range of 2–10 per cent of ash for this sample.

It is well known in rubber science that elastic constant, viscosity coefficient and tensile strength at first decrease with loading with carbon black (up to 10 per cent by volume[5]), followed by an increase of these properties for greater loadings up to a point (30 per cent by volume[5]) where the stiffening ends by overloading. The similarity in variations of rheological properties between the two systems, with 'filler' and matrix, is interesting, despite the numerical differences in ranges of filler content. It may be suggested that the first minima at 2 per cent of ash content correspond to the state where the micellar spheres, in which the coal molecules are solvated by ash particles as nuclei, first touch each other, forming a sort of scaffolding, and the second maxima at approximately 10 per cent of ash content represent the point where the micellar spheres form a close-packed state.

Taking a sample with 10·13 per cent ash by volume of Takashima coal, the specific surface area was found by the iodine adsorption method[6] at 25·0° C. to be 9·51 × 10⁴ cm.²/gm. (dry basis) and the density in methanol was 1·24 (25·0° C.). Assuming the close-packed state of micellar spheres for the range of 10 per cent ash and that each micelle has an untruncated surface, the radius of the sphere was calculated as 2540 A., and the radius of the ash particles serving as nuclei was estimated as 1160 A.; these dimensions of ash are nearly the same as those of some kinds of carbon blacks. The micellar dimensions are expected to be largest for caking coals, because the solvation factors of molecules around ash are highest[1,2] and, as is widely recognized, the variation of the specific surface area with the rank of coals shows a minimum for the bituminous coal group.



Experimental results on the variations of rheological properties of Takashima bituminous coal: *E*, Young's modulus; *η*, internal viscosity coefficient; *f*, breaking strength

The detailed results of this investigation will be published in *Bull. Chem. Soc. Japan*, as part of an investigation of the rheology of coal. I am indebted to Mr. H. Tani for help in the experiments.

KATSUYA INOUYE
Resources Research Institute,
Saitama-Kawaguchi,
Japan.
Aug. 20.

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[1] Inouye, K., *J. Colloid Sci.*, **6**, 190 (1951).
[2] Inouye, K., *Bull. Chem. Soc. Japan* (in the press).
[3] Inouye, K., and Tani, H., *Bull. Chem. Soc. Japan* (in the press).
[4] Bangham, D. H., Franklin, R. E., Hirst, W., and Maggs, F. A. P., *Coal Research*, 153 (1948).
[5] Guth, E., *J. App. Phys.*, **16**, 20 (1945).
[6] Inouye, K., *J. Fuel Soc. Japan*, **29**, 112 (1950).

## Diffusion of Silicon in Ferrite

WE have recently carried out some measurements on the diffusion of silicon at low concentrations in ferrite at one temperature near to the melting point. Specimens (cylinders of ¼ in. diameter) were made of pure iron butt-welded to a 3–4 per cent silicon iron alloy. These were heated for differing times at the temperature 1,435 ± 5° C., cooled and sectioned along a plane perpendicular to the weld interface. The diffusion of silicon into the iron across the interface was measured by traversing the section with a spectrograph spark. By correcting for the finite size of the sparked zone and standardizing the spectrograph with samples of known silicon content, curves of silicon concentration versus distance were plotted. The diffusion coefficient of silicon was obtained by applying Fick's law and the result (mean of five determinations) was $D_\gamma = 1\cdot1 \times 10^{-7}$ cm.²/sec. The grain-sizes of the specimens were large enough to assume that at the temperature used the contribution of grain-boundary diffusion was small, and it is thought that overall error in $D$ should not be greater than ± 20 per cent.

The variation of $D$ with temperature may be calculated if Zener's theory[1] is assumed. Depending on whether vacancy or ring diffusion occurs, respectively, $D_\gamma = 16 \exp(-64{,}000/RT)$, or $310 \exp(-74{,}000/RT)$ cm.²/sec.

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K. SPEIGHT
Metallurgy (General) Divisional Laboratory,
British Iron and Steel Research Association,
Royal School of Mines,
London, S.W.1.
Oct. 1.

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[1] Zener, C., *J. App. Phys.*, **22**, 372 (1951).

# FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

## Saturday, March 14

Botanical Society of the British Isles (at the Linnean Society of London, Burlington House, Piccadilly, London, W.1), at 2.15 p.m.—Annual General Meeting.

## Monday, March 16

Society of Chemical Industry, London Section (at the Chemical Society, Burlington House, Piccadilly, London, W.1), at 6.30 p.m.—Scientific Papers.

Royal Geographical Society (at 1 Kensington Gore, London, S.W.7), at 8.15 p.m.—Prof. W. Q. Kennedy, F.R.S.: "The Mountains of the Moon" (Mrs. Will Gordon Lecture).

## Monday, March 16—Wednesday, March 18

Institution of Electrical Engineers, Measurements Section (at Savoy Place, Victoria Embankment, London, W.C.2).—Symposium on "Insulating Materials".

## Tuesday, March 17

London Mathematical Society (at the Royal Astronomical Society, Burlington House, Piccadilly, London, W.1), at 5 p.m.—Prof. T. Fort: "Boundary-Value Problems for Ordinary and Partial Linear Difference Equations".

Society of Chemical Industry, Crop Protection Panel of the Agriculture Group (at the Chemical Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Dr. E. H. Turtle: "Rodenticides".

## Wednesday, March 18

Royal Sanitary Institute (at 90 Buckingham Palace Road, London, S.W.1), at 2.30 p.m.—Mr. H. A. Cox: "The Importance of Timber Preservation in the National Economy".

Royal Society of Arts (at John Adam Street, Adelphi, London, W.C.2), at 2.30 p.m.—Mr. H. A. R. Binney: "Fifty Years' Work on Industrial Standards".

Geological Society (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Dr. R. G. S. Hudson and Mr. D. M. Martin: "The Structure of the Jebel Hagab Area, Trucial Oman".

Royal Meteorological Society (at 49 Cromwell Road, London, S.W.7), at 5 p.m.—Mr. B. J. Mason: "The Growth of Ice Crystals in a Super-cooled Water Cloud"; Mr. R. Wexler: "Theory of the Radar Upper Band"; Mr. I. C. Browne: "Precipitation Streaks as a Cause of Radar Upper Bands".

Royal Society of Medicine, Comparative Medicine Section (at 1 Wimpole Street, London, W.1), at 5 p.m.—Discussion on "Some Biological Aspects of Mucin".

Royal Statistical Society, Research Section (at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 5.15 p.m.—Dr. C. A. B. Smith: "The Detection of Linkage in Human Genetics".

British Ornithologists' Union (at the Zoological Society of London, Regent's Park, London, N.W.1), at 6 p.m.—Annual General Meeting.

Royal Institute of Chemistry, London Section (joint meeting with the London Section of the Society of Chemical Industry, in the Large Chemistry Lecture Theatre, University College, Gower Street, London, W.C.1), at 6.30 p.m.—Dr. F. Sanger: "The Chemistry of Insulin".

## Thursday, March 19

Institute of Metal Finishing (at Charing Cross Hotel, Strand, London, W.C.2), at 2.30 p.m.—Inaugural Meeting of the Organic Finishing Group; at 3 p.m.—Mr. A. A. B. Harvey: "Problems of Paint Application"; at 4.30 p.m.—Mr. D. H. Lloyd: "Problems of Dip and Spray Painting".

Royal Society (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Scientific Papers.

Imperial College Chemical Society (in the Main Chemistry Lecture Theatre, Royal College of Science, Imperial Institute Road, London, S.W.7), at 5 p.m.—Prof. R. G. W. Norrish, F.R.S.: "Recent Studies in the Combustion of Hydrocarbons".*

Linnean Society of London (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Mr. Frank L. Hill: "The Natural History of the Monte Bello Islands".

Society of Chemical Industry, Microbiology Group (at the Medical Society of London, 11 Chandos Street, Cavendish Square, London, W.1), at 6 p.m.—Annual General Meeting; at 6.15 p.m.—Dr. H. S. Holden: "Microbiology and Crime".

Society of Chemical Industry, Road and Building Materials Group (at the Building Centre, Store Street, London, W.C.1), at 6 p.m.—Mr. D. B. Honeyborne: "Differential Thermal Analysis and its Application to the Study of Building Materials".

Oil and Colour Chemists' Association, London Section (at the Royal Society of Tropical Medicine and Hygiene, Manson House, 26 Portland Place, London, W.1), at 7 p.m.—Mr. W. A. Caldwell and Mr. J. Creasy: "The Effect of some Physical Properties of Nitrocellulose on Lacquer Performance".

Chemical Society (at Burlington House, Piccadilly, London, W.1), at 7.30 p.m.—Prof. J. R. Partington: Nernst Memorial Lecture.

Royal Society of Tropical Medicine and Hygiene (at the Royal Army Medical College, Millbank, London, S.W.1), at 7.30 p.m.—Laboratory Meeting.

## Friday, March 20

Society for Water Treatment and Examination (at the Laboratories, Metropolitan Water Board, New River Head, Rosebery Avenue, London, E.C.1), at 10 a.m.—Annual General Meeting; Scientific Papers.

Royal Microscopical Society, Industrial Section (joint meeting with the Industrial Spectroscopy Group of the Institute of Physics, the Optical Group of the Physical Society and the Physical Methods Group of the Society of Public Analysts and other Analytical Chemists, at King's College, Strand, London, W.C.2), at 2.30 p.m.—Symposium on "Developments in Microscopical Methods".

Institute of Navigation (at the Royal Geographical Society, 1 Kensington Gore, London, S.W.7), at 5 p.m.—Dr Samuel Herrick: "Dead Reckoning in Space".

Institution of Mechanical Engineers (joint meeting with the Applied Mechanics Group, at Storey's Gate, St. James's Park, London, S.W.1), at 5.30 p.m.—Dr. J. H. Lamble and Dr. Salah E. A. Bayoumi: "A Room Temperature Photoelastic Technique for Three-dimensional Problems"; Mr. J. D. C. Crisp: "The Use of Gelatin Models in Structural Analysis".

British Institute of Radiology (in the Reid-Knox Hall, 32 Welbeck Street, London, W.1), at 6.30 p.m.—Dr. L. F. Lamerton: "A Study of the Phases of Radiation Response in the Rat".

Royal Institution (at 21 Albemarle Street, London, W.1), at 9 p.m.—Prof. H. W. Melville, F.R.S.: "The Size and Shape of Big Molecules".

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# APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Principal Scientific Officer at the Atomic Energy Research Establishment, Harwell, to take charge of small group engaged in problems of heat transfer, and special problems arising in development of nuclear energy for power purposes, involving design of special experimental apparatus—The Civil Service Commission, Scientific Branch, Trinidad House, Old Burlington Street, London, W.1, quoting S.4190/53 (March 19).

Senior Scientific Officers (with a first- or second-class honours degree in chemical engineering, or in chemistry or engineering with postgraduate diploma in chemical engineering, or equivalent qualification) for pilot plant and process development; a Senior Experimental Officer or Experimental Officer (with a comprehensive experience of chemical plant operation and control); and a Senior Experimental Officer to assist in design, construction and operation of apparatus to be used in development of methods of handling liquid metals, to supervise running of test rigs and to train junior staff; in the Chemical Engineering Division of the Atomic Energy Research Establishment, Harwell—The Civil Service Commission, Scientific Branch, Trinidad House, Old Burlington Street, London, W.1, quoting S.4188/53 (March 19).

Experimental Officer to investigate rejection tests for raw farm milk (extensive laboratory experience is necessary with, preferably, a degree or equivalent qualification in bacteriology or chemistry)—The Secretary, National Institute for Research in Dairying, Shinfield, Reading, quoting Ref. 53/5 (March 21).

Lecturer (with good honours degree in chemistry and appropriate teaching experience) in the Department of Chemistry and Biology, to teach physical chemistry, with some inorganic chemistry, to final degree standard, and a Lecturer (with good honours degree in physics and appropriate teaching experience) in the Department of Physics and Mathematics, to teach physics to final degree standard—The Principal, Acton Technical College, High Street, Acton, London, W.3 (March 21).

Senior Agricultural Economist in the Agricultural and Marketing Branch of the Department of Agriculture and Lands, Southern Rhodesia Government—The Secretary, Rhodesia House, 429 Strand, London, W.C.2 (March 21).

Statistician (part-time) in the Health and Welfare Department—The Medical Officer of Health, Willowbank House, Willowbank Road, Aberdeen (March 21).

University Assistants in Genetics, Civil Engineering, Animal Husbandry and Preventive Medicine (chemist or biochemist)—The Secretary of University Court, The University, Glasgow (March 21).

Assistant Lecturer in Chemistry—The Registrar, College of Technology, Manchester 1 (March 23).

Assistants (with first- or second-class honours degree in electrical or mechanical engineering or in physics and, preferably, some research experience) on the scientific staff of the B.E.A. Research Laboratories at Leatherhead—The Director of Establishments, British Electricity Authority, British Electricity House, Winsley Street, London, W.1, quoting AE/337 (March 23).

Educational Psychologist—The Chief Education Officer, Education Office, Margaret Street, Birmingham 3 (March 23).

Plant Pathologist (Scientific Officer grade) and an Assistant Experimental Officer—The Secretary, National Vegetable Research Station, Wellesbourne, Warwick (March 23).

Physicist to assist in the general work of the Physics Department—The National Coal Board, Central Research Establishment, Stoke Orchard, Cheltenham, quoting TT/595 (March 25).

Assistant Agricultural Economist (with a degree in economics or agriculture with economics)—The Registrar, The University, Manchester 13 (March 28).

Cytologist to the Division of Plant Industry, Canberra—The Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2 (March 28).

Dental Research Fellow—The Dean, Guy's Hospital Medical School, London, S.E.1 (March 28).

English Electric Company Research Fellowship in Aeronautics—The Secretary of University Court, The University, Glasgow (March 28).

ENTOMOLOGIST (Grade II), an ENTOMOLOGIST (Grade I), an AGRONOMIST (Grade II), an AGRONOMIST (Grade I), a PLANT BREEDER (Grade II), a PLANT BREEDER (Grade I), and a SOIL SURVEY OFFICER (Grade I) in the Department of Agriculture, Stock and Fisheries, Papua and New Guinea—The Official Secretary, Australian High Commissioner's Office, Australia House, Strand, London, W.C.2 (March 28).

LECTURER IN BIOCHEMISTRY—The Registrar, The University, Sheffield (March 28).

SENIOR GEOLOGIST (with a degree in science or engineering, and some experience in prospecting for mineral resources, preferably in the United Kingdom) to act in a general advisory capacity—The National Coal Board, Establishments (Personnel), Hobart House, Grosvenor Place, London, S.W.1, quoting TT/302 (March 28).

ASSISTANT LECTURER IN MATHEMATICAL STATISTICS—The Registrar, The University, Manchester 13 (March 31).

H.M. INSPECTORS (with appropriate professional qualifications and teaching, and practical experience desirable in agriculture, mechanical engineering, mining, architecture, building or management studies)—The Secretary (Inspectors' Section), Ministry of Education, Curzon Street, London, W.1 (March 31).

JOHN MURRAY TRAVELLING STUDENTSHIP IN OCEANOGRAPHY AND LIMNOLOGY—The Assistant Secretary, Royal Society, Burlington House, Piccadilly, London, W.1 (March 31).

LECTURER (with special interests in soil science or plant nutrition) IN AGRICULTURAL CHEMISTRY, and a LECTURER (with special interests in some branch of electrochemistry) IN CHEMISTRY—The Secretary of University Court, The University, Glasgow (March 31).

MEDICAL STATISTICIAN to the Nuffield Department of Industrial Health—The Professor of Industrial Health, King's College, Newcastle-upon-Tyne (March 31).

ANIMAL GENETICIST (with a degree in agriculture and at least two years postgraduate study of animal genetics) in the Department of Agriculture, Nigeria—The Director of Recruitment, Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting CDE.03/14/012.

ASSISTANT (graduate in medicine, biology, psychology, sociology, or any other social science) IN THE DEPARTMENT OF PUBLIC HEALTH AND SOCIAL MEDICINE—The Secretary, The University, Edinburgh.

ASSISTANT CHEMIST (B.Sc., preferably with power station experience), ELECTRICAL ENGINEERS, MECHANICAL ENGINEERS (Grades I, II and III), and a CIVIL ENGINEER—The Liaison Officer, Electricity Corporation of Nigeria, 11 Manchester Square, London, W.1.

ASSISTANT EXPERIMENTAL OFFICER at the Atomic Energy Research Establishment, Harwell, to abstract and subject-index scientific literature, and to supply information in response to inquiries—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting F.49/53A.

ASSISTANT MANAGER (Pile) at Sellafield, to be responsible for physical aspects of atomic pile operation and associated nuclear calculation—The Ministry of Supply, Division of Atomic Energy (Production), Risley, Warrington, Lancs, quoting 427.

ASSISTANT METEOROLOGIST for the British Caribbean Meteorological Service—The Crown Agents for the Colonies, 4 Millbank, London, S.W.1, quoting M.33526.E.

ASSOCIATE PROFESSOR OF CHEMISTRY (Organic), and an ASSOCIATE PROFESSOR OF CHEMISTRY (Physical)—The Registrar, Memorial University of Newfoundland, St. John's, Newfoundland, Canada.

BIOCHEMIST—The Group Secretary, Nottingham No. 2 Hospital Management Committee, Sherwood Hospital, Hucknall Road, Nottingham.

CHEMIST/ASSAYER (with an honours degree in chemistry) in Northern Rhodesia, to carry out assays and analyses of ores, minerals and rocks in the laboratory of the Geological Survey Department—The Director of Recruitment, Colonial Office, Great Smith Street, London, S.W.1, quoting 27106/57/52.

ELECTRICAL ENGINEERS and PHYSICISTS for the SCIENTIFIC OFFICER grade (Ref. A.5/53A) and EXPERIMENTAL and ASSISTANT EXPERIMENTAL OFFICER grades (Ref. A.6/53A) for research and development work on radio and electronic equipment in the Radar, Physics and Engineering Departments of the Telecommunications Research Establishment, Malvern—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting the appropriate Ref. No.

ENGINEER to the Ministry of Supply at Christchurch, to take charge of section engaged on design and development of electrical equipment for Royal Engineers—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting D.74/53A.

ENGINEER to the Ministry of Supply at Woolwich, to organise, administer and control small production plant for manufacture of electro-mechanical equipment, plastics and woodwork—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting C.432/52A.

ENTOMOLOGIST IN THE COLONIAL INSECTICIDE RESEARCH UNIT at the Ministry of Supply Chemical Development Experimental Establishment at Porton, Salisbury, to conduct research on entomological problems relating to the application of insecticides—The Under-Secretary of State, Research Department (S 610), Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1.

FISHERIES OFFICER (with a degree or diploma in zoology or allied subject and some experience of marine biology and fishing craft) in Gambia—The Director of Recruitment, Colonial Office, Great Smith Street, London, S.W.1, quoting CDE.65/12/01.

GAME WARDEN (with an honours degree in natural science and aptitude for field observation), Federation of Malaya—The Director of Recruitment, Colonial Office, Great Smith Street, London, S.W.1, quoting CDE.152/60/01.

GENETICIST AT THE FISH CULTURE RESEARCH AND TRAINING INSTITUTE, Federation of Malaya, to study genetics of pond-reared fish—The Director of Recruitment, Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting CSC.65/60/02.

GEOLOGISTS (with first- or good second-class honours degree in geology) in Malaya, for investigations of mineral resources and detailed geological mapping—The Director of Recruitment, Colonial Office, Great Smith Street, London, S.W.1, quoting CDE.106/60/03.

HEAD OF THE DEPARTMENT OF HOP RESEARCH, and a PLANT BREEDER IN THE DEPARTMENT OF HOP RESEARCH—The Registrar, Wye College, Wye, Ashford, Kent.

HEAD OF THE SPINNING DEPARTMENT—The Director of Research, British Cotton Industry Research Association, Shirley Institute, Didsbury, Manchester 20.

MATHEMATICS LECTURER in the Institute of Education, Bakht er Ruda—The Sudan Agent in London, Sudan House, Cleveland Row, London, S.W.1, endorsed 'Mathematics 1017'.

PHYSICAL CHEMIST for work on the oxidation of cellulosic materials, a PHYSICIST (with mathematical leanings) to continue experimental and theoretical work on fibre assemblies, and PHYSICISTS (10, with sound research training) for research work on problems arising out of the normal textile operations—The Secretary, British Rayon Research Association, Barton Dock Road, Urmston, Manchester.

PHYSICIST (with first- or second-class honours degree or equivalent in physics) at the Atomic Energy Research Establishment, Harwell, for X-ray analyses—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.46/53A.

PHYSICIST or ELECTRICAL ENGINEER at a Ministry of Supply Design Establishment near Sevenoaks, for development of V.H.F. oscillators and amplifiers or design of amplifiers for special purposes (circuit techniques involving time bases, trigger circuits, etc.)—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting A.22/53A.

PHYSICISTS (1) for operational research in wool textile mills, (2) for research on woollen carding and spinning processing and design of machinery, (3) for work on physical properties of fibres and fibre assemblies, and (4) for weaving research (honours degree men preferred for all posts, and essential for No. 4)—The Wool Industries Research Association, Torridon, Headingley, Leeds 6.

PHYSICISTS or CHEMISTS (with honours degree in physics or chemistry, or A.I.Inst.P. or A.R.I.C., or equivalent) for nuclear radiation protection duties in the Health Physics and Safety Department at Windscale Works, Sellafield—The Ministry of Supply, Division of Atomic Energy (Production), Risley, Warrington, Lancs, quoting 430.

PRINCIPAL SCIENTIFIC OFFICER at a Ministry of Supply establishment, Aldermaston, to direct and control the design of electronic equipment and electro-mechanical devices of a varied nature—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting D.64/53A.

PROTOZOOLOGISTS (with first- or second-class honours degree in zoology or zoology and botany) for research on the ciliate protozoa of ruminants and protozoan-bacterial interrelationships—The Secretary, Rowett Research Institute, Bucksburn, Aberdeenshire.

RESEARCH ASSISTANT (with a university degree) to aid and initiate researches in the DEPARTMENT OF AERONAUTICAL ENGINEERING—The Registrar, The University, Southampton.

RESEARCH ASSISTANT IN THE DEPARTMENT OF APPLIED CHEMISTRY—The Secretary, Northampton Polytechnic, St. John Street, London, E.C.1.

RESEARCH ASSISTANT (with honours degree in biology with experience of or inclination towards mathematical aspects of biological problems) IN THE DEPARTMENT OF TSETSE CONTROL, Gold Coast, to compile and analyse data on tsetse incidence with the purpose of evaluating the necessity for various control methods and of studying the biology of tsetse species in order to develop new control methods—The Director of Recruitment, Colonial Office, Great Smith Street, London, S.W.1, quoting 27059/311.

RESEARCH ASSISTANT TO UNIVERSITY BIOCHEMIST, to supervise routine clinical work of the Biochemical Laboratories, Addenbrooke's Hospital, Cambridge—The Professor of Biochemistry, Department of Biochemistry, Tennis Court Road, Cambridge.

RESEARCH DIRECTOR (university graduate with honours degree in physics or textiles, considerable practical experience in the cordage or textile industry, and well versed in spinning problems) to establish and undertake research in the United Kingdom into the utilization of sisal fibre, with special reference to ropes and cordage—The Secretaries, Overseas Sisal Research Committee, 10 Old Jewry, London, E.C.2.

RESEARCH FELLOWSHIP FOR WORK IN THE APPLIED BIOCHEMISTRY DEPARTMENT on the contributions of energy, amino-acids and vitamins by cereals to the nutrition of non-ruminant animals—The Secretary, Rowett Research Institute, Bucksburn, Aberdeenshire.

RESEARCH OFFICER (chemist or chemical engineer, with first- or second-class honours degree or A.R.I.C.) for work concerned initially with the processing of fibrous raw materials and recovery or disposal of waste products—The Director, British Paper and Board Industry Research Association, Welcomes Road, Kenley, Surrey.

SENIOR PHYSICIST (with an honours degree in physics, and previous hospital physics experience)—The Medical Director, Hogarth Radiotherapeutic Centre, General Hospital, Nottingham.

SHIFT MANAGER (with honours degree in chemistry or chemical engineering, A.R.I.C. or A.M.I.Chem.E., or equivalent) with managerial experience in a large chemical factory, and thoroughly conversant with modern methods of dealing with highly corrosive materials, inflammable solvents, and toxic hazards, AT THE ATOMIC ENERGY FACTORY at Salwick—The Ministry of Supply, Division of Atomic Energy (Production), Risley, Warrington, Lancs, quoting 426.

STATISTICIANS (with first- or second-class honours degree in statistics, or in mathematics, economics or other appropriate main subject combined with statistics) IN THE COLONIAL SERVICE—The Director of Recruitment, Colonial Office, Great Smith Street, London, S.W.1, quoting CDE.59/02.

UNIVERSITY GRADUATES and QUALIFIED TEACHERS (mainly with qualifications in mathematics, science (physics, chemistry, metallurgy) or engineering), for Short Service Commissions in the Instructor Branch, Royal Navy—The Director (P), Naval Education Service, Admiralty, London, S.W.1.

ZOOLOGIST (male, university graduate with first- or second-class honours) for general and experimental work on marine plankton—The Director, Marine Station, Millport, Isle of Cumbrae.

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# COUNCIL FOR THE PROMOTION OF FIELD STUDIES

THE annual report of the Council for the Promotion of Field Studies for 1951–52 maintains the high standard, in presentation and in interest, which we have already, within ten years, come to expect of the Council's reports. With the director's report, and those of the wardens and the accounts, are printed four articles illustrative of the work being done through the field-centres and which will interest a wide range of scientific and professional workers no less than amateurs. They cover excavations in East Suffolk, the aims and methods of geographical field-study developed at Juniper Hall under Prof. S. W. Wooldridge's guidance to train students in the art of looking at country, bird navigational studies on Skokholm Island and the vegetation of Malham Moor.

These articles testify both to the value of the educational work being carried out at the centres and to the potentialities of the centres for the advancement of scientific work. As such they have a fit place alongside the annual report, though the main importance of the document as a whole must lie in the frank account of the activities of the Council and the needs and difficulties of the centres given by the director and his wardens. It is abundantly clear from these plain records how much is due to the enthusiasm and untiring efforts of the director and wardens, the president (Sir Arthur Tansley), the successive chairmen of the Executive Committee (Prof. W. H. Pearsall and Prof. S. W. Wooldridge) and other officers, that the Council has brought its affairs through a critical year to a hopeful issue and kept open its opportunities, alike for science and the amateur scientist.

There may not be in Britain the myriad of voluntary endowments for scientific and other social purposes that characterizes the United States and to which Dr. R. B. Fosdick has directed attention in his recent book on the Rockefeller Foundation. Nevertheless, to a modest degree, the Council for the Promotion of Field Studies undoubtedly provides already in its field-study centres not merely educational opportunities but also potential growing points for scientific work, and it does so partly through voluntary effort. To an increasing extent the maintenance, still more the expansion, of its work depends on further financial support from voluntary sources, and the clear but eloquent exposition of the Council's claims in this report should be sure of sympathetic reception, particularly by scientific workers in Great Britain.

Prof. Wooldridge points out in his foreword to the report that, in accordance with the Ministry's declared intention throughout that the field-centres should become self-supporting, the Ministry of Education's grant is to be reduced in future by at least £3,000 annually from the £8,000 received during 1951–52. This necessitated drastic economies during 1952, including the closing of the central office and severe cuts at the field-centres, three of which are without a full-time assistant warden. In spite, however, of considerable strain and anxiety, a full season was worked at the field-centres with bookings exceeding those for 1951: 900 at Dale Fort and Skokholm; nearly 800 at Flatford Mill; 923 at Juniper Hall; and 990 at Malham (slightly less than in 1951). With the new charge of five and a half guineas weekly, continued support from the universities, an increasing number of subscribers and, more recently, some generous grants from industrial organizations, the Council managed to achieve a small balance of income over expenditure.

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* Council for the Promotion of Field Studies, 1951–52. Pp. 52. (The Director, F. H. C. Butler, Ravensmead, Keston, Kent.)

Besides the reassurance thus given by the experience of the 1952 season, the Council has been registered as a 'charity', which offers the benefit of remission of income tax on covenanted donations additional to the minimum membership subscription. The first large grant under this arrangement was one given by Imperial Chemical Industries, Ltd., which will increase the Council's income from voluntary sources by £750 annually. Besides an anonymous donation of £500 and contributions of £250 (for Malham) from the Albert Reckitt Charity and £250 from Messrs. Fisons of Ipswich, the financial position has been strengthened by closer co-operation with local-authority associations. To facilitate this, the modification of the Council's articles of association was approved at an extraordinary general meeting on December 11, 1952, and in consequence it is anticipated that some help in the way of capital grants may be forthcoming from interested authorities to permit the improvement of the amenities and scientific equipment of the field-centres, particularly Juniper Hall and Dale Fort. The report acknowledges a generous response by some Welsh counties to a recent appeal for capital grants made from Dale Fort itself.

Apart from this question of capital grants, the director's report emphasizes that the maintenance costs of the field-centres are unlikely to be met solely by securing increased numbers of students, even at the higher weekly charges. Additional income from voluntary sources is urgently required, and the two main purposes for which the director suggests such funds are required are most likely to be served effectively if the Council retains the character of a voluntary body. First and foremost, it is necessary to increase the present meagre allocation of scientific staff at the field-centres, both to relieve pressure on the present minimum staff of two throughout the busy part of the season, and to free the staff to undertake those special researches and organize those long-term investigations for which their special qualifications and the unique position of the field-centres together fit them, and which are fundamental to the intellectual life of the centres. Secondly, the Council requires freedom to experiment by introducing courses which should undoubtedly be held but may not necessarily, when first introduced, attract those students who give the best results in term of economics.

It is unnecessary to recapitulate here what was said in these columns two years ago (cf. *Nature*, 167, 1041; 1951) as to the value to Britain's economy to-day of the ecological studies and the field-work which the Council is so well equipped to foster. The present report shows how ably the Council has maintained that work and its potentialities in spite of acute financial difficulties. That record, with Mr. F. H. C. Butler's convincing exposition of the reasons why it is important that the Council should remain a voluntary body and a movement, and not become an institution entirely dependent on State support, warrants the hope that there will be a generous response to this fresh appeal for support from voluntary sources.

One particular appeal is made in this report which deserves a generous response from the smaller industrial firms, as well as from local societies and institutions and private individuals, whether scientific or not. Two years ago, the Council initiated a Bursary Fund for assisting meritorious students, of all ages, who would otherwise be unable to afford the fees for working at the field-centres. During the year a grant of £400 was received from Mrs. F. E. Thornton, widow of the ornithologist C. E. Thornton, who knew and loved the Malham moors, to be invested for this purpose. Grants of £100 for the same purpose have been received from the Thomas Wall Trustees and the Worshipful Company of Grocers, and the steady accretion of this Fund by such and smaller gifts would enable the field-centres to take in each year a number of keen young students who could not otherwise visit them, and who are the most likely to undertake the important advanced work.

Hope for a generous response to this and the more general appeal of the Council for voluntary financial support is encouraged by the degree of co-operation which has already been established between the Council and representatives not merely of the local education authorities but also of the universities and learned societies. In the active and growing amateur and professional membership of the Council, there is room for an increasing number of scientists, who, no matter in what scientific discipline they have been trained, should appreciate the importance of a clear and widespread understanding of ecological problems in this era of critical relations between population and food supply and other natural resources. It may well be that this educational aspect of the Council's activities is even more important than its scientific work; but, on either count, scientists should not be less generous than industry or their fellow citizens in responding to this appeal, either personally or corporately through societies or institutions with which they are connected.

## CONIFERS UNDER THE POCKET-LENS CAMERA

**Conifers in Britain**

An Illustrated Guide to Identification. By B. Alwyn Jay. Pp. 47+136 plates. (London: Adam and Charles Black, Ltd., 1952.) 35*s*. net.

IT is useful at the outset to realize what this book is not. In spite of its sub-title it is not really a guide to the identification of the conifers growing in Britain, in the sense of being a full guide. It does not pretend to compete with such well-known manuals as Dallimore and Jackson's "Handbook" or Jackson's adaptation of it; for, in any good arboretum, a wide range of conifers would be found which are not even named in this book.

Nevertheless, within its scope, this is an interesting and valuable production and, to anyone who has also dabbled in photography, will be, in many ways, a delight. The volumes of Clinton Baker's "Illustrations of Conifers" are now collectors' pieces; but this book continues and modernizes the tradition. Apart from some pages of script, it is essentially a collection of 136 photographic reproductions of the branchlets from sixty-four different conifers. Except in three cases, each species is represented by a photograph, natural size, of the upper and lower aspects of typical branchlets, followed by one at an eight-fold magnification of smaller suitable zones. It is this latter development, the application of pocket-lens photography to conifer branchlets on an extensive scale, which is new and which is the real value of the book because it has been really well done. Mr. B. A. Jay, being an associate of the Royal Photographic Society, is not a tyro in photography, and he has certainly shown his paces in these records. The typical vegetative features used in identification are all here, perfectly and critically displayed, just as they would appear in strong light under a good hand-lens. To the beginner, examining certain conifers for the first time, these photographs must be an inestimable boon; to the older hand their beauty and clarity yield an unfailing pleasure. If one comments that the reproduction in an occasional plate is not perfect, or that, for example, the two characteristic horny points on the leaf of *Abies firma* might be more distinct, it is because most of the others are so good that one wonders at even such small occasional departures from perfection. Perhaps in his next volume of studies Mr. Jay may be induced to give his photographer readers some details of the technique which has proved so successful in his hands.

The set of photographs illustrating each species is very usefully accompanied by a precise diagnostic description which seems accurate in every case. Introductory to the plates is the separate script giving a key to the genera illustrated, specific keys for those genera such as *Pinus* and *Abies* in which a number of species appear, and a useful table giving for each species brief data on nomenclature, occurrence in Britain and sylvicultural importance. A few flaws were noticed in this script. *Pinus coulteri* appears in the diagnostic key (p. 19) to the species of *Pinus* but nowhere else. *Abies procera* is *Abies nobilis* (p. 27) in the key for *Abies*. *Cryptomeria* and *Sequoia wellingtonia* are both said on p. 15 to bear scale-like leaves similar to those of *Cupressus* and then, in the key to the genera, *Cryptomeria* is separated on the basis of having awl-shaped leaves. The leaves of *Sequoia wellingtonia*, described as scale-like in the key to the genera, are referred to in the description under its plate as awl-shaped. This is a little confusing, especially as the foliage of neither can really be considered cupressoid. On p. 10 *Sequoia sempervirens*, obviously accidentally, is bracketed with *Metasequoia* as having linear leaves opposite or decussate. These, and a few other such points, can of course be readily corrected in subsequent issues, if only by an erratum slip. I regret, however, that there is little in the notes on classification on pp. 16–17 with which I can agree, though I am glad to record that Mr. Jay is not responsible for these pages. The nomenclature used follows the 1949 edition of Dallimore and Jackson's "Handbook". It is pleasant, therefore, to see that here, too, the Sierra redwood is still *Sequoia* and not segregated to the indefensible *Sequoiadendron*, though perhaps not everyone will be happy about the specific name now standard and, apparently, necessarily standard.

But the scope of the book must always be remembered in spite of its many excellences. It only deals with sixty-four conifers, and this deliberate limitation definitely lessens its general range of usefulness. Without question, in an arboretum containing only these sixty-four the veriest novice could with certainty identify each. The beginner, however, meeting types outside the selected sixty-four, would soon find himself at a loss because the diagnostic keys given are only valid for the conifers actually illustrated. Even then the selection seems a little unbalanced. The common ones are here and also those of importance in afforestation schemes as well as some of the less common ornamental forms. But surely there are many conifers more commonly to be met with in Britain and thus more deserving of inclusion in this introductory volume than, say, *Agathis australis* or *Pinus cembroides* var. *monophylla* or even *Abies koreana*? However, this criticism only applies to about eight of the forms included.

The book, therefore, must be taken for what it is—a really valuable and instructive collection of photographs of branchlets of a number of selected conifers, mostly fairly common. The excellence of the photographs, especially those at the pocket-lens level, induces one to hope that Mr. Jay will continue to apply his fine skill along the same lines to give us in the near future companion volumes to illustrate those many other interesting conifers which, even if not common, are at least frequent or occasional in Britain.

J. Doyle

# GARDEN FLORA OF HARDY PLANTS IN FRANCE

## Flore Illustrée des Jardins et des Parcs

Arbres, arbustes et fleurs de pleine terre. Par Dr. P. Fournier. (Encyclopédie biologique, 38, 39, 40.) Tome 1: Fougères, gymnospermes et monocotylédones. Pp. 340. Tome 2: Dicotylédones. Pp. 552. Atlas. 182 plates. (Paris: Paul Lechevalier, 1951–1952.) 3 vols., 11,000 francs.

MANY of those who are interested in practical horticulture would wish for a not too bulky work that will enable them to identify the plants that are commonly grown in their gardens. The work under review furnishes a key for the identification of the families, the genera and some 6,730 species of trees, shrubs and herbs that are grown in the open air in France. A volume of plates provides line-drawings of details of more than two thousand species to illustrate the text. The value of such a key can only be assessed by its extended use, especially by those who do not already know too many of the answers; but it is obvious that, for a large number of gardeners, this will fill a very real need and should often enable the horticulturist to name his plant with a minimum of trouble. However, as in most such aids to rapid identification, the fact that flowers and fruits are too often not simultaneously available is sometimes forgotten.

Naturally, in southern France plants can be grown in the open that would not be hardy in Britain, so that the inclusion of six species of fuchsia, of several epiphytic orchids or of forty-five different kinds of palm, compared with the single species which is hardy in Britain, causes no surprise. To the British reader, however, the important question is to what extent those species which are hardy in his country are cultivated in France. In the recently published "Gardeners' Dictionary" more than eighty species of *Dianthus* are listed as hardy in Britain, and, of these, twenty-eight are included in the work under notice; of *Cornus*, the French book includes eighteen of the twenty-nine cultivated in the British Isles. So it will be appreciated that a considerable degree of selection has been exercised, and many of the less commonly cultivated species have been omitted. Clearly the author, faced with the choice between the production of a work that would be comprehensive and unwieldy or one that would be relatively convenient to handle but restricted in its scope, has chosen, perhaps wisely, the latter.

It should be added that the illustrative drawings, though often diagrammatic in presentation, are quite adequate for their purpose as aids to identification.

Issued in paper covers at the equivalent of about £11, which presumably includes the third volume of text not yet available, it is to be feared that there will be comparatively few horticulturists outside France who will see their way to buying for themselves a work of this character. E. J. SALISBURY

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# POPULATION CHANGES IN EUROPE SINCE 1939

### Population Changes in Europe since 1939

A Study of Population Changes in Europe during and since World War II as shown by the Balance Sheets of Twenty-four European Countries. By Gregory (Grzegorz) Frumkin. Pp. 191. (London: George Allen and Unwin, Ltd., 1951.) 30*s*. net.

SHORTLY after the end of the Second World War the United Nations Economic Commission for Europe began a survey of European man-power. Yet the present cannot be understood without a knowledge of the past, and it quickly became clear that the demographic upheaval caused by the War was largely uncharted and very ill-recorded. M. Gregory Frumkin, formerly editor of the "Statistical Yearbook of the League of Nations" and now a member of the United Nations Secretariat, undertook the heavy task of piecing together the demographic history of Europe for the War period. The result is a scholarly compilation of the main changes in total population of twenty-four European countries for the two periods end-1938 to end-1945, and the succeeding years 1946–47. The U.S.S.R. is excluded from the main account because accurate data are non-existent.

A valuable feature of the work is the author's insistence on a standard treatment for every country. National statistics, based on a variety of definitions and relating to a multiplicity of dates, have been rearranged to conform to a standard pattern. This commendable attack on the difficult problem of international comparability inevitably results in estimation and its attendant errors. Yet these will be of small account compared with the uncertainty which still surrounds the extent of the loss of human life from genocide, and the size of the migratory movements, voluntary and involuntary, which swept across Europe in the wake of the Nazi terror.

M. Frumkin insists on independent estimates of all components of population change. These are: births, deaths (divided into those directly attributable to military operations, mass murders and 'normal' deaths), losses and gains from territorial changes, and the successive waves of migration during and after the War. Official statistics, amended to fit the author's standard form, provide starting and finishing check-points. If the account for any country does not balance, and it rarely did, then one at least of the estimates must be wrong. The major part of the author's research has been the patient examination and reconciliation of the many discrepancies he uncovered. He has avoided residual or balancing items which merely reflect an accumulation of errors in the remaining figures.

The general approach is described in Chapter 2. The next chapter is the core of the work and contains a survey of population changes for each country separately. The whole account is preceded by a brief description of the characteristics of population growth during the 1930's, and concluded by a summary of the changes wrought by the War. One of the more horrifying tendencies of modern warfare is laid bare: "Out of 10 million war losses in countries under Nazi control . . . 8·6 millions related to losses among the civilian population and only 1·4 million were military losses". Not least in interest is the evidence of the remarkable recuperative power of a population. By the end of 1947 the total population of the countries surveyed had overtaken war losses and exceeded the total at the end of 1938 by some four millions.

H. SILCOCK

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# LIPID METABOLISM

### Biochemical Society Symposia

No. 9: Lipid Metabolism, a Symposium held at the London School of Hygiene and Tropical Medicine on 16 February 1952. Organized and edited by R. T. Williams. Pp. v+102. (Cambridge: At the University Press, 1952.) 13*s*. net.

THIS volume contains the papers communicated in substance to the Biochemical Society's symposium on February 16, 1952 (see *Nature*, 169, 569; 1952). The publication in full of the memoirs then dealt with is welcome, since in each instance a fairly full survey is presented which offers a more-or-less complete picture of each subject considered. The collection, which has been prepared by Prof. R. T. Williams and published for the Biochemical Society in the clear and excellent format common to all the Society's publications, is therefore of value to both students and investigators who are concerned with the problems discussed at the symposium.

The first three communications (by Prof. A. C. Frazer, Dr. R. P. Cook and Dr. J. M. French) deal with the absorption of fat by animals. Prof. Frazer's review of the work of his own school and of others during the past thirteen years on the mechanism of fat absorption gives a picture of the conclusions reached up to the present time. It suggests that the balance of evidence is in favour of his partition hypothesis, which presupposes only partial hydrolysis of ingested glycerides with intraluminar emulsification of glycerides as an important step in their absorption; and that the alternative view of complete hydrolysis of glycerides to fatty acid and glycerol, followed by re-synthesis in the intestinal cell to phospholipids (as an essential intermediate), is no longer tenable.

The contributions of Dr. G. Popják and Dr. S. J. Folley on the synthesis of fatty acids in animals, especially in their mammary glands, from acetate (or from glucose via acetate or pyruvate) will receive much notice, since the recent important studies of both authors in this field are collected and discussed in relation to results obtained by other workers. It is of great advantage to have the results which have been disseminated in a large number of individual papers in the scientific journals brought together by two of the most prominent investigators of this subject. Dr. Popják's review concerns the evidence, based on work with radioactive acetate, of synthesis of fats in general from small (two-carbon) molecules, while Dr. Folley's is more specifically devoted to the biosynthesis of milk fat in ruminant mammals. The two articles together give a complete account of the subject as it stands at present.

Dr. A. L. Lehninger gives in some detail an account of recent work by himself and his colleagues on the mechanism of the enzymatic oxidation of fatty acids. The discussion includes sections on the properties of the fatty-acid oxidase system of animal tissues, on the mechanism of acetoacetate formation and oxidation, and on the significance of recent work on fatty-acid oxidation and synthesis in extracts of *Clostridium kluyveri*.

The final paper, by Dr. H. M. Sinclair, deals with the fatty acids (linoleic, linolenic, arachidonic) essential to growth and their relation to pyridoxine. This very interesting contribution, which merits careful study, brings out an analogy between deficiency of essential fatty acids and deficiency of pyridoxine. It is suggested that failure of growth in essential fatty-acid deficiency may be connected with inability to form the phospholipids necessary for cell membranes, and also that the essential poly-unsaturated acids may be concerned in controlling the water retention of animal tissues.

It is to be hoped that this, necessarily brief, notice of the contents of the volume may serve to indicate its usefulness to all interested in the role of lipids in biochemical processes.

## COSMIC RAYS AND THE CLOUD CHAMBER

### Cloud Chamber Photographs of the Cosmic Radiation

By G. D. Rochester and J. G. Wilson. Pp. viii+128. (London: Pergamon Press, Ltd., 1952.) 70*s*.

THE authors of this book, Dr. G. D. Rochester and Prof. J. G. Wilson, are to be congratulated on its production; in bringing together in one volume a very fine collection of photographs, they have paid worthy tribute to the part the cloud chamber has played in revealing the nature and associated properties of the fundamental particles which are found in the cosmic radiation. To each photograph (the total number of which is one hundred and twenty-three) the authors have prepared a most useful synopsis giving not only the details of the actual chamber and the geometry of the accessory equipment such as position and size of lead plates, but also an analysis of the physics of the event in question; this includes both the results of the measurements made upon the tracks and a discussion of the resulting interpretation of the event. It cannot be stressed too strongly that all nuclear physicists will benefit from a study of the photographs whether or not they are versed in the technique of the use of expansion chambers. It is true that to those who are so versed the book will be of extra value in that it shows the results obtained from chambers covering a great range of sizes, operating pressures, etc.; but the outstanding merit of the book is the fact that it describes and discusses, in an interesting manner, real fundamental physics. The quality of the reproduction of the photographs is excellent and is immediately impressive.

The photographs are grouped in six sections. Section 1 is entitled "Technical Features of Operation" and illustrates the process of formation of drops, the efficiency of condensation upon ions, the effects of turbulence and contamination within a chamber, and other features. Section 2 deals with electrons and cascade showers, and the first few plates show the tracks which revealed the existence of the positron and the cascade process; photographs of extensive showers show not only the presence of cascade particles, but also penetrating particles together with nuclear interactions associated with such showers. Section 3 is concerned with the existence and subsequent decay of the $\mu$-meson; a most important group of photographs demonstrates the way in which the mass of a particle may be determined from momentum and range measurements, and includes an indication of the nature and magnitude of the uncertainties involved.

Nuclear disintegrations and interactions of secondary particles form Section 4, which covers reactions observed in multi-plate chambers (for example, of carbon and lead), as well as stars produced in the gas of the chamber.

The photographs which have made it necessary to postulate the existence of charged and uncharged *V*-particles are shown in Section 5. The interpretation of these photographs is clearly discussed and well illustrates the vital contribution to physics which may be contained in only a few photographs. Section 6 consists of a single photograph showing the track of a primary cosmic-ray particle in a chamber operated at an altitude of 95,000 ft.; this photograph is indeed a tribute to the skill and ingenuity of the research worker, as well as the reliability of the expansion chamber.

It is to be hoped that the authors intend to keep the material of the book up to date either by appropriate revision or by the publication of a second volume when sufficient progress has been made. On this assumption, a few minor suggestions may be offered. In the technical descriptions of the chambers, more details of the magnets, lamps, cameras and general illumination geometry would be useful. In the case of experiments where the counter selection is complicated, a simple schematic diagram would be valuable; in the first section dealing with technical operation of chambers, more 'faults' should be included showing the different effects of intrinsic chamber faults (for example, inadequate temperature control), control faults, and illumination and/or recording faults.

The price of the present volume is rather high, but it must be appreciated that, where it is required to have an overall reproduction of such a high standard, a high cost is unavoidable. J. R. Atkinson

## Management and Conservation of Vegetation in Africa

A Symposium. (Commonwealth Bureau of Pastures and Field Crops, Bulletin No. 41.) Pp. 97+14 plates. (Farnham Royal: Commonwealth Agricultural Bureaux, 1951.) 10*s.* 6*d.*

THE title of the symposium which this book records is perhaps liable to lead to unfulfilled expectations. There is relatively little emphasis on management and a lack of data on conservation. The emphasis is rather on the need for vegetation surveys, which, however desirable in themselves, as a record of what now exists, can alone do little, if anything, to arrest the losses we all deplore. One of the great needs in Africa concerns the controversy that still rages as to whether to burn or not to burn, and I recently heard in South Africa both views defended with great vigour. Even where there is a measure of agreement that some burning is desirable, or at least unavoidable, there are few precise data as to when and how often to burn so as to attain the optimum result.

The first of the contributions included in this volume is by J. P. Scott, who does in effect consider, all too briefly, the actual principles involved in conservation. G. C. Edwards, writing on the vegetation types of East Africa, stresses the need for a changed system of agriculture based upon the ecological conditions, of which the native vegetation is the best indication, and he advocates the value of a temporary ley as the best means of building up and conserving soil fertility. H. J. Rensberg strikes a similar note for the Tanganyika area. An interesting account of the ecology of savanna in Nigeria is provided by R. N. J. Keay, while A. Fogie gives a summary of the forest reservation in the Gold Coast. There are also brief accounts of what is being attempted in the Sudan and Sierra Leone.

With such a title, however, one might have anticipated some account of the experimental results achieved in various areas, such as those carried out at the experimental station at Frankenwald. Nevertheless, with all its limitations, this is a book that all those interested in such problems will find of value.

E. J. SALISBURY

## Statistical Methodology Reviews, 1941–1950

Edited by Oscar Krisen Buros. Pp. xi+457. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1951.) 56*s.* net.

THIS is the third compilation issued by Prof. O. K. Buros, the last being published in 1941. It assembles in one large well-printed volume the reviews of books on statistical methodology published in English during the decade 1941–50 and contains 842 review excerpts from 112 journals covering 342 books. There are, in addition, useful indexes of periodicals, publishers, titles and authors' names, as well as a classified index to the books themselves.

A would-be student of statistical methods will find it useful to consult this work to see what books have been published and what reviewers think about them. But for statisticians and reviewers of any class of scientific book the work will have a wider appeal, not to say a considerable entertainment value. It is a fascinating study to compare a number of reviews of the same work and to observe the variation of opinion expressed in them. Review editors will also find much here of help in framing their general policy. One of Prof. Buros's objects in embarking on this work some fifteen years ago was to improve the quality of reviews, and a comparison of this book with its predecessor, the "Second Yearbook", indicates that he has been partly successful. It is to be hoped that he will continue to find support for this useful enterprise.

## Understanding Heredity

An Introduction to Genetics. By Richard B. Goldschmidt. Pp. ix+228. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1952.) 30*s.* net.

THIS book is intended for the educated layman who wishes to acquire an elementary knowledge of genetics. Its aims are to give a broad outline of the subject and of its implications in biology and in everyday life, and to stimulate enough interest to make the reader eager to attack some more advanced treatise. There is no denying that to many it will come somewhat as a disappointment. From Prof. R. B. Goldschmidt, who has been constantly and successfully ahead of the times in criticizing the shortcomings of accepted genetical concepts, one would have expected better. The very necessary sacrifices required by simplification and conciseness do not justify the omission of the salt and pepper, that is, the problems still unsolved and the wider vistas opened up. As an addition to the number of books giving in a simplified form the main facts and ideas of genetics, it will have its value.

G. PONTECORVO

## Substances naturelles de synthèse

Préparations et méthodes de laboratoire. Collection publiée sous la direction de Dr. Léon Velluz. Vol. 4. Pp. 165. (Paris: Masson et Cie., 1952.) 1800 francs.

VOL. 4 of this series follows the same plan as the earlier volumes (see *Nature*, 169, 169; 1952). The more important and larger part of the book gives experimental details, taken from recent chemical literature, for the laboratory preparation of certain biologically important substances.

The preparations described are *d*-pantothenic acid (Stiller, Harris, Finkelstein, Keresztesy, and Folkers, *J. Amer. Chem. Soc.*, 1940), adermine (Harris, Stiller, and Folkers, *J. Amer. Chem. Soc.*, 1939), riboflavine (Karrer and Meerwein, *Helv. Chim. Acta*, 1936), testosterone (Serini and Köster, *Ber.*, 1938), and *dl*-$\alpha$-tocopherol (Smith and Sprung, *J. Amer. Chem. Soc.*, 1943). Each synthesis is prefaced by a short introduction and is followed by a lengthy series of notes on related processes, etc.—for example, analogues of pantothenic acid, $\beta$-alanine, the phthalimide synthesis, elimination of hydroxyl from aromatic heterocyclic compounds, ethoxyacetylacetone, 3 : 4-xylidene, amino-saccharides, etc. In several cases, alternative syntheses are discussed.

The second half of the book contains lengthy sections on cyclizations leading to derivatives of pyridine and on adsorption chromatography, including practical notes on the preparation of adsorbents. There are finally some tables relating metric to other measurements, °F. to °C., and lb./sq. in. to kgm./sq. cm. The price of the book is very high considering that all the factual information is readily available elsewhere. If many of the notes and addenda were omitted, these volumes would lose little of importance and could be published at a lower price.

W. BAKER

# UPWELLING IN THE BENGUELA CURRENT

By RONALD CURRIE
National Institute of Oceanography

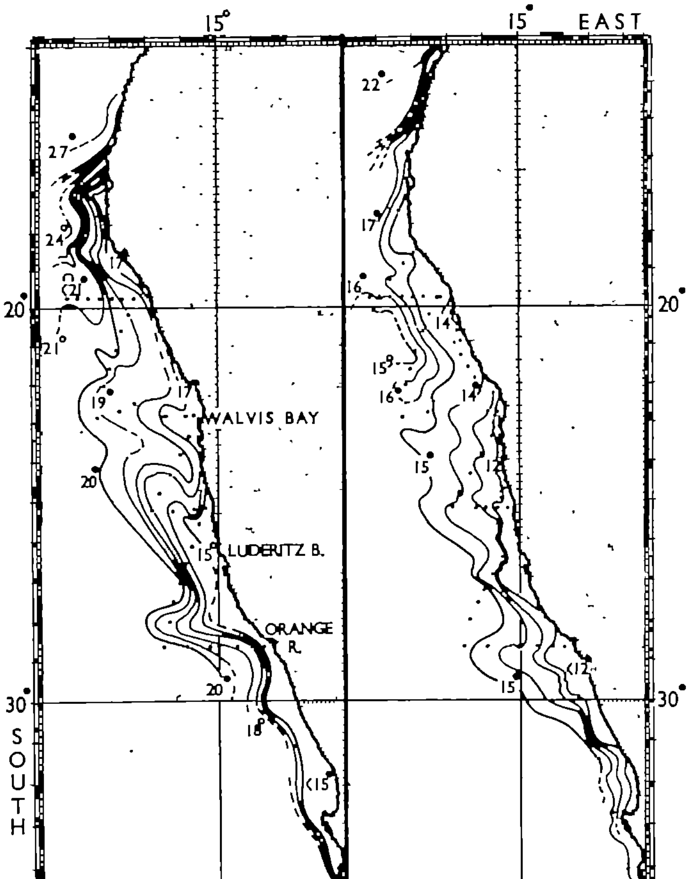
THE Benguela Current is one of the major features of the circulation of the South Atlantic Ocean. Extending northwards along the African coast from the neighbourhood of Cape Town to about lat. 15° S., the current is a region of upwelling of relatively cold water rich in nutrient. The resultant high fertility of the surface waters gives rise to great production of planktonic plants and animals, while the presence of the cool water has extensive climatic effects. In such features the Benguela Current has much in common with the Peru Current, which was surveyed by the R.R.S. *William Scoresby* under the Discovery Committee in 1931. When this ship visited South African waters in 1950, two surveys of the Benguela Current were carried out, first in March and again in September–October. The programme for the voyage was planned by Dr. N. A. Mackintosh, and it included these surveys not only to allow a comparison to be made with conditions in the Peru Current but also because such regions are specially favourable to investigations on the production of life in the sea.

The German Atlantic Expedition (in the *Meteor*) was the first to study the current extensively, and it enabled Defant[1] to produce the most comprehensive account of it so far. The *Meteor* observations, however, were relatively widely scattered in space and time; they provide a broad picture of the current and its effects in relation to the South Atlantic as a whole, but leave much to be learnt of the fluctuations of the current and the mechanism of upwelling. Hence the *William Scoresby*'s work included lines of closely spaced 'stations' off the South West African coast (Fig. 1). Limited time restricted them to the coastal region, but these intensive observations covered the area which, in view of Defant's findings, was most likely to be of interest.

As the surface currents of the eastern side of the South Atlantic are principally wind-driven systems, to understand them one must have a knowledge of the prevailing winds. Over the South Atlantic the surface winds blow out anticyclonically from a large region of persistent high pressure, and the component blowing over the eastern part of the ocean is the South-East Trade Wind. Near land, however, the trade wind develops a landward component which varies with the fluctuations of pressure over the continent, this in turn resulting from the great heating and cooling which the land mass undergoes. This landward wind or sea breeze thus shows a marked diurnal variation, and frequently attains considerable force, blowing from almost due south in lat. 30° S., and veering to south-west northwards along the coast.

It is not surprising, therefore, that the sea surface currents should show considerable irregularity in the coastal region. Defant, from an analysis of the Dutch current observations, found that inside the relatively constant drift current produced by the South-East Trade, the coastal currents were extremely irregular, and were separated from the drift current by a "one-sided line of divergence". Further, Defant showed that the region of strong negative temperature anomaly was confined to the coastal current.

*Distribution of temperature and salinity.* The accompanying charts (Fig. 1) show the distribution of surface temperature, compiled from the 'station' observations and supplemented by the data from a distant-reading thermograph with which the ship was equipped. On both surveys, the most outstanding feature of the distribution was the pronounced irregularity of the isotherms. Whereas the isotherms of the open ocean run more or less latitudinally, in the



(a) (b)

Fig. 1. Sea surface isotherms (a) during March, (b) during September–October 1950. Isotherms are drawn for each whole degree C. Stations are shown by dots

Benguela Current they run approximately parallel to the coast. The existence of the interlocking tongues of relatively cool and warm water suggests that the upwelling of cool water to the surface occurs not everywhere, but at separated points along the coast. The distribution of salinity follows a pattern similar to that of temperature, the lower salinities occurring in the cool water against the coast. Offshore, one finds that, while the temperature rises relatively steadily, there is a sharp contrast between the salinity of the inshore waters (c. 35·00‰ or less) and that of the offshore waters (c. 35·20‰). It appears, therefore, that there are two distinct surface waters, generally with a fairly sharp boundary between them, although in places mixtures occur. The inshore water generally has similar properties to the water at subsurface depths farther offshore.

Examination of the vertical distributions of temperature and salinity shows that on both surveys a well-developed homogeneous surface layer was present offshore. This was separated from the underlying water layers by a strong temperature discontinuity. Inshore, however, there was evidence of considerable variation: during the first survey no such homogeneous layer was detected, and strong heating had apparently taken place on the surface; but during the second survey, there was a thin homogeneous surface layer overlying a weak discontinuity. This difference indicates the contrasting effects of the calm conditions during March and the strong winds during September–October.

Below the upper water layers, both temperature and salinity fell steadily to the salinity minimum of the Antarctic Intermediate Current. Fig. 2 shows the dispersion of all the temperature and salinity observations made in 1950 by the *William Scoresby*, between a depth of 100 metres and the Antarctic intermediate salinity minimum. It can be seen that all lie within narrow limits of the characteristic temperature – salinity curve of the South Atlantic Central Water[2]. As the Antarctic Intermediate Water moves north, it mixes vertically with the overlying and underlying more saline waters. Consequently, the salinity minimum becomes less pronounced towards the north until, finally, it becomes obliterated completely. Using Wüst's 'Kernschichte Methode'[3] —the heavy line in Fig. 2—one finds that in the core of the Antarctic Intermediate layer off South-West Africa only 50 per cent of the original water type remains and this at a depth of more than 600 metres. Since our data indicate that the upwelling does not extend much below 300 metres, it is only a relatively small proportion of Antarctic intermediate water which is subject to upwelling.

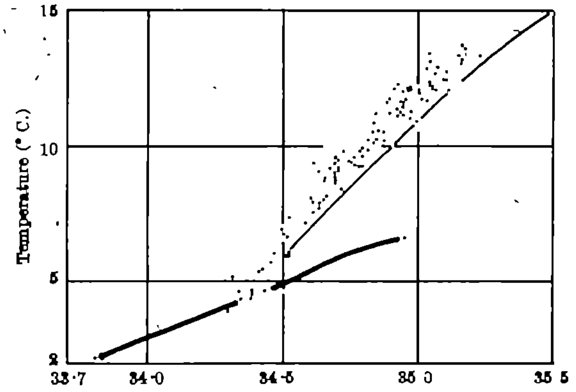


Fig. 2. Temperature – salinity relationships of the water layers between 100 metres and the salinity minimum of the Antarctic Intermediate Water. The heavy line shows the relationship of the core of the Antarctic Intermediate Water from the source (left) to the northern limit (right) after Wust (ref. 3). The thin line is the line characteristic of South Atlantic Central Water (Sverdrup, ref. 2)

The strong indications of active offshore transport of surface water during September–October, compared with the more quiescent conditions found in March, demonstrate the difference between active upwelling and the more advanced stage of mixing of previously upwelled water. The dynamical principles of the movement of a northward-flowing current in the southern hemisphere require that the more dense water should lie in the east side of the current, and upwelling may purely be a lifting effect within the current.

The wind records for the periods preceding the two surveys leave no doubt, however, that the great difference between the surveys was a direct result of the prevailing wind conditions. No detailed observations of the wind over the sea are available; but it is known that the trade winds were much stronger during September–October than during March. In addition, wind records from three South-West African shore stations show that whereas the sea-breeze was light and variable during February and March, it would have been conducive to a longshore transport of surface water during September–October.

Since there are no direct observations of current, the anomalies of dynamic depth of the isobaric surfaces have been calculated, with reference to the 600-decibar surface. Although in a region where vertical movements are important this method must be used with much caution, the inferences appear reasonable, and show similar features to findings in other regions[4,5]. During March, the computed currents show a general movement to the north with a rather weak southerly movement inshore, reaching to about Luderitz Bay. During September October, a series of horizontal eddies was present inside a much stronger northerly flow. Vertical sections through the eddies indicate that the sea surface slopes upward from the coast to a line of convergence, and then falls into a trough, and farther offshore slopes upwards again. On some of the sections the observations did not extend far enough seawards to show this trough, although the line of convergence was always well marked. Since the sea surface must eventually rise towards the open ocean, however, it is probable that such a trough was there. An example of this distribution is given in Fig. 3. Sverdrup[4] has pointed out that in a region such as this (Sverdrup deals with the Californian coast), strong convection will develop between the more dense water upwelling and being transported offshore and the light offshore water, sufficiently well defined to be regarded as a boundary. Seawards of this boundary there is a tendency for divergence within the offshore water due to the increasing effect of the wind on the surface. A circulation of two vertical cells would thus be formed, separated by a strong convection current. As the boundary moves offshore, there must be a compensation flow into the inner cell, and this Sverdrup defines as the upwelling movement, the upward movement above being part of the cellular circulation. Superimposed upon this vertical circulation must be a horizontal eddy formation.

It appears, therefore, that the circulation is somewhat more complex than Defant could deduce from the data at his disposal, and the 'one-sided divergence'

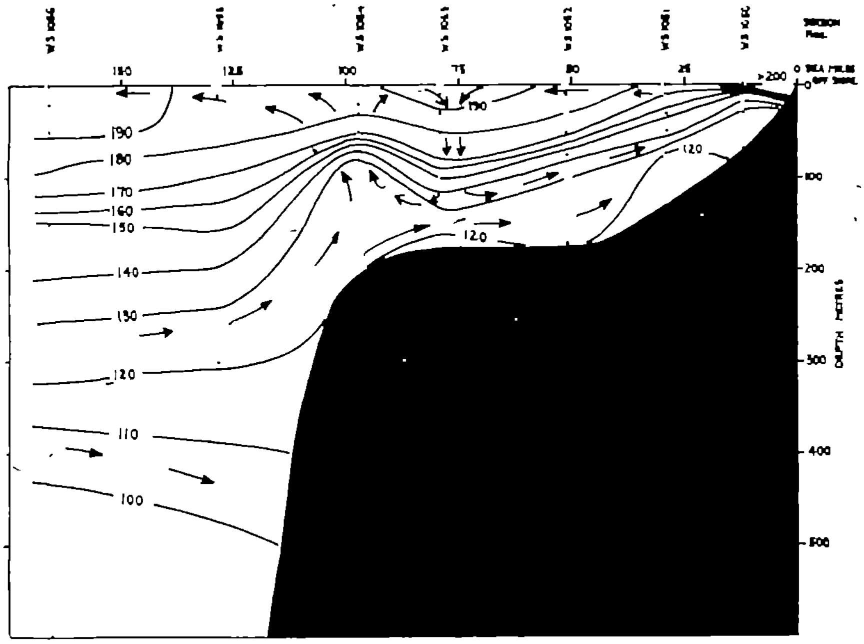


Fig. 3. Vertical section normal to coast in lat. 23° 40′ S. showing isosteres and probable direction of water movement in the vertical plane. (Isosteres are the lines of equal specific volume expressed as the difference × $10^5$ from the specific volume of sea water of 35 parts per 1,000 salinity and 0° C. at the same pressure)

seems to be an eddy-like system rather than one long continuous divergence line. The size and stability of these eddies must depend upon the intensity of the forces which produce the upwelling, and about which there is still little precise information. The distance to which they persist must be variable and governed by the variability of the external forces. Whether the eddies are consistently formed in any particular regions is difficult to say without more intensive observations, although the continuous low temperatures and high productivity of the region around Luderitz Bay (c. lat. 26° S.) suggest that this may be one region where eddies often form.

Although no significant temperature – salinity differences occur in the underlying water layers (Fig. 2), there is a great depletion of dissolved oxygen and enrichment of phosphate close to the continental slope. This layer of oxygen minimum and phosphate maximum is similar to that found extensively over the equatorial regions of the ocean. It probably results from a balance between the rates of decomposition of organic matter, and the turbidity and diffusion rates between those layers and the neighbouring water masses. Upwelling brings some of this poorly oxygenated, highly nutrient water into the euphotic zone. Although this will favour great phytoplankton production in the surface layer, the low oxygen content will help the effects of local decomposition of organic matter to maintain almost anaerobic conditions in the shallow reaches of the continental shelf.

The inorganic phosphate content of the upwelled water is very high (> 2·0 mgm. atoms phosphorus/$m.^3$, about four or five times the present normal winter maximum of the English Channel[6]), in contrast to the almost complete absence of phosphate in the offshore surface waters. Local maxima and minima occur, as the oxygen shows varying degrees of saturation with the varying abundance of the phytoplankton populations. It was found that the phosphate content on the shelf was often greater than that in the upwelling water. This may be due to intense local regeneration from decaying plankton.

During the second survey an attempt was made to measure the extent of the 'azoic zone', a region of reducing mud[7], and this was found to cover a larger area than was previously supposed. A series of Baillie rod soundings revealed that it extended, at least in patches, between depths of 50 and 150 metres, for about 400 miles north of lat. 25° S. The sediment, a dark green diatom mud, is populated with sulphate-reducing bacteria; their production of hydrogen sulphide must further reduce the oxygen content of the local shelf waters. The oxygen depletion was most marked near Walvis Bay: during March the water with less than 1·0 c.c. oxygen per litre extended to the sea surface; during September–October, however, these low concentrations were confined to the lower third of the water column. In the determination of the oxygen, steps were taken to eliminate the effect of large quantities of reducing substances and organic matter.

At times, the concentration of hydrogen sulphide becomes so high that the gas is actively evolved from the sea surface. As this frequently occurs at the same time as mass mortalities of marine organisms, some authorities have attributed the mortality primarily to an oxygen deficiency. Brongersma-Sanders[8] has, however, preferred to consider the effects of toxins released from mass outbursts of certain dinoflagellates as being the primary cause, principally on evidence from other similar regions.

Dr. T. J. Hart has found 3,000–5,000 cells/ml. of small dinoflagellates in samples collected from discoloured water patches during these surveys. They have not been finally identified, but probably belong to one of the several genera known to include species capable of producing toxic effects. Small mortalities actually occurred during March 1950, but there is insufficient evidence to show which factor was the more important. The effect may well be due to several unfavourable factors acting together.

A paper on preliminary results of analyses of the other plankton samples by Dr. Hart will appear shortly. This shows that good agreement between the plant and animal distributions and the physical and chemical data is often apparent. Thus all the very heavy diatom populations occurred in the upwelled water; and they coincided with the highest supersaturation values of the surface water with oxygen. At times, dense concentrations of Chætocerids imparted an olivaceous colour to the upwelled water, in contrast to the transparent blue offshore water. The scanty phytoplankton of the latter included a relatively high proportion of the diatom *Planktoniella sol*, which seems a useful indicator of intrusions of offshore water towards the coast, as

Gunther and Rayner[9] had found previously, off Peru.

The physical and chemical results will be published shortly by the National Institute of Oceanography in the 'Discovery' Reports, and further studies are being made of some of the problems which have been mentioned with the particular object of obtaining evidence about the factors which affect oceanic productivity.

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# MAGNETIC PROPERTIES OF ROCKS

THE significance of the natural-remanent magnetism of igneous and sedimentary rocks has not yet been determined. On one hand, there is the hypothesis that the direction of magnetization can be interpreted in terms of a widely varying magnetic field and, on the other, that the adverse polarizations arise from intrinsic properties of the rock assemblage. These aspects formed the main theme of a geophysical discussion at a joint meeting of the Royal Astronomical Society and the Geological Society, held in London on January 23, with Prof. E. C. Tilley (Department of Mineralogy and Petrology, Cambridge) in the chair. Prof. Tilley noted that the magnetic properties of rocks have also been found to be of considerable value to geologists by yielding magnetic anomalies reflecting the distribution of certain rock-types, the measurement of such anomalies culminating in aeromagnetic surveys.

In opening the discussion, Dr. J. M. Bruckshaw stated that the value to the geologist of the results he proposed to discuss would be controlled by their final interpretation. Of recent years the study of permanent rock magnetism has been intensified, and Dr. Bruckshaw's interest was first aroused by the discovery that the tholeiite dykes of northern England are magnetized in a direction opposite to that of the present earth's field. Since these dykes represent the final phase of igneous activity centred upon Mull, it was an obvious step to examine the rocks in the earlier phases of this activity. The earliest phase was the quiet extrusion of a sequence of lava flows followed by the cyclic intrusion of basic and acid ring dykes and cone sheets about a centre which migrated twice towards the north-west. The final phase was the production of the north-west dyke swarms, of which the tholeiite dykes were the last members. Since a known time-sequence of events exists, it is possible to sample rocks of different periods and, in the present case, some of the basalt flows, some early basic intrusions, the ring dykes of Glen More and Loch Bà and some of the north-west dykes were examined. After a rock has been polarized, many factors may tend to modify it, and some influences will result in random magnetization. For example, a partially solidified lava-flow might be broken up by a further supply of lava. Thus a number of specimens from each formation must be examined, and they usually show a scatter of directions. Inspection may be sufficient in some cases to determine if the mean direction has a significance, but the probability that the observed set of directions can be selected from a random distribution is used for indicating what weight can be attached to the mean direction; the smaller the probability the more significant the mean direction.

Using those formations associated with significant directions, the basalt flows proved to be adversely magnetized and also the early basic intrusions. The more acid ring dykes of Glen More and those of Loch Bà were normally magnetized; but a dolerite dyke, earlier than the Loch Bà granophyre, proved adversely magnetized. The dykes of the north-west swarm were normal, and to this must be added the adverse phase of the tholeiite dykes, giving a total of three adverse phases.

The large observed intensities of magnetization in relation to the earth's magnetizing field can only be explained in terms of thermoremanence acquired during the initial cooling, the only occasion when the present rocks were at the necessary high temperature. If this is accepted, the amazing stability of this polarization follows; and laboratory observations support this conclusion, the coercive force of the rocks being comparable with that of modern magnet-steels. In all respects the rocks exhibited ordinary magnetic properties under a variety of conditions and, in particular, acquired normal polarization when cooled in the earth's field. It would thus appear that the simplest explanation of the facts is a number of reversals of the earth's magnetic field in the past, a suggestion to which there are no theoretical objections.

Mr. K. M. Creer pointed out that the main evidence on adverse magnetization comes from igneous rocks, which are magnetized either normally or at 180° to the normal direction. Although there are no theoretical objections to a reversal of the earth's polarity, other explanations of adverse magnetism are possible, such as those suggested by Néel. One of these assumes a constituent having a spinel structure in which two sub-lattices exist, one tetrahedral and the other octahedral. The spontaneous magnetic vectors associated with the sub-lattices have opposite directions and, in suitable conditions, the resultant magnetization would change sign with temperature, thus allowing adverse polarity. This property of imperfect antiferromagnetism is not known. Another process involves two magnetic constituents with widely differing Curie temperatures. On cooling, the constituent of higher Curie point is first magnetized and produces a demagnetizing field. Due to its large negative temperature-coefficient, the initial intensity grows rapidly and the demagnetizing field ultimately exceeds the original field at the Curie point of the second constituent, which becomes adversely magnetized. The ferromagnetic constituents must occur in aggregates of high local concentration.

Mr. Creer recorded that a hypersthene hornblende dacite discovered by Nagata does exhibit adverse magnetization when cooled in a weak field. From it, two magnetic constituents have been separated by Dr. G. D. Nicholls, of the University of Manchester. One (probably magnetite) behaves normally, but the other shows reversed thermoremanent magnetism. He suggested that the normal behaviour of naturally adversely polarized rocks in the laboratory could be attributed to the rapid rate of cooling, when the components required by Néel do not have time to exolve.

Finally, Mr. Creer considered the evidence of sediments which, on Néel's theory, should not possess inverted magnetism. In the Appalachian Mountains, adversely magnetized Silurian sediments are interbedded with similar but normally magnetized sediments, and these are contemporary, as revealed by the presence in both sets of ostracods of short-time duration, with flat-lying and normally magnetized sediments outside the geosyncline. Thus, any field reversal must have been of a local character, and the reversed sediments in the geosyncline may be the result of a complex history during the mountain-building orogeny. Certain physical differences between the sets of sediments suggest a second interpretation that the polarization of the geosynclinal sediments is stable, but in the flat-lying beds it has, on the whole, followed the subsequent changes in the earth's field. In fact, the absence of any widespread reversals in sediments may be due to instability. Graham's experiments on sediments over a wide time-range show that the most frequent direction of magnetization agrees with a normal dipole field, while conglomerates, which should exhibit random magnetization of the pebbles, show a systematic direction agreeing closely with the present field.

The testing and use of magnetic-survey methods by H.M. Geological Survey and Museum was outlined by Dr. A. F. Hallimond. The problem of the correlation between the observed anomaly and that computed for the structure was initially examined in 1929 by a magnetic survey over the Swynnerton Dyke in Staffordshire; but certain aspects of the interpretation of the field observations proved difficult, since the anomaly due to the splitting of the dyke into two branches gave results similar to that over a dyke with concentrations of magnetite near its flanks. In the simpler cases, however, the observations conformed with theory. Later work over the Lornty Dyke at Bairgowie in Perthshire gave a totally different anomaly from that predicted on the basis of its induced magnetism due to abnormal permanent magnetism. Just before the Second World War, it was demonstrated, in association with Prof. J. T. Whetton, that shallow deposits of weakly magnetic hæmatite could be located by their associated magnetic field. Among others, investigations were carried out over the Brockhill Dyke (Worcestershire) and also in Teesdale over faults in the Whin Sill. The former resulted in the tracing of the extensions of the dyke to the east and west, but estimates of width were rendered difficult because of the appreciable width of the adjoining, and magnetically altered, sediments. Two well-defined faults were followed in the Whin Sill and, in addition, observations over two outcrops, with strikes roughly parallel to and at 45° with the magnetic meridian, permitted the rough resolution of the permanent and induced intensities. The measurements were compatible with an induced polarity based on a susceptibility agreeing with direct observation, together with a horizontal permanent intensity directed approximately due south. The value of magnetic observations as an aid to geological investigations has been fully confirmed by the tests.

Mr. J. Hospers stated that his experiments support the suggestion of a reversed field, rather than that of some property of the rock, to account for adverse magnetism. In Iceland the examination of historical flows between A.D. 1766 and 1948 gives a mean direction of magnetization making an angle of 7° with the present field and 1° with an axial dipole field, and post-glacial flows, between two and six thousand years old, have a mean declination of 1·1° and a dip of 73·8° downwards, very near the dipole field. On the other hand, Early Quaternary flows, of a million years old, have a mean direction making an angle of 8° with the opposite direction of the present field. Below these there is a zone of normally magnetized Tertiary lavas followed by zones of alternate adverse and normal magnetization. The picture revealed is consistent with the idea of a sequence of field changes, occupying about ten thousand years, followed by a period of steady conditions, either normal or adverse, for some half a million years. It was emphasized that, the polarization of sediments between the flows conforms with that of neighbouring flows.

This conclusion is supported by the behaviour in the laboratory of rock specimens when heated and cooled. A rock, possessing adverse magnetization assumed to have been acquired by Néel's two-component mechanism, when heated should show a reduction in intensity as the temperature approaches the lower Curie point of the two constituents and, at some temperature just below this critical point, the reduced adverse polarization should be balanced by the normal polarization of the constituent of high Curie temperature. At the lower transition temperature the normal polarization only would operate, and this would finally fall to zero at the higher Curie point. Thus, the curve of intensity against temperature should show a reversal of polarity, a behaviour which was, in fact, observed for the dacite discovered by Nagata. Both normally and adversely magnetized specimens from Iceland, however, exhibit a monotonic fall to zero with increasing temperature, with no evidence of a reversal. Thus, Néel's two-component mechanism cannot apply. Some curves suggest two similarly magnetized constituents of differing Curie temperatures. On cooling in the laboratory field, each specimen recovers its polarization, the cooling curve matching closely the heating curve, a behaviour consistent with the hypothesis of a field reversal.

Prof. Tilley read a contribution from Prof. A. F. Buddington (Princeton University) in which some extensive negative anomalies, revealed by an aeromagnetic survey of the north-western Adirondacks, were discussed. Specimens of the gneisses, with which these anomalies are associated, possess inverse polarization in all cases, and this appears to be related to the ilmeno-hæmatite or titaniferous hæmatite in the rocks. The literature shows the presence of hæmo-ilmenite, titaniferous maghæmite and other similar minerals in rocks possessing adverse magnetization, and the general conclusion is that these minerals, with abnormal magnetic properties, are responsible for the phenomenon. The fact that magnetite, contemporary with these, often possesses normal polarity adds weight to this conclusion. No inference concerning the earth's magnetic field can thus be made until the possible significance of these minerals has been ascertained, the identification of the minerals requiring X-ray, chemical and microscopic examination.

The general discussion was opened by Sir Lewis Fermor, who described some of his early experiences in the Central Province of India during 1906, following the discovery that certain manganese minerals were magnetic. A dip needle gave very different readings over manganese ores and over the adjoining gneisses and schists. Due to a defect in the instrument, a systematic survey was not made and the observations were not published. Nevertheless, it was of interest to note that the Geological Survey of India had employed successfully the magnetic method in the search for manganese. Referring to the production of adverse magnetization by the processes suggested by Néel, Dr. S. A. Vincenz stated that the first need not be discussed since no such substance is known; but the second process is feasible. The latter is based upon the presence of two constituents, of differing Curie points, and their concentrations in aggregates or "amas". Using the formula developed by Néel and the observed properties of the Mull rocks, the required concentration in the aggregates can be determined. For the lavas and the olivine gabbros, these prove to be 42 per cent and 58 per cent, respectively, and he asked if there is any evidence for a distribution of ferromagnetic minerals in concentrations of this type. Dr. Vincenz also stated that the Swynnerton Dyke possesses remanent magnetism perpendicular to the present field, and similar results have been observed in some Tertiary Welsh dykes. It was pointed out by Dr. H. Manley that only one rock shows adverse magnetism in the laboratory compared with the many hundreds which behave normally.

A remarkable anomaly, associated with a dolerite sill in New South Wales, was described by Mr. A. Day, in which comparable positive and negative centres occur. As titanium is found in the rock, he suggested that a microchemical analysis for titanium in the magnetite of abnormally magnetized rocks might be useful. A similar case in the Allard Lake District, Quebec, was cited by Prof. D. Williams, where massive ilmenite-hæmatite gives negative anomalies but disseminated ore gives positive anomalies. A plea for the examination of the accessory minerals was made by Dr. W. Bullerwell, who indicated that, in Mull, the acid rocks are all normally magnetized. He inquired if their magnetism is less stable than that of the basic rocks, but was informed that their behaviour does not suggest this. On this point Dr. J. Sutton said that valuable data might be obtained from the mixed acid and basic formations of Mull. Replying to a further question by Dr. Bullerwell, Mr. Hospers stated that his suggested time for a change in the field was not based on theory but on observations of consecutive lava flows.

Mr. F. Lowes showed that Graham's argument, repeated by Mr. Creer, which is based on two oppositely magnetized deposits that are contemporary on the basis of their fossil content, does not condemn the idea of a field inversion. A fossil may persist for a million years—a period sufficient to embrace a number of reversals. The discordantly magnetized Welsh Dykes may represent a period of change. Mr. R. Hide pointed out that sedimentary rocks might show the secular change in the past, and the direction of drift during a period of reversal would be an important factor in sustaining or condemning modern theories of the main field.

Summarizing, Prof. Tilley said that many outstanding questions still remain and further data are necessary on sediments and igneous rocks. In particular, a knowledge of the accessory minerals is essential.

J. M. Bruckshaw

# OBITUARIES

## Prof. Philipp Ellinger

Philipp Ellinger died in London on September 12, 1952, after a long and painful illness. He was born in 1887 in Frankfurt am Main, where he spent his early years before proceeding to Munich to study natural sciences under von Bayer and Roentgen. He took the D.Phil. degree in chemistry at Greifswald under von Auwers in 1911, and passed on to Heidelberg to study medicine and finally graduated D.Med. in 1913. During the First World War he served as a medical officer in the German Army and returned after the cessation of hostilities to Heidelberg, where he occupied successively the position of assistant, lecturer and deputy director in the Pharmacological Institute there and served under three distinguished pharmacologists, Gottlieb, Wieland and Heubner. Towards the end of 1931 he was called to the chair and directorship of the Pharmacological Institute at the Medical Academy of Düsseldorf. By 1933, however, the political situation in Germany rendered his position untenable, and he found refuge in Britain, where, at the Lister Institute, he took up his research problems again and remained until his retirement in June 1952.

Ellinger's early work was largely in the field of toxicology; but by the time he came to Britain he had already turned to physiology, had published important work on renal function and had invented a technique for intravital microscopy which employed fluorescent dyes. With Koschara in 1933 he worked on flavin pigments which he isolated from whey, and thus he contributed materially to the discovery and identification of lactoflavin (riboflavin) as a member of the vitamin B complex and helped to establish the presence of this biologically important material as a constituent of Warburg's yellow enzyme. In 1937 he visited Egypt on behalf of the Medical Research Council to study pellagra, and returned to complete his investigations in 1938. During the second visit he became seriously ill and never fully recovered his normal health in after-years. As a result of the studies carried out in Egypt he concluded that the occurrence of pellagra resulted from two concomitant but independent factors. First, that a condition of latent pellagra arose from malnutrition, or malabsorption, due to the presence of intestinal infections. He believed that external factors such as hard physical work brought on an active pellagra when the latent state had developed. Ellinger examined the effects of a deficiency of different members of the vitamin B group on the excretion of abnormal porphyrin pigments, and just before the Second World War attempted to isolate and identify the light-sensitizing materials in buckwheat. Somewhat later (1942) he interested himself in the metabolism of nicotinamide in man and animals, and studied very thoroughly, during the next few years, the elimination of nicotinamide methochloride in normal and nicotinamide-deficient persons. The results of these researches revealed that the intestinal bacterial flora can form a very significant extra-dietary source of nicotinamide. His last investigations, on the heredity of the nicotinamide methylating mechanism in the rat and the elaboration of a new spectrophotometric method for tracing unknown urinary metabolites, remained unfinished.

Ellinger was highly cultured and widely travelled, and had many of the qualities of the typical German

*Gelehrter*, particularly the encyclopædic knowledge derived from much reading. He had a special love for pictures and a keen appreciation of the fine arts.

He was never a robust man, and during the closing years of his life, when his health deteriorated rapidly, his colleagues were deeply impressed by his fortitude, his complete occupation with the problems in hand and his absolute disregard of his own general frailty. Ellinger is survived by his wife, two sons and a daughter.

W. T. J. MORGAN

WE regret to announce the following deaths:

Prof. Jules Haag, director of the Institute of Chronometry at Besançon and non-resident member of the Paris Academy of Sciences, on February 16, aged seventy.

Dr. T. A. Jaggar, since 1940 research associate in the Hawaii National Park and an authority on volcanology, aged eighty-one.

Prof. Sergius Winogradsky, For.Mem.R.S., the distinguished bacteriologist, on February 24, aged ninety-six.

# NEWS and VIEWS

## Physical Chemistry in the Chester Beatty Research Institute, London: Dr. J. A. V. Butler

DR. J. A. V. BUTLER, who has just been appointed to the recently established chair of physical chemistry in the University of London tenable at the Chester Beatty Research Institute (Institute of Cancer Research, Royal Cancer Hospital), graduated in 1921 in the University of Birmingham, of which he became D.Sc. in 1927. During 1922–27 he was assistant lecturer in chemistry at the University College of Swansea, and in 1928 was awarded the Meldola Medal of the Institute of Chemistry. Then for the next twelve years he was lecturer in chemistry in the University of Edinburgh, and later spent two years as Rockefeller Research Fellow at the Rockefeller Institute, Princeton, N.J. He played an important part in the early days of the British Commonwealth Scientific Office in Washington, of which he was executive officer during 1942–44. In 1945 he became Courtauld Research Fellow at the Courtauld Institute of Biochemistry, Middlesex Hospital Medical School, London. Dr. Butler joined the Chester Beatty Research Institute in 1949, from which time he has devoted himself, with his school, to the application of the methods of biophysical chemistry to the problems of growth, the mode of action of ionizing radiations, and the mechanism of interaction of carcinogenic agents with nucleic acid and nucleoprotein.

Prof. Butler has contributed a notable series of papers and other publications to the scientific literature. A specially distinguished essay was his "General Thermodynamical System of Gibbs" (in "A Commentary on the Scientific Writings of J. Willard Gibbs", ed. F. G. Donnan and A. Haas, Yale 1936). A successful general work is his "Man is a Microcosm" (1950), and Prof. Butler has more recently acted as editor of "Electrical Phenomena at Interfaces" (1951), and (with Prof. J. T. Randall) of the important series "Progress in Biophysics and Biophysical Chemistry". His interest in the application of physical chemistry to biological problems is a new and significant development which the establishment of this new chair is intended to encourage and extend.

## William Froude Memorial Fund

FOLLOWING a suggestion made at the Sixth International Conference of Tank Superintendents, held in Washington, D.C., during 1951, the Council of the Institution of Naval Architects has been considering a proposal to commemorate the pioneer work of William Froude, F.R.S. (1810–79), a pioneer in ship model research and naval architecture generally. His main work was carried out for the Admiralty, and in 1872 he undertook the building of an experimental tank for ship research at a site near Torquay, Devon, this being the first tank of its kind in the world. It has been decided that the memorial should consist of two parts: the erection of a bronze plaque at a suitable point (in a country lane) nearest to the site of the experimental tank; and the publication of a volume containing all Froude's published technical papers. The total sum for this is estimated at £2,500, and subscriptions to the memorial fund are invited. It is understood that about half the proposed sum has already been promised. Subscriptions should be sent to the Secretary, Institution of Naval Architects, 10 Upper Belgrave Street, London, S.W.1, from whom all further information can be obtained.

## Finances of Research Associations

A DEBATE was held on March 3 in the House of Commons on the Draft Cotton Industry Development Council (Amendment No. 2) Order, 1953, the chief purpose of which is to increase from £300,000 a year to £450,000 the maximum amount of the levy which the Cotton Board can, with the approval of the Board of Trade, impose, and during the course of the debate numerous tributes were paid to the work and achievements of the Cotton Industry Research Association. The Order will make it possible for the Cotton Board to increase by the amount of the additional levy its contribution to the British Cotton Industry Research Association (Shirley Institute) for the promotion of research, and the Order received warm support from all sides of the House. Nevertheless, and in spite of general recognition that the work of this and of other research associations is already seriously embarrassed by rising costs, the debate was marked by general concern for more information regarding the actual expenditure on research of the research associations and the Department of Scientific and Industrial Research. Some of the questions in the minds of members, such as the possibility of effective development, of overlapping in technical research and of proper liaison between different research associations concerned with natural and synthetic fibres, could not be raised under the terms of the debate. It was clear that members wished to be satisfied that the considerable sums of money concerned are, in fact, being wisely expended and without waste. The debate, in fact, testified to the value of more independent scrutinies of the work of the research associations such as has already been conducted for the British Leather Manufacturers' Research Association.

## Russian Institute of Scientific Information

A new Institute, to be known as the Russian Institute of Scientific Information, has been established in the U.S.S.R. for the systematic supply of information from home and foreign sources relating to scientific and technical progress (*Vestnik Akad. Nauk*, 10, 92; 1952). Its main purposes, as specified by the U.S.S.R. Academy of Sciences, are: beginning with 1953 to publish an abstracting journal thoroughly covering world literature in mathematics, physical and chemical sciences, and from 1954 to extend its work to deal with biology, geology, geography and technology (engineering); to compile and publish reference books and bibliographies; to compile subject (thematic) reviews on developments in individual branches of science and technology in the U.S.S.R. and abroad; and to undertake translations and duplicating (photostating, etc.) work of journal articles as required by national institutions and industrial concerns. Three main divisions have been constituted as follows: scientific information work and editing of abstracts (referata); industrial publication; and administrative, etc. The Director of the new Institute, who is appointed by the Academy Presidium, is D. Yu. Panova.

## Twenty-fifth Anniversary of the Discovery of the Raman Effect

A meeting of the members of the Indian Association for the Cultivation of Science was held on March 7 in the premises of the Association at Jadavpur to celebrate the twenty-fifth anniversary of the discovery of the Raman effect; Prof. M. N. Saha was in the chair. The sequence of events leading to the discovery of the Raman effect on February 28, 1928, was first narrated briefly by Prof. S. C. Sirkar, with the help of slides and demonstrations. Prof. Saha then pointed out that the discovery was one of the most important in science of this century and that not only the Association but also the whole of India took pride in the fact that such a discovery was made in the laboratories of the Association. A resolution congratulating Prof. C. V. Raman on the anniversary was passed and forwarded to him.

## The United Nations Organization

Two recent publications by the United Nations Organization have been designed to direct popular attention to the activities of the Organization. The first, "Looking at the United Nations", gives a pictorial cross-section of the United Nations up to the end of 1951. Although only a brief sampling of the 34,000 pictures in the photo library of the United Nations Department of Public Information, they cover most of the important activities of the Organization during the past six years. The second, "United Nations in Pictures", has been compiled from picture features which have appeared in recent issues of the *United Nations Bulletin*. The picture stories in the booklet are grouped under general subject-headings including peace, security, economic progress, social advancement, the work for subject peoples and the development of international law. Copies of both booklets may be obtained from H.M. Stationery Office, London.

## The Gannet in New Zealand

Apparent changes in the gannet population of New Zealand led to a desire that a census be taken to ascertain past population trends and to provide a basis for discussion of future changes. In 1946–47 the Ornithological Society of New Zealand adopted the gannet census as a project for co-operative study during the 1946–47 breeding season, and C. A. Fleming and K. A. Wodzicki were appointed organizers of the survey. They have now prepared a paper giving details of the census project and a summary of available data on the past history of the gannetries (*Notornis*, 5, No. 2; October 1952). The paper shows that there has been a general increase in the New Zealand gannet population during the past century. The reason for the suggested increase in total population cannot be stated. The Maoris used young gannets as food; but this was probably on a small scale. During the nineteenth century, Maori use of gannets became negligible. The gannet was protected in the Animal Protection Amendment Act, 1910. The effect of legal protection cannot have been great for there was no habitual use of gannets as bait by fishermen, or as food, before the Act was passed. There is no record of destruction on a large scale. The use of gannet guano on a commercial scale was once contemplated; but it has never been taken regularly in large quantities. A little guano is still removed from some gannetries; but there is no evidence that this affects the success of breeding. The change in man's influence on gannets is not enough to account for their increase in New Zealand. The apparent trend is perhaps due to fundamental changes in the ecology of the sea, possibly of a cyclic nature.

## Seasoning Behaviour of Indian Timbers

In *Indian Forest Bulletin*, No. 154 (new series), M. A. Rehman, of the Wood Seasoning Branch of the Forest Research Institute, Dehra Dun, discusses "The Seasoning Behaviour of Indian Timbers" (Part 1; pp. 5+1 plate; Delhi: Manager of Publications, 1952; 8 annas or 9*d*.). In the days before the Research Institute came into being at Dehra Dun, seasoning of timber was practically unknown. Green timber from the forests, by the time it reached the market, may have become air-seasoned to a small extent, but usually not sufficiently to withstand the trying conditions of the climate in the variety of species now used in wood-work. A considerable amount of data on the air- and kiln-seasoning properties of Indian woods has been collected by the Wood Seasoning Branch during the past thirty-five years in the experiments carried on at Dehra Dun, as well as in the field in other parts of the country. Systematic accounts of the results of most of the air-drying tests have been published from time to time, but little information has so far been published by the Institute on kiln-drying studies. The object of this publication and subsequent parts is to assemble all the available information on air- and kiln-drying timbers of important Indian timber trees. The importance of adopting proper methods of seasoning wood before use is emphasized. The advantages of seasoning are discussed. The air and kiln seasoning of fir is described, and the kiln-drying schedule recommended for 1-in. planks of fir and for several other light hardwoods suitable for packing-cases is given.

## Fossil Mammals of Africa

Two further papers based upon material collected by the British–Kenya Miocene Expedition have appeared in the series 'Fossil Mammals of Africa", published by the British Museum (Natural History).

The first, No. 4, is on "Miocene Anthracotheriidæ from East Africa", by D. G. MacInnes (pp. 24+4 plates, 1951). The author comments on the fact that most of the East African fossil material is fragmentary, possibly as the result of scavenging animals attacking the dead bodies. The presence of a well-preserved skull and also some fragments of others enables the author to establish satisfactorily, and in some detail, a new species *Brachyodus æquatorialis*. The material included some limb bones and metapodials which, while not directly associated with the skulls, can reasonably be attributed to the same, or a closely allied species. Further information on *Hyoboops africanus* is also provided.

The second, No. 5, by W. E. Le Gros Clark and D. P. Thomas, is based on specimens of "The Miocene Lemuroids of East Africa" (pp. 20+3 plates, 1952). The material includes mandibular and maxillary fragments, a brain case and an endocranial cast. It all belongs to the sub-family Galaginæ and to the genus *Progalago*. The name was given because, when the type species *P. doræ* was described by D. G. MacInnes, it was considered that it represented a group from which the modern *Galago* might well have been derived. The paper adds considerably to our knowledge of the type species and also describes two further species of the genus, and the authors comment that none of the new evidence is contrary to the suggestion made with regard to the relationship of the genus with *Galago*. The plates accompanying both papers are of a high quality and very well reproduced.

### Radioactive Starch and Hexose Sugars

THE preparation of radioactive starch, glucose and fructose from tobacco leaves after assimilation of $^{14}CO_2$ has been described by H. K. Porter and R. V. Martin (*J. Exp. Bot.*, 3, 9, 326; 1952). In the photosynthesizing process, the experimental control of which is described, at least 80 per cent of the $^{14}CO_2$ supplied appeared in the leaves as starch and sugar and more than 80 per cent of the radioactivity was accounted for in these carbohydrates. Small amounts of radioactive carbon were also found to be incorporated in the protein, cellulose, hemicellulose and polyuronide components of the leaf.

### 3-Indolylacetonitrile: an Important Plant Hormone

INVESTIGATIONS of the recently discovered and important plant growth hormone, 3-indolylacetonitrile, and of 3-indolylacetaldehyde (reported to be present in plants), and both now available as pure synthetic substances, are described by J. A. Bentley, S. Housley and A. S. Bickel (*J. Exp. Bot.*, 3, 9, 393, 406; 1952). As measured by their effects on cell-elongation in the coleoptile of *Avena*, 3-indolylacetaldehyde is considerably less active than 3-indolylacetic acid. An acidic substance is produced by the aldehyde during the period of assay, and in some experiments the aldehyde's activity could be accounted for on the assumption that it is transformed into 3-indolylacetic acid. Other evidence indicates that the aldehyde itself is either inactive or inhibitory. The nitrile, which is considerably more active than 3-indolylacetic acid, shows little production of acid during the period of assay. As the nitrile is destroyed by treatment with alkali but not with acid, the authors consider that earlier work on the identification of auxins in plants by their acid and alkali sensitivity should be re-examined. By using the *Avena* straight-growth test, in which the nitrile shows activity, evidence has now been obtained that it is present in various members of the Cruciferæ. Transport of the nitrile, like that of the acid, is polar, but it is considered that the nitrile can reach the growing cells as easily, if not more so, than the acid —a finding that is important in attempts to postulate the mechanism of nitrile action. The nitrile is less active in the *Avena* curvature test than the acid, and is inactive in the pea curvature and straight-growth tests except at high concentrations. It is inactive or only slightly active in the inhibition of lateral buds, in the inception of roots, and in petiole abscission at the concentrations tested. It is also less active than the acid in root inhibition in cress, but about as active in *Avena*. It is of about the same activity as the acid in the development of parthenocarpic fruit and the stimulation of cambial activity.

### Total Eclipse of the Sun on June 30, 1954

A SUPPLEMENT to the "American Ephemeris and Nautical Almanac" for 1954 has been issued by the U.S. Naval Observatory, entitled "Total Eclipse of Sun, June 30, 1954" (pp. 42. Washington, D.C.: Govt. Printing Office, 1952; 40 cents). It is designed primarily for use along the path of the total phase of this eclipse, which will be visible in the United States, Canada and Greenland; but data are also given for the Atlantic Ocean and Europe. The maps provide local circumstances of the eclipse for all places within the limits of the eclipse region extending from the southern limit of the eclipse to lat 73° N., and from long. 170° W. to 80° E. Two tables give the necessary data for finding the position of the central line at various heights above sea-level and in the ionosphere up to 300 km., and also the duration of totality on the central line and the width of the path, at the earth's surface and at heights ranging from 100 to 300 km. The "American Ephemeris and Nautical Almanac" for 1954 gives a map for the complete eclipse area and also the Besselian elements and other usual eclipse data not given in the supplement, including an example of the calculation of the circumstances of the eclipse for a given place.

### Catalogue of Horrebow Star-Pairs for the determination of Northern Latitudes

A CATALOGUE of star-pairs for northern latitudes from 55° to 70° for astronomic determination of latitudes by the Horrebow–Talcott method has been compiled by Pentti Kalaja (Suomen Geodeettisen Laitoksen Julkaisuja, No. 41. Pp. 191. Helsinki: Finnische Geodätischen Institute, 1952). The stars of Horrebow-pairs appearing in this catalogue have been selected from the "General Catalogue of 33,342 Stars for the Epoch 1950", by Benjamin Boss, and in the selection of the stars certain principles have been observed, among which the following may be noticed. The right ascensions of the stars must lie between 17h. and 24h. and their declinations between 30° and 85°. Stars of magnitudes between 3 and 7 only are admitted; experience has shown that it is not advantageous to use very bright stars, although their declinations are generally determined with great accuracy. The parallax of the star used must be less than 0·05″ and the probable error of the declination must be smaller than ± 0·40″. In addition, double stars, of which the distance from each other lies between 0·1″ and 6″ and the difference in magnitude is less than 3 m., have been rejected. Double stars which have circular or elliptical motion, and those which have peculiarities in proper motion, have also been excluded. As the catalogue is intended for latitudes 55°–70° N., which includes nearly all of Finland, Sweden and Iceland, most of Norway, Denmark, Scotland and Alaska, the greater portion of Canada, and most of the Soviet Union, except the northernmost parts, the mean declinations of the stars must lie between 55° and 70°. Other conditions are that differences of magnitude of the stars must not exceed 2 and differences of right ascension for the stars of 1950·0 must lie between 2m. and 15m. More than 176 pages of tabular matter are included in the catalogue.

### Earthquake Waves reflected at the Earth's Core

PROBABLY the first mention of a transverse wave reflected at the boundary of the earth's core is to be found in a paper by F. J. Scrase in 1931 ("The Reflected Waves from Deep Focus Earthquakes", *Proc. Roy. Soc.*, A, 132; 1931). These pulses were observed by K. Wadati for an earthquake on November 13, 1932, and H. P. Berlage observed the waves at Amboina, his results being published in 1937 and 1939. S. W. Visser also noted the waves on the Amboina records of an earthquake on June 29, 1934, his book being published in 1937. R. A. Garrick (*New Zealand J. Sci. Tech.*, B, 31, No. 2; September 1949) has noted these pulses on New Zealand seismograms at epicentral distances of 0·92°, 2·25° and 3·45° for the earthquake of January 15, 1948, and has tabulated the readings. These results extend the observations by E. Tillotson (1939) and form a very valuable check on the "Seismological Tables".

### Iron and Steel Institute: Awards

THE following awards have been made by the Iron and Steel Institute: *Bessemer Medal for* 1953, to R. Mather, of Skinningrove Iron Co., Ltd., and past-president of the Institute, for his distinguished services to the Institute and to industry; *Sir Robert Hadfield Medal for* 1953, to W. E. Bardgett, research manager of the Central Research Laboratories of the United Steel Companies, Ltd., in recognition of his contribution to the development of alloy steels, with particular reference to steels for service at elevated temperatures; an *Andrew Carnegie Silver Medal for* 1952, to Dr. E. T. Turkdogan, now with the British Iron and Steel Research Association, for his research on slag-metal reactions reported in various papers, his results being written in collaboration with Dr. W. R. Maddocks (*J. Iron and Steel Inst.*, July 1949, and June and September 1952); *Ablett Prize for* 1952, jointly (£50 each) to Dr. S. A. Burke and G. A. Sparham, of the British Coal Utilization Research Association, for their paper on the automatic control of coal feed in steelworks gas-producers (*J. Iron and Steel Inst.*, November 1952). No award was made of the Williams Prize.

### Grants of the U.S. National Science Foundation Awards

THE National Science Foundation has recently made seventy-eight grants, totalling 685,200 dollars, to institutions in the United States for research in the biological and the physical sciences and for the support of studies and conferences on science and scientific education. This is the second group of awards to be announced under the Foundation's programme for the support of basic research, bringing the total number of research grants made this year to one hundred and thirty, worth 1,340,650 dollars. The fields included are astronomy, chemistry, developmental biology, earth sciences, engineering, environmental biology, genetic biology, mathematics, microbiology, molecular biology, physics, psychobiology, regulatory biology, research education in the sciences, scientific information, studies in science and systematic biology. The duration of research grants in this latest group of awards ranges from eight months to three years, with an average length of 1·6 years; the average grant amounts to 5,475 dollars a year.

### University of London: Appointments

THE following appointments have been made in the University of London: Mr. J. Durbin, lecturer in statistics at the London School of Economics and Political Science, to the university readership in statistics tenable at the School; Dr. D. A. McDonald, senior lecturer in physiology at St. Bartholomew's Hospital Medical College, to the university readership in physiology tenable at the College; Mr. A. E. Smailes, reader in geography at University College, London, to the university readership in geography tenable at Queen Mary College.

### Announcements

DR. KEITH MURRAY, rector of Lincoln College, Oxford, has been appointed chairman of the University Grants Committee in succession to Sir Arthur Trueman, who is retiring on October 1 for reasons of health.

THE second international conference on the biology and cultivation of the mushroom will be held at Gembloux, Belgium, during June 16–24. Further information can be obtained from the honorary secretary, Mlle. L. Engels, C.E.R.E.C., Institut Agronomique de l'État, Gembloux.

THE spring conference of the Institute of Metal Finishing will be held in the Hotel Majestic, Harrogate, during April 22–25. The conference will begin with an informal reception and dinner on April 22, and during the next three days there will be four technical sessions on, respectively, organic and other non-electrodeposited coatings, electrodeposition, fundamental electrode processes and shop practice. Further information can be obtained from the Conference Secretary, 32 Great Ormond Street, London, W.C.1.

THE Textile Institute is offering a Cotton Industry War Memorial Trust Scholarship, of maximum value £950, for a three-year course in textile technology at an advanced level, with provision for industrial training and experience of a special character in Britain or overseas. The closing date for applications is April 30. The Institute is also offering a new scholarship, to be known as the 'Peter Coats' Scholarship, since it has been established by the will of the late Mr. Coats, of Paisley, and this award, which is of maximum value £200, is intended to enable a person who has already been awarded or promised a scholarship in advanced textile technology to pursue a year of full-time study preparatory to taking up his main course at a university or college. The closing date for applications is May 30. Candidates for both these awards must be male British nationals less than twenty-four years of age. Application forms and further information can be obtained from the General Secretary, Textile Institute, 10 Blackfriars Street, Manchester 3.

# RECENT ADVANCES IN MICROBIOLOGICAL METHODS

VARIOUS aspects of recent advances in microbiological methods were discussed at a joint meeting of the Society for Applied Bacteriology and the Microbiological Group of the Society of Chemistry and Industry, which was held at the Institution of Civil Engineers, Great George Street, London, on January 14. Dr. J. G. Davis presided at the meeting.

Prof. M. Stacey opened the meeting with a paper on the "Chemistry of Gram Staining and of the Feulgen and Dische Reactions for Nuclear Material". Mention was made of the need to put the important microbiological and histological staining techniques on to a firm chemical basis. Profound chemical differences exist between the two groups of organisms: the Gram-positives, which can be stained by Gram's basic fuchsin – iodine technique; and the Gram-negatives, which do not retain the stain on being washed with alcohol. By means of bile salts Gram-positives can be stripped of their surface material, leaving a Gram-negative cytoskeleton. When this is kept under reducing conditions, it is found that magnesium ribonucleate from the bile salt extract or from other sources will combine with it in such a way that the Gram-positive state can be restored. It is considered that the dye-retaining complex is a magnesium ribonucleoprotein located near the cell surface of Gram-positives. Gram-negatives, on the other hand, although possessing ribonucleic acids, have surface material composed of phospholipids, protein and polysaccharides.

The significance of ribonucleic acid in the Gram-complex can be emphasized by the use of ribonucleases and autolytic enzymes from the cell. Cells rendered Gram-negative by the action of lytic enzymes are difficult to reconstitute unless they are first treated with the protein component of the Gram-complex, followed by addition of the magnesium ribonucleate. Mechanical disruption of cell surfaces completely destroys the possibility of reconstituting the Gram-complex.

Deoxyribonucleic acid plays no part in the Gram-complex; but its deoxy sugar component is implicated in both the Dische diphenylamine and Feulgen reactions for nuclear material. The Dische reaction is explained by the finding that 2-deoxypentoses under the strongly acidic conditions of the test are transformed into ω-hydroxy lævulic aldehyde that combines with diphenylamine to give a blue dye which, in the Spekker, has a characteristic band with a single peak.

The Feulgen test can be explained as a result of extensive investigations on the properties of 2-deoxy sugars. Under mildly acidic conditions the 2-deoxyribofuranose component of the nuclear material readily loses some of the groups attached at the reducing carbon atom, and the sugar ring opens to give an aldehydo-sugar. This gives an intense insoluble dye with the Schiff's reagent used in the Feulgen test. Further implications of the known behaviour of deoxy sugars were mentioned. In the discussion which followed, Prof. Stacey was unable to explain some of the observations of various investigators during Gram-staining, and he mentioned that magnesium is not completely specific in the Gram-replating technique.

The next speaker was Dr. E. Windle Taylor, who described the "Use of the Membrane Filter in the Bacteriological Examination of Water". He said that collodion membranes not only retain all micro-organisms from a large volume of liquid, but can also be placed in contact with a substrate which conveys nutrients through the pores to the deposited bacteria so that they can be cultivated *in situ*. The substrate takes the form of an absorbent pad which can be soaked with concentrated nutrient. The use of the apparatus is quite simple, but sterilization of the membranes requires great care. After much trial it has been found possible, without harming the membranes, to autoclave them for ten minutes at 10 lb./sq. in. pressure if they are stacked alternately with absorbent pads and the pile wrapped in kraft paper.

The main lines of investigation were to ascertain whether the apparatus and technique could be applied to media and methods commonly employed in Britain for the bacteriological examination of water, and this has been established in a satisfactory manner. The amount of liquid that can be filtered in a given time through each membrane depends upon the amount of suspended matter, and varies from two litres in ten minutes for tap water to a quarter of a litre in one hour for sewage effluent. Double-strength nutrient broth is used for colony counts, and figures obtained closely follow the corresponding agar counts, while in certain circumstances, such as pure chalk waters, larger volumes can be examined. Colonies first become visible after eight hours incubation and reach a maximum after eighteen hours. MacConkey broth can be used for the coliform examination, if made up in triple strength but with bromcresol-purple indicator of twelve times strength. The lactose-fermenting colonies are clearly distinguishable as pale yellow colonies on a blue background. Colonies are first seen after eight hours incubation, and a maximum number is reached after twelve hours incubation. Preliminary resuscitation of bacteria with nutrient broth and the achievement of direct *Bact. coli* counts are matters for further study.

Pathogenic bacteria have been successfully isolated by membrane filtration by cultivating the membrane in selenite broth, thus saving a large volume of medium; no success has yet been achieved in producing typical colonies of enteric organisms on a membrane and pad impregnated with a liquid form of Wilson–Blair medium.

The chief advantages of the technique are concentration of organisms, removal of inhibitory substances in the water itself, saving of glassware and media and, in the case of the coliform test, the avoidance of false presumptive results due to spore-forming anaerobic lactose-fermenters. There appears to be a field of exploration along three main lines to assess the applicability of filter membranes in the bacteriological examination of water: for examining a series of samples, as in a river or a lake survey; where a rapid result is required; and for isolating pathogenic organisms from sewage effluents and polluted waters.

In the lively discussion which followed, various speakers mentioned their own experiences with the membrane filters and the commercial availability of various types, and the general feeling was reached that the filters would prove very valuable.

In the next paper, Dr. L. A. Allen described the "Enumeration of *Bacterium coli* and of *Streptococcus fæcalis*". Growth of *Bact. coli* on bile salts – lactose agar at 44° C. has been found to be conditioned by a number of factors. The temperature of 44° C. is critical for this organism, and an accurately controlled water-bath is essential. The inclusion of phosphate in the medium reduced the count of all strains tested, and some strains were virtually unable to grow under these conditions. When the bacteria are suspended in water, the proportion of the total population able to grow on the bile salts medium at 44° C. tends to decrease as the period of suspension is prolonged. This result of attenuation can be largely overcome by dividing the medium into two parts, each of double strength—lactose broth; and a solution containing the bile salts, indicator and agar —and subjecting the inoculum to a short period of incubation in the lactose broth at 37° C. before adding the second part of the medium and incubating at 44° C. 'Resuscitation' for one hour in this way results in a count on bile salts – lactose agar at 44° C. which approximates to the count on Yeastrel – glucose agar at 37° C. The film of agar is formed in a rotating bottle which can afterwards be directly immersed in a water-bath. The temperature cannot be controlled with sufficient accuracy if Petri dishes are used.

Evidence has accumulated in recent years that *Str. fæcalis* may be a useful indicator of fæcal contamination when used in conjunction with conventional tests for coliform bacteria. As a result of a similar study of the growth of this organism on 'Yeastrel' – glucose azide agar, a technique has been formulated for obtaining a colony count on this medium at 45° C. *Str. fæcalis* was found to be so sensitive to neutral red that it was necessary to leave this indicator out of the medium altogether. Phosphate exerts no depressing action on the count, provided it is not included with the other constituents of the medium before autoclaving. As with *Bact. coli*, 'resuscitation' largely overcomes the inability of attenuated cells to form colonies on this medium.

The principle of resuscitation has been applied to the determination of the most probable number of both organisms for use with samples in which the numbers of bacteria are too small to permit of an accurate colony-count. The resuscitation method has been found to give significantly higher results than existing methods for both organisms, it requires less time for completion, and it is virtually specific for the organism concerned.

Following the comments on this paper, Dr. S. T. Cowan dealt with "Microchemical Methods for the Characterization of Bacteria". He said that the reproducibility of a biochemical test depends on the ability of the organism to produce appropriate enzymes and also on the medium, temperature and duration of incubation, volatilization or utilization of the end-product, and the sensitivity of the test reagents. Bacteria are essentially complex enzyme systems and are most easily studied by letting non-growing cell suspensions act on defined substrates. This principle can be applied to the biochemical tests used in bacteriological laboratories, one enzyme system being tested at a time. Each test depends on the action of a very heavy suspension of the organism: the heavier the suspension, the quicker the reaction; and a minimum density equivalent to $10^9$ *Bacterium coli*/ml. is essential.

Fermentations are carried out by mixing sugar solution, bromthymol blue and bacterial suspension and incubating at 37° C. The method is sensitive and shows acid production by organisms which, in growing cultures, appear to lack fermentative ability. Other tests for glucose breakdown can be adapted to the micro-methods using suspensions. A micro-method for the methyl red test (ability to produce a *p*H of 5 or less from glucose) is being developed. Acetoin (acetylmethylcarbinol) can be detected readily; but, as the enzyme is adaptive, the suspension should be made from growth on a glucose medium. Hydrogen sulphide production can only be observed when there is an adequate source of sulphur available; cysteine hydrochloride is suitable for all the bacteria examined, but the test using cysteine and lead acetate paper is so sensitive that it has little differential value.

Nitrate reduction, the production of indole, and urease are other tests that can be carried out quickly with suspensions and the appropriate substrates. All the micro-methods so far developed are simple to set up and are quick in action; the specificity of the tests depends on the test reagents.

By testing each enzyme system separately, it should be possible to characterize a bacterium by its enzymic formula, much as a serologist characterizes it by an antigenic formula. The micro-methods should be readily adaptable to studies on the availability of different amino-acids.

Numerous speakers commented on the paper, and the useful suggestion was made by Mr. H. B. Hawley that the chromatographic purity of the sugars used by Dr. Cowan should be checked.

Finally, Mr. J. Tramer spoke on "Use of Bacterial Phosphatases in Differentiating Certain Micro-Organisms". Bray and King investigated, in 1943, the production of phosphatase by growing organisms as a possible aid for their differentiation. They assessed the phosphatase activity of a wide variety of species by incorporating phenolphthalein phosphate in an egg medium. The amount of phenolphthalein liberated from the substrate by phosphatase served as an indication of the amount of enzyme produced. They found their relative simple technique of value in differentiating between members of certain genera, but thought the slow rate of hydrolysis of their substrate to be a disadvantage.

Barber and Kuper examined, in 1951, the possibility of distinguishing between pathogenic and non-pathogenic staphylococci by their respective phosphatase reactions. They used phenolphthalein diphosphoric acid which, when suitably incorporated into an agar medium, allowed good differentiation between phosphatase-negative colonies, which were found to be coagulase-negative and therefore non-pathogenic, and phosphatase-positive colonies which proved to be coagulase-positive and only rarely coagulase-negative.

Yet another substrate, disodium *p*-nitrophenylphosphate, has been shown to be useful in the estimation of phosphatase activity. It is colourless in solution but produces, on hydrolysis by phosphatase, free *p*-nitrophenol, which is yellow in neutral and alkaline solution and serves as a measure of enzyme activity. Although not heat-stable, solutions can be Seitz-filtered and incorporated into solid and liquid media. On solid media, colonies of phosphatase-producing organisms will show a yellow colour after a suitable incubation time, and liquid media will turn yellow if such organisms are present. Plates containing media into which disodium *p*-nitrophenylphosphate has been incorporated can be used for streaking, and it has been found practicable to flood inoculated and incubated normal milk agar plates with a small amount of a disodium *p*-nitrophenylphosphate solution. In the latter case, surface colonies of strong phosphatase-producing organisms will turn yellow in a few minutes.

The estimation can be made quantitative by incubating a measured amount of bacterial suspension with a suitably buffered or unbuffered solution of disodium *p*-nitrophenylphosphate for a certain time (half an hour to several hours) and estimating the colour developed in a comparator using permanent colour standards, or photo-electrically. Using such a procedure, a good relationship was found between phosphatase activity and gelatine liquefaction time of Voges–Proskauer positive, methyl red negative Coli-aerogenes organism. *Bact. cloacæ* appears to be in general a non-, or only weak, phosphatase-producer, while *Bact. aerogenes* and also the 44° C. positive type (Irregular VI) are strong phosphatase-producers.

In addition to the degree of phosphatase activity and its correlation to another biochemical reaction, there are certain characteristics of the bacterial phosphatase produced which may be of value in differentiating micro-organisms. Pett and Wynne have shown that the *p*H optimum may be of value in this respect, and it is suggested that the heat stability in certain media and the activity of a cell-free filtrate may also be of use.

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# CHEMISTRY AND INTER-RELATIONSHIPS OF ENDOCRINE SYSTEMS AND THEIR PSYCHOLOGICAL EFFECTS

An evening discussion meeting on this theme was held on February 26 by the Society for Visiting Scientists at 5 Old Burlington Street, London, W.1, Dr. A. S. Parkes (National Institute for Medical Research, Mill Hill) being in the chair.

Prof. Jean Roche (Collège de France, Paris) spoke first, his subject being the biochemical aspects of hormone actions. One of the major concepts influencing biochemical thought and research in the present century is that of bio-catalysts—substances of great importance profoundly influencing the rate of chemical reactions in the body, and effective in small or minute amounts. Within this general group are substances which were at first thought of as being of a very different nature—vitamins, hormones and enzymes. The demonstration that many, perhaps all, vitamins act by virtue of their intimate association with the enzymes concerned with fundamental metabolic processes in the body is of immense significance.

In the case of the hormones, early work was concerned mainly with their physiological, rather than with their biochemical, actions; the biochemist could approach their study only indirectly by studying their effects on tissue enzymes, and after this action had been shown to be specific, both for the hormone and the enzyme involved. For example, the administration of œstrogens to the castrate female animal produces a marked rise in the alkaline phosphatase content of the uterus, but not of other tissues. Progesterone alone has almost no effect but, given with œstrogens, prevents this rise in enzyme content. Arginase is an enzyme of great importance in the mammals, because of its part in the Krebs cycle for the conversion of ammonia to urea—the main nitrogenous excretion product in this group. More recently, androgens have been shown to increase the concentration of this enzyme in the kidney; the concentration in other organs and of other enzymes in the kidney is not affected. The response is not produced by other sterol hormones without androgenic activity. Similarly, Folley and Greenbaum have demonstrated a marked (hundred-fold) increase in the concentration of this enzyme in the mammary gland following parturition as lactation begins under hormonal influence. These and other observations suggest that tissues can respond by specific enzyme changes in response to specific hormones, and that through such studies the biochemist can make valuable contributions to the least well-known aspect of endocrine function—the mechanism of their peripheral action.

Prof. F. G. Young (Cambridge) suggested that hormones might be defined as substances liberated into the blood stream to produce changes in tissues at a distance. As Prof. Roche had already emphasized, their action is most probably exerted by their effect on the chemical processes of the receptor cells. As a parallel to their marked actions in chemically small amounts, the early workers in this field had difficulty in gaining general acceptance for their concepts as there was reluctance to admit that such physically insignificant organs as the pituitary and adrenal glands and the apparently unimportant islet cells of the pancreas could be of supreme importance to the maintenance of life. Full acceptance was delayed until it was shown that the disastrous results of experimental removal of these 'inner secreting' or endocrine glands could be reversed by injections of potent extracts from them. Even the central nervous system, which at the time when the early observations were made, such as that of Addison in 1855, was thought to be the dominant controlling system, has been shown to depend largely on the maintenance of the correct balance of endocrine activity for its proper functioning. The level of sugar in the circulating blood is largely under hormonal control: a doubling leads to diabetes and severe metabolic upset; a halving to coma, convulsions and death.

Chemically, the hormones are a very heterogeneous group; even in a single gland there is often a multiple secretion rather than a single hormone. Very recently it has been shown that the thyroid, formerly thought to secrete only one effective chemical substance—the iodo-amino-acid thyroxine—probably secretes also the closely related and more active 3′-3-5-tri-iodothyronine.

In conclusion, Prof. Young pointed out that many endocrine glands are derived embryologically from 'barrier' tissues—the ectoderm separating the animal from the external environment, and the endoderm of the alimentary canal coming between the body as a whole and the gut lumen. He postulated that one important action of hormones in the tissues might be concerned with increasing or decreasing the rate at which important metabolites cross the barrier of the cell membranes.

Prof. G. W. Harris (Institute of Psychiatry, University of London) said that the profound effects of the endocrines on the nervous system and behaviour, and more recently the influence of the nervous system on endocrine function, have been known in a general way to those engaged in medical practice for many years. The deliberate experimental study of the extent and mechanism of these inter-relationships is a more recent development. Of the influence of hormones on behaviour, still very little is known except in certain limited fields. The studies of Beach on the modification of animal behaviour under the influence of sex hormones are outstanding in this field. Nervous control of the endocrine glands has been more extensively studied and more is known of this.

Despite the fact that only two endocrine glands—the adrenal medulla and the posterior pituitary—are known to have an anatomically obvious and functionally important direct nerve supply, nervous factors are known to play an important part in endocrine function. Marshall's original investigations on the importance of "exteroceptive factors", such as light and temperature, on the sex rhythms of lower animals, have been confirmed and extended in great detail. More recently the responses of the adrenal cortex under the control of the adrenocorticotrophic hormone of the anterior pituitary have been exhaustively studied. An animal exposed to physical or chemical trauma, or to various procedures such as forced immobilization or loud noises, all presumed to cause mental disturbance and, for want of a more precise term, grouped together as 'emotional stresses', exhibits definite signs of increased adrenal cortical activity. Recent work in Prof. Harris's laboratory seems to indicate that in rabbits the activity of the thyroid gland, under the control of pituitary thyrotrophic hormone, decreases in response to such 'stresses' that are known to activate the suprarenal gland. The clinical impression that emotional disturbance may be a precipitating factor in the onset of human hyperthyroidism is another indication of nervous influence on thyroid function.

There is, therefore, a very considerable body of evidence, from many sources, of nervous and mental influence on endocrine function, mediated mainly via variations in the output of the trophic hormones of the anterior pituitary gland.

The discussion at the meeting centred mainly on the influence of psychological factors on endocrine function. Various speakers commented on the difference in response of the experimental animal and man with respect to thyroid function. Prof. Harris replied that the depression seen in his animals was unexpected in view of the information available about human disease. A species difference was postulated by other members of the audience. Different responses in the same species to similar physical stress accompanied by presumably different emotional states were described; in the ritual fighting of male mice kept together, the blood sugar of the aggressor is elevated, but not that of the attacked animal, though both exhibit violent physical activity.

Dr. Parkes, in his summing-up, re-emphasized the importance of the approach discussed by Profs. Roche and Young—the detailed study of the mechanism of peripheral action of the hormones. For the non-chemical endocrinologist, perhaps the most valuable and promising field for future research is the influence that the external environment, acting through the central nervous system, exerts upon the endocrine state of the organism.

# ANALYSIS OF MECHANICAL AND ELECTRICAL ENGINEERING FAILURES

BEFORE the Second World War the British Engine Boiler and Electrical Insurance Co., Ltd., issued annually a technical report dealing both with original work and with the investigation of engineering failures. Vol. 1 of a new series has just been published, which more than maintains the high standard of its predecessors*. This publication will be found to be of the very greatest interest by all engineers and metallurgists who are concerned with the field common to the two professions.

The first forty-five pages are devoted to a most commendable discussion from the practical point of view of caustic cracking in steam boilers, possibly the most comprehensive treatment which has so far appeared. A very considerable number of cases are discussed in detail, and since neither chemists nor metallurgists are as yet in complete agreement as to the details of the fundamental mechanism involved, and since no reliable means of preventing this dangerous form of deterioration has been developed, these are the more valuable. It is suggested that the best advice that can be offered in the light of present knowledge is that the workmanship of new boilers should be of a high standard, particularly as regards the sealing of the riveted seams on the water side; that care should be taken to avoid over-heating, rapid fluctuations of temperature, and other factors arising under working conditions which may disturb the seams; that special care is required in repair work in connexion with the sealing of such seams; and the maintenance of a minimum caustic alkalinity of the boiler water and the maintenance of a sodium sulphate/sodium hydroxide ratio above 2·5.

A most interesting account by Mr. G. A. Cottell of original work on the sources of error in notched-bar testing concludes this publication. The apparatus is described and the sources of error carefully differentiated; in particular, the influence of the seat between the specimen and the machine has been investigated and a new form suggested which cuts down the loss very considerably and, at the same time, eliminates much of the scatter found under normal conditions. It is shown that the results of such losses may reach as high a value as 25 per cent. It is of more than a little interest that, when using a modified form of specimen or a modified type of test, the yield point is clearly shown, even under notched-bar conditions. A fact of great interest which emerges from this work is the evidence that the speed of fracture exerts a considerable influence on the results. A comparison is made between impact and slow-bend tests on identical specimens, and it is shown that the total work of fracture with the Izod specimen is almost 20 per cent higher in impact than when the specimen is broken slowly. A continuation of this work will be looked for by many.

The remainder of the report is concerned with the examination of twenty-seven cases of service failure, a typical one being that of the brittle fracture of a crane hook, which is referred to strain age-embrittlement in a rimming steel, resulting from the strain and heating due to compression and abrasion. A similar example of strain age-embrittlement in a rimming steel occurred in the case of some boiler rivets, the brittleness being traced to the presence of nitride 'needles'. Such work is in a direct line with the tradition in these reports, since Stromeyer's work on the effect of nitrogen in embrittling steel was carried out in the laboratories of the Manchester Steam Users' Association, now taken over by the Company which has issued this report. Incidentally, the same tradition can be traced in the work on the notched-bar test, a subject on which Schuster carried out considerable research.

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* British Engine Boiler and Electrical Insurance Co., Ltd. Technical Report, New Series, Vol. 1. Pp. 212. (From the Company, 24 Fennel Street, Manchester 4, 1952.) 12s. 6d.

The account of these investigations on engineering parts which have failed is very welcome. Only too often, service failures are hidden in the scrap heap, and careful investigation can be of immense value in minimizing the danger of further fractures from the same cause. These investigations cover both the mechanical and electrical fields. In the latter there is also an article by D. C. Bacon on "Excess Current Protection of Electric Motor Circuits". Among the failures which are reported are those due to the cracking of a riveted seam due to excess riveting pressure, tube failures, butt-welded joints, failure of turbine blades and shaft, fracture of a steam engine crank-shaft, an accident to an electric goods-lift, defective squirrel-cage motor-rotors, the disruption of a hydro-extractor, and the explosion of an air vessel. In all, these reports provide a very considerable amount of information which should be of value both in design and in the maintenance of mechanical and electrical equipment.

The presentation of this work is more than good, the illustrations and micrographs are excellent, and at the low price at which it is issued should appeal to a very wide range of readers. F. C. THOMPSON

# UNIVERSITY OF WITTENBERG (1502–1952)

THE Martin-Luther University of Halle-Wittenberg, in the East Zone of Germany, held a celebration during October 18–25, 1952, to mark the four hundred and fiftieth anniversary of its foundation at Wittenberg, nearly two hundred years before the separate foundation of the University at Halle, with which it was merged on reopening in 1815 after being closed in 1813 by Napoleon. The pro-rector, Prof. Leo Stern, acted for the rector, Prof. Rudolf Agricola, who was absent through illness. The following details are given in a letter from one of the West Zone delegates.

The opening ceremony was in the Theatre of Peace at Halle. A colourful scene was provided by the university professors, deans, pro-rectors and rectors in their robes. The celebration on Sunday, October 19, took place in the town church of Wittenberg; Prof. Aland gave the address, and at a church service in the afternoon the sermon was preached by Bishop Dibelius. The ceremony was attended by Hungarian and Roumanian bishops, by a representative of the Chinese Christian Reform Movement, and by the Rev. Edward Charles, from Great Britain. On October 20 there was a function, at which scientific addresses were given, at the Institute for German History, a student youth demonstration in the market, and musical performances (Handel, Bach, Brahms and others). On the following day a special meeting of the Leopoldina Academy was held, with lectures and demonstrations on the theme "Der schwerhörige Mensch". The birthplace of the Leopoldina Academy—Schweinfurt in the West Zone of Germany—was officially represented by its mayor, Dr. O. Schön, and by Dr. J. Helfrich, who had already represented his town at Halle for the tercentenary of the Leopoldina Academy in February 1952 (see *Nature*, 169, 576, and 170, 1105; 1952), and they were most warmly received. There followed numerous parallel sittings of the different faculties, with exhibitions. Receptions were held by members of the East Zone Government, by the regional and civic authorities and by the University Senate, and a performance was given of Handel's opera "Tamerlano". R. C. H. YOUNG

# FORESTRY RESEARCH AND ORGANIZATION

TWO papers read at the Sixth British Commonwealth Forestry Conference, held in Canada last year, and now published by the Forestry Commission (London: H.M.S.O., 1952), deserve to be more widely noticed for the scientific importance of their message. The first was by Mr. J. N. R. Jeffers, of the Forestry Commission, London, who discussed the use of statistical methods in forest research. "To-day," he said, "the handling of figures has become a necessity; they are required for administration, management and research, and their collection, analysis and interpretation have become part of the forester's everyday work." The functions of these methods are to provide a sound basis for the design of experiments, to summarize data so that they can be correctly and readily interpreted, and to give an estimate of the probability that the effects indicated by the results are true effects. Statistical methods have become indispensable tools of forest research. It is now a question of making more foresters familiar with them and of asking statisticians to develop new methods when the existing ones are inadequate.

It may be pointed out, in passing, that this is more applicable to the research officer, for the forester's everyday work is, or should be, out in the forests and woods studying the methods of growth and well-being of his trees and their several requirements from the practical sylvicultural point of view on the ground. His job is to produce the timber, etc., of the future by practical sylviculture and constant supervision on the ground. Statistics, though necessary, will not do this.

The other paper was by Mr. N. V. Brasnett, on the "Organization of Sustained Yield in previously Unmanaged Forests". He stated: "For periods within the physical rotations of the species which comprise them, mature, unmanaged forests can be assumed to be in a state of dynamic equilibrium. Large old trees are generally in excess of medium-sized and small trees of the same species, which only have an opportunity of entering the top canopy as overmature trees die. Because no increment is harvested, it has slowed down until it is practically balanced by decay. The smaller trees are not all necessarily younger than the large ones, but may merely be suppressed and even capable of responding to release. Abundant seedlings are liable to appear on the forest floor in most years, but most of them fade away in a few years, leaving only individuals to survive in gaps here and there". The British have the greatest experience in dealing with large areas of tropical and sub-tropical, previously unmanaged forests. British foresters in India for nearly ninety years have been studying and wrestling with the problem of introducing an orderly management and a sustained yield in forests of these types, and a great deal of valuable sylvicultural knowledge has been gathered. The numerous working plans in force throughout India furnish evidence of the advanced position attained. Mr. Brasnett's paper deals with the various problems entailed in introducing a detailed management into the previously unmanaged forest.

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# A NEW METHOD OF MEASURING SPERM SPEEDS

By Lord ROTHSCHILD

Department of Zoology, University of Cambridge

IN Chandrasekhar's review on "Stochastic Processes in Physics and Astronomy"[1], the following footnote occurs on p. 89: "Fürth made systematic counts of the number of pedestrians in a [street] block every five seconds. . . . It is amusing that by systematic counts of the kind made by Fürth it is possible actually to determine the average speed of a pedestrian!" The principle involved in such determinations is known as probability-after-effect, and it occurred to me that if the average walking speed of a pedestrian can be determined by this method, the same should apply in the case of spermatozoa, though the latter move in three or in certain circumstances two dimensions, whereas in Fürth's problem the pedestrians only moved in one dimension, that is to the right or the left.

Very little is known about the relationship between the speeds at which spermatozoa swim and their fertilizing capacity, or about the effects of changes in the physical and chemical properties of the medium on sperm movement. These gaps in our knowledge are mainly due to the difficulties which have been experienced in measuring the speeds at which spermatozoa swim. Hitherto such measurements have presented great problems, mainly because photographic methods are not readily applicable to dense sperm suspensions. If the suspensions are diluted sufficiently for photography, the spermatozoa may exhibit pathological changes unless protective substances, which interfere with the measurements, are added to the medium. The electrical method of measuring sperm activity cannot be applied to human spermatozoa because the number of sperm per millilitre of ejaculate is not sufficient to cause the 'wave formation' observed in bull and ram semen, upon which the method depends[2]. Recently, Bosselaar and Spronk[3] have reported a new way of measuring what they call the 'motility' and concentration of spermatozoa. Apart from the objections made to the method by the authors themselves, no estimates of sperm speeds are given in that article.

One can, of course, take a high-speed cinemicrograph of a dense suspension of spermatozoa and then project the film frame by frame on to squared paper, marking the consecutive positions taken up by individual spermatozoa and joining these points together by straight lines. The total length of these lines divided by the overall magnification and the duration of the film gives the speed of each spermatozoon. This process is much too slow and expensive for regular use, though it has been used for verifying the experiments described in this communication; moreover, the person joining up the consecutive positions of sperm heads may have to make difficult decisions as to where a spermatozoon on frame 1 has got to on frame 2. One experiment lasting 30 sec., which takes $2\frac{1}{2}$ hr. to analyse by the new method, takes about a week to analyse by examination of high-speed cinemicrographs.

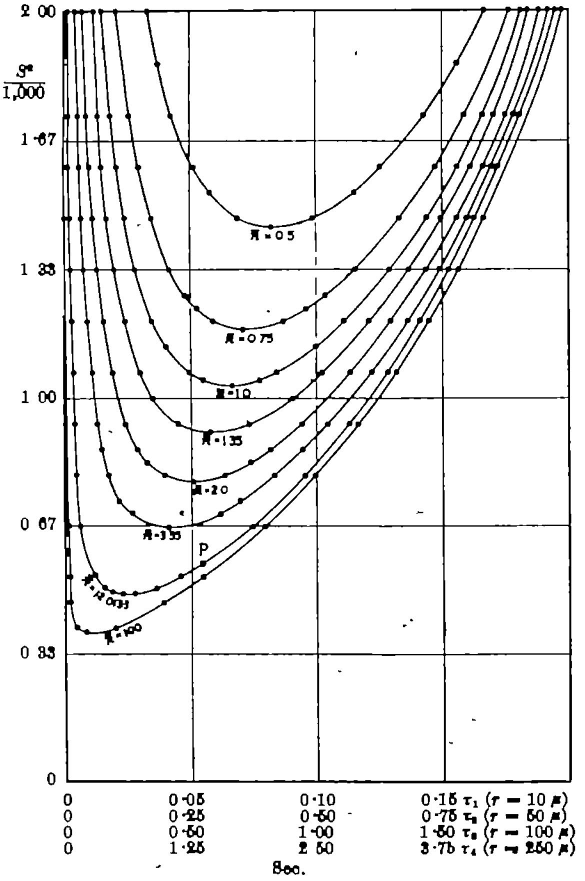
In the probability-after-effect method of measuring the average speed of spermatozoa, a small drop of semen, or semen diluted 1 : 2—1 : 5 with a suitable diluent, is placed on a microscope slide. A coverslip is gently put on top of the drop, which should be of such a size that, after the coverslip is placed on top, the spermatozoa only swim in one plane. This is not difficult to achieve as spermatozoa often tend to swim in one plane when constrained by a coverslip. A cinematograph film is then taken of the suspension, preferably with a phase-contrast microscope. An overall magnification of about 200 is convenient. The camera should run at 4–10 frames/sec. After developing and fixing, the film is projected on to paper on which a circle of known radius $r$ has been drawn; the number of spermatozoa in this circle is then counted on consecutive frames. The circle should be of such a radius that it contains between 10 and 20 spermatozoa. After the counts have been made we have a series of numbers, as in the row labelled $n$ in the accompanying table. The calculation of the average speed of the spermatozoa from these numbers requires no knowledge of mathematics beyond logarithms and the use of standard tables. The average value of these numbers, $\bar{n}$, and the average value of the squares of the differences between consecutive numbers, $\overline{\delta^2}$, are first calculated, as in the table. Suppose that in this experiment the camera speed was 3·7 frames a second, which means that the time interval, $\tau$, between photographs was 0·27 sec.; and that the radius of the circle was 51 μ. The average speed, $\bar{c}$, of the sperm suspension is given by the equation:

$$c = -3\cdot6169\, r/\tau \log_{10}(1 - \overline{\delta^2}/2\bar{n}). \qquad (1)$$

The minus sign in front of the right-hand side of this equation arises because $\log_{10}(1 - \overline{\delta^2}/2\bar{n})$ is negative. Substituting the values obtained above in this equation, we obtain $\bar{c} = 120$ μ/sec., the average speed of the spermatozoa in bull semen diluted 1/4 with Ringer fructose at 37° C.

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| No., $n$, of sperm in circle | 9 | 10 | 15 | 11 | 12 | 12 | 9 | 10 | 14 | 15 | Sum, 117 |
| Difference, $\delta$, between consecutive numbers | 1 | 5 | 4 | 1 | 0 | 3 | 1 | 4 | 1 | | |
| $\delta^2$ | 1 | 25 | 16 | 1 | 0 | 9 | 1 | 16 | 1 | | Sum, 70 |
| Average value of $n$, $\bar{n} = 117/10 = 11\cdot7$<br>Average value of $\delta^2$, $\overline{\delta^2} = 70/9 = 7\cdot7778$ | | | | | | | | | | | |

To obtain reasonable precision, more counts than ten, a number chosen for purposes of illustration of the method in the table, should be made. When the number of spermatozoa in 75 consecutive circles was counted in a similar experiment, an operation which took $2\frac{1}{4}$ hr., the average speed was found to be 111 μ/sec., with a standard error of 24·5. The actual average speed of the suspension, measured by the slow projection method mentioned above, was 117 μ/sec.



Relationship between $s^2$, the square of the standard error of $\bar{c}$, and $\tau$, the time interval, in seconds, between consecutive sperm counts. The scale of $\tau$ varies according to $r$, the radius of the circle in which sperm counts are made; $\bar{n}$ is the average number of sperm in the circle; $\hat{c}$, the estimate of the average speed of the sperm suspension, is assumed to be 110·5 μ/sec. Number of sperm counts, 75. The point $P$ refers to a 0·27-sec. time-interval between counts, on the $r$ = 50 μ $\tau$ scale

The square of the standard error, $s^2$, is calculated by means of the formula:

$$s^2 \doteqdot \frac{\bar{c}^2}{k\bar{n}(x \ln x)^2}\left\{\frac{\bar{n}(1-x)^2(3+x)}{(1+x)}+x(1-x)\right\}, \quad (2)$$

where $k$ is the number of counts and $x = \exp -(\bar{c}\tau/1{\cdot}5708\,r)$.

Equation (2) shows that $s^2$, which is a measure of the precision of the estimate of the average speed, depends on $k$, the number of frames on which sperm counts are made, $\bar{n}$, the average number of spermatozoa in a count, and $\tau$, the time interval between successive frames. Assuming 75 sperm counts, the variations in $s^2$ with $\tau$, for different values of $\bar{n}$ and $r$, are given in the accompanying figure. These curves are useful for determining experimental conditions. Suppose, for example, that the average speed of spermatozoa is about 110 μ/sec. and that it has been decided to make 75 counts of the number of spermatozoa in circles of radius 50 μ, the number in these circles being about 12. The time interval of 0·27 sec. between photographs will make $s^2 = 567$ ($s$ = 23·8) if $\bar{n} = 12$, which was approximately the value obtained in the experiment mentioned above. The disparity between this value of $s$, 23·8, and the earlier value, 24·5, is explicable but unimportant in this context.

A quantitative method of measuring the average speeds at which spermatozoa swim may be of importance in the investigation of human sterility, in the artificial insemination of livestock, and in academic studies on the physiology and biochemistry of spermatozoa. The method described in this communication is still in its infancy, in the sense that further trials are needed to test its efficacy and the extent to which suspensions of spermatozoa approximate in their behaviour to the model upon which the principle of probability-after-effect is based. A fuller account of the theory and practice of the method will be published in the *Journal of Experimental Biology*.

This work is supported by the Medical Research Council.

[1] Chandrasekhar, S., *Reviews of Modern Physics*, 15, 1 (1943).
[2] Rothschild, Lord, *J. Exp. Biol.*, 25, 219 (1948).
[3] Bosselaar, C. A., and Spronk, N., *Nature*, 169, 18 (1952).

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# LIMITING PRODUCTS IN THE PHOTOLYSIS OF ACETALDEHYDE AT HIGH INTENSITY

By M. A. KHAN, PROF. R. G. W. NORRISH, F.R.S., and DR. G. PORTER

THE study of the photolysis of acetaldehyde[1,2] has led to the conclusion that the primary photochemical change is compounded of two reactions, the relative incidence of which appears to be dependent on wave-length:

$$CH_3CHO + h\nu = CH_4 + CO \qquad (1a)$$

$$CH_3CHO + h\nu = CH_3 + CHO \qquad (1b)$$

Investigation at elevated temperatures has revealed the onset of a chain reaction, the quantum yield rising from a value less than unity at 25° C. to 300 at 300° C., for which Leermakers[1] proposed the following scheme, derived from reaction (1b):

$$CH_3 + CH_3CHO = CH_4 + CH_3CO \qquad (2)$$

$$CHO + CH_3CHO = CO + H_2 + CH_3CO \qquad (3)$$

$$CHO + CH_3CHO = CO + CH_4 + CHO \qquad (4)$$

$$CH_3CO = CH_3 + CO \qquad (5)$$

$$2CH_3 = C_2H_6 \qquad (6)$$

$$CH_3 + CHO = CH_4 + CO \qquad (7)$$

At the lowest temperatures and highest intensities investigated, however, it has been found impossible to detect any ethane at all, even by mass-spectrometric analysis[3], though in the reaction above 100° C. small amounts have recently been observed mass-spectrometrically[4,5].

On this account, and on the basis of further analytical results at temperatures below 100° C., Blacet and Blaedel[6] replaced the chain-ending reaction 6 by a recombination of acetyl radicals, leading to the formation of diacetyl, which was detected in roughly the expected amount. There seems little doubt about the correctness of their conclusions. If, however, a sufficiently high concentration of methyl radicals could be generated by reaction (1b) the incidence of reactions (6) and (7) should predominate over that of reaction (2), since the rates of the former are proportional to the second power of the concentrations of radicals and that of the latter to the first power. There is one other second-order radical reaction resulting in non-condensible products to be considered:

$$2\mathrm{CHO} = 2\mathrm{CO} + \mathrm{H_2}, \qquad (8)$$

which, like the other reactions of formyl, may proceed via hydrogen atoms without affecting the present discussion. At limiting high intensities, when terms involving $I_{\mathrm{abs}}^{-\frac{1}{2}}$ become negligible, reactions (1)–(8) lead to the following expression for the ratios of products formed in unit time:

$$\frac{\mathrm{CH_4}}{\mathrm{C_2H_6}} = \frac{\mathrm{CH_4}}{\mathrm{H_2}} = \frac{2k_a}{k_b} + \frac{k_7}{\sqrt{k_6 k_8}}\left(1 + \frac{k_a}{k_b}\right).$$

We have investigated the photolysis of gaseous acetaldehyde at 20° C. and at intensities of the order of $6 \times 10^{-3}$ $Nh\nu$ cm.$^{-3}$ sec.$^{-1}$, using the full radiation of the gaseous flash discharge[7]. We have found that not only is ethane a major product of the reaction but also that the ratio $(\mathrm{CH_4})/(\mathrm{C_2H_6})$ is independent of intensity. Previous photochemical studies at flash intensities have shown that the rise of temperature resulting from the adiabatic nature of the reaction is of major importance[8,9], and it was therefore first necessary to eliminate this complication. This was done by reducing the energy/flash and by addition of inert gas (carbon dioxide) until further addition had no effect on the products. The accompanying table gives the proportions of gaseous products as a function of relative intensity, obtained by photolysing 60 mm. acetaldehyde in the presence of 480 mm. carbon dioxide.

| Relative intensity | $\frac{\mathrm{CH_4}}{\mathrm{CO}}$ | $\frac{\mathrm{C_2H_6}}{\mathrm{CO}}$ | $\frac{\mathrm{CH_4}}{\mathrm{H_2}}$ | $\frac{\mathrm{CH_4}}{\mathrm{C_2H_6}}$ |
|---|---|---|---|---|
| 1·0 | 0·44 | 0·21 | 1·8 | 2·1 |
| 2·4 | 0·45 | 0·21 | 1·9 | 2·1 |
| 5·0 | 0·45 | 0·20 | 1·9 | 2·2 |
| 23 | 0·50 | 0·22 | 1·7 | 2·3 |
| 40 | 0·47 | 0·20 | 1·6 | 2·3 |
| 69 | 0·45 | 0·21 | 1·5 | 2·1 |

Over a seventy-fold intensity-range, the ratio $\mathrm{CH_4/C_2H_6}$ is constant to ± 5 per cent. As ethane can scarcely arise from any reaction other than (6), it follows that reaction (2) does not occur to any significant extent in the intensity-range investigated. Direct confirmation of the absence of reaction (2) was obtained in the following way. A mixture of diacetyl and acetaldehyde in the ratio 1 : 3 was photolysed in excess carbon dioxide using wave-lengths absorbed by diacetyl alone but at an intensity giving rates of decomposition comparable with the above. The decomposition of diacetyl results in the formation of methyl and acetyl radicals[10], and if reaction (2) occurs, methane will be formed. It was found that the gaseous products were ethane and carbon monoxide exclusively. When the same mixture was decomposed by a conventional mercury arc source, again using radiation absorbed only by diacetyl, methane became the major hydrocarbon product. This confirms that the methane found in the high-intensity experiments with acetaldehyde does not arise from reaction (2), in agreement with our conclusions based on the constancy of product ratios.

Our results lead immediately to the following conclusions about the mechanism of this reaction:

(1) For the full wave-length radiation used, $k_a/k_b \nless 1{\cdot}1$.

(2) Since the minimum possible value of $k_a/k_b$ is zero, it follows that $k_7/\sqrt{k_6 k_8} \nless 2{\cdot}2$. Now it is known that the rate constant of the bimolecular chain termination step in the high-temperature photolysis corresponds to unit collision efficiency[11], and it has been concluded that this refers to reaction (6) or (7). If this is so, it follows that the recombination of methyl radicals occurs with a collision efficiency very near unity, since if the constant measured is $k_7$, both $k_6$ and $k_8$ must be nearly equal to $k_7$, because neither $k_6$ nor $k_8$ can exceed the measured value of unit efficiency.

(3) In view of the large proportion of ethane obtained in these experiments, the total absence of ethane at low intensities must be attributed to reaction (2). In this case the fact that chains are not propagated must be accounted for by the statement that in the low-temperature photolysis of acetaldehyde the rate-determining step is not reaction (2) but the decomposition of the acetyl radical by reaction (5).

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# NEGATIVE-ION FORMATION IN GASES OF HIGH DIELECTRIC STRENGTH

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It is widely known that certain polyatomic molecular gases, for example, sulphur hexafluoride, carbon tetrachloride and $\mathrm{CCl_2F_2}$, possess appreciably higher breakdown voltages than certain common gases, such as oxygen, hydrogen and nitrogen, for a wide range of electrode arrangements, gap-spacings and pressures. In an earlier communication[1], we have mentioned some of the relevant papers, to which the following should be added for data on breakdown voltages: Camilli and Chapman[2] for data on $\mathrm{SF_6}$, $\mathrm{CCl_2F_2}$, $\mathrm{CClF_3}$, $\mathrm{CF_4}$, $\mathrm{CHClF_2}$ and $\mathrm{CHF_3}$; Geballe and Linn[3], $\mathrm{CSF_8}$; Wilson, Simons and Brice[4], $\mathrm{C_3F_8}$, $\mathrm{C_4F_{10}}$ and $\mathrm{C_5F_{12}}$; and Kowalenko[5], HCl, HBr and HI. Burhop, Massey and Watt[6] give dissociation data on $\mathrm{UCl_4}$ and $\mathrm{UF_6}$. The dielectric (breakdown) strengths are those measured at pressures of approximately 1 atmosphere in short gaps, for example, between spheres when the spacing is much less than the sphere diameter, where the electric field is approximately uniform.

The purpose of this communication is to extend the discussion given earlier[1] and to present new experimental results on dissociation processes, notably in sulphur hexafluoride.

It is clear[1] that the formation of negative ions during the breakdown process in a gas will tend to reduce, other things being equal, the value of Townsend's $\alpha$ coefficient (particularly for low $X/p$), as Geballe and Harrison[7] have recently suggested for oxygen, and as Penning[8] had earlier pointed out (see also Massey[9], pp. 66, 103). Penning showed how attachment coefficients could, on certain assumptions, be deduced from $\alpha/p - X/p$ data.

Thus, since $\alpha$ is the predominating single factor governing breakdown, higher dielectric strengths would in general be expected for gases showing appreciable electron attachment. This general argument needs further examination, however, since chlorine has, in the conditions of the first paragraph above, a relative dielectric strength (cf. nitrogen) of about 1·5, while appreciably higher values are known for carbon tetrachloride, 6·3–6·4, and certain other gases[1]. Further, carbon tetrafluoride has a relative dielectric strength of only 1–1·1, whereas sulphur hexafluoride has a value of 2–2·5.

Consider, therefore, the following simplified outline of processes of negative-ion formation by electron impact[9], where $Y$ has a positive electron affinity :

$$\left.\begin{array}{l} XY_n + e \rightarrow XY_{n-1} + Y + e \\ \text{followed by the separate process,} \\ Y + e \rightarrow Y^- \end{array}\right\} \qquad (1)$$

$$XY_n + e \rightarrow XY_n^{-*} \rightarrow XY_{n-1} + Y^- \qquad (2)$$

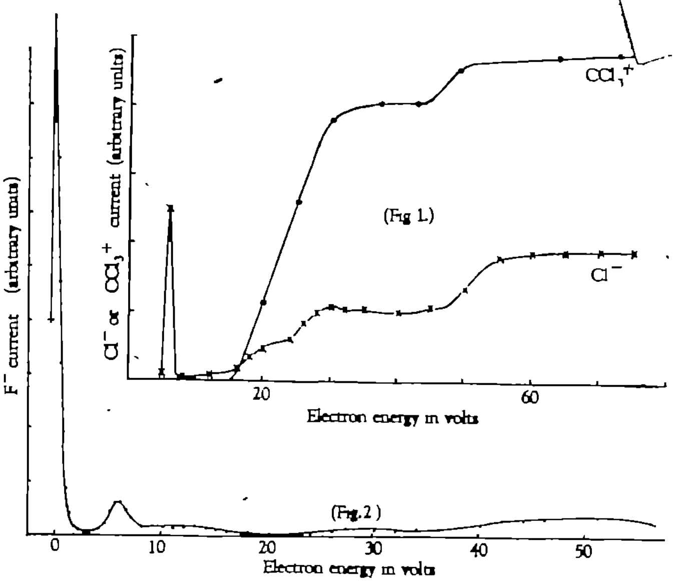
$$XY_n + e \rightarrow XY_n^{-*} \rightarrow XY_n^- \qquad (3)$$

$$XY_n + e \rightarrow XY^+_{n-1} + Y^- + e \qquad (4)$$

Reaction (3) becomes operative at pressures where three-body collisions are probable, whereas (2) is a two-body process. Process (1) doubtless occurs, as Mohr and Weissler[10] indirectly suggest, but the cross-sections would probably be low (Massey[9]) compared with those for processes (2) or (3) and (4). Further, the dielectric strength of chlorine, in which process (1) would be expected to occur at least as strongly as in carbon tetrachloride, is inconsistent with process (1) as the major mechanism. It is also difficult to explain the relative dielectric strengths of carbon tetrafluoride and sulphur hexafluoride on process (1) by itself.

As a preliminary step in the study of electrical breakdown in such gases, we have studied the dissociation patterns due to electron bombardment in a Nier mass-spectrograph source, in $CCl_4$, $CCl_3F$, $CCl_2F_2$, $CClF_3$, $CF_4$, $SF_6$ and in certain other gases. The negative-ion abundances found in the first five of these gases are consistent with the relative dielectric strengths. Figs. 1 and 2 show negative-ion current/electron energy curves for carbon tetrachloride (showing processes (2) and (4) ) and sulphur hexafluoride (process (2) only). The $Cl^-$ curve in Fig. 1 probably rises again near zero electron energy, and $SF_6$ shows large $SF_6^-$ and $SF_5^-$ currents (process (3) ), as first shown by Ahearn and Hannay (to be published). Vought[11] shows a similar curve for $SiCl_3^-$ from silicon tetrachloride. It is likely that the co-existence of processes (2) and (4) would tend to give higher dielectric strengths than process (2), of the same probability, by itself.

The extent to which the low-pressure ($\sim 10^{-3}$ mm. mercury) data on process (2) apply to swarm conditions depends on the probability with which $XY_n^-$ reverts to $XY_n$ (cf. process (3)). This should be unimportant if the electron affinity of $Y$ is greater than the appropriate bond-strength (Massey[9], pp. 47 and 64) ; but space does not permit of a further discussion of this and other related problems.



Variation of negative ion and positive ion currents with electron energy in (1) carbon tetrachloride and (2) in sulphur hexafluoride

Information on the relative importance of processes (2) or (3) and (4) in gaseous breakdown might be obtained by measurements on the dielectric strengths of appropriate mixtures of xenon with sulphur hexafluoride, or with a gas giving processes (2) or (3) and (4), since the ionization potential of xenon is below the critical potential for process (4) in certain of the gases listed above.

The full quantitative testing of the importance of electron-attachment processes in the determination of Townsend's $\alpha$ needs measurement of the basic quantities involved therein[12] together with sparking potential measurements at the same pressures. The quantities are : electron-drift velocity, ionization cross-sections so measured as to include the effect of attachment cross-sections, and the electron energy distribution function[13]. It is thought to be more feasible to evaluate the attachment coefficients from measured values of Townsend's $\alpha$ and to compare them with attachment coefficients measured in the same swarm conditions.

We are greatly indebted to Prof. H. S. W. Massey for advice in the preparation of this communication.

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# LETTERS TO THE EDITORS

*The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications*

## Staining and Plastic Embedding of Small Mineralized Plant Fossils

Oospores of charophytes are of considerable importance for age determination of freshwater deposits from the Devonian up to the present time. Minuteness and often indistinct sculpture make them difficult objects for study and photographic reproduction, however. During investigations on charophytes from the Triassic of Sweden, some new methods of overcoming these difficulties have been worked out with the assistance of Mr. K. E. Samuelsson, technician of the Palæobotanical Department, Riksmuseum, Stockholm.

The oospores studied are distinctly polar bodies, 0·25–0·50 mm. in length and provided with a faint transverse striation by alternating ridges and furrows. The walls and contents are almost completely calcified; the oospores are therefore semi-translucent and whitish. Observations on sculpture and photographic reproduction are accordingly extremely difficult without previous preparation.

Good results have been obtained by embedding the oospores in plastic after staining them. Plastic has been used for palæobotanical purposes by Leclercq and Discry[1] to elucidate the anatomical structure of larger fossil plants. Two methods were described: in one methyl methacrylate at high pressure and high temperature was used; in the other the object was embedded in a plastic termed 'Marco 26 C' after immersion in alcohol and styrene. A similar method was described by Purves and Martin[2] and was used by Croft[3] for charophyte oospores. The specimens were embedded in 'Marco' resin and ground sections were prepared for studies on the anatomy. When preparing orientated thin sections of various microfossils, Meyer[4], Levinson[5], Emiliani[6] and Kremp and Johst[7] obtained good results with the aid of certain thermoplastics. For the same purpose, Cummings[8] embedded foraminifers in blocks of 'Marco' resin which were cut into smaller pieces, polished, ground down and sectioned.

In the material now studied the oospores were first thoroughly cleaned from fat by immersion in ether. The cleaning is essential because fats lead to irregular distribution of stain; also they may obscure the oospore sculpture, and make the preparation of ground sections difficult by preventing contact between the plastic and the object. Certain specimens were directly stained after cleaning. Generally, the calcite surface is too compact to be stained effectively, however; because of that, the oospores were immersed in a saturated sodium hydroxide solution for some minutes before staining. Etching in a weak solution of acetic acid for a short time also gave good results. After this treatment, the sculpture often revealed a different susceptibility to the dyes used, the furrows becoming deeply stained, the ridges retaining their natural semi-translucent surface. Sometimes, the oospore surface became stained throughout. In some cases, all efforts to stain oospores gave negative results. Hæmatoxylin and methylene blue were found to be the most satisfactory.

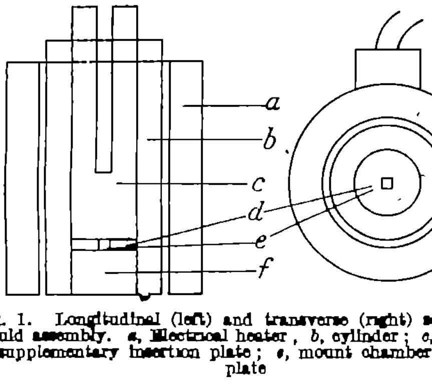

Fig. 1. Longitudinal (left) and transverse (right) sections of mould assembly. *a*, Electrical heater, *b*, cylinder; *c*, plunger; *d*, supplementary insertion plate; *e*, mount chamber; *f*, base plate

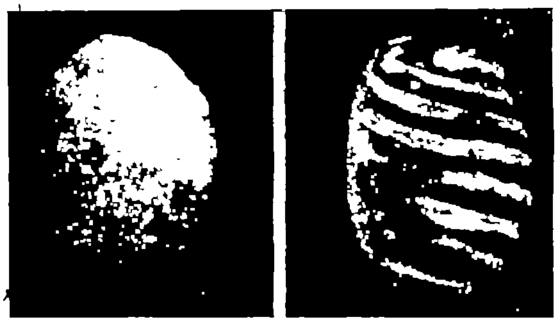

Fig. 2. Oospore of Triassic charophyte not prepared (left), and embedded in polyvinyl chloride after hæmatoxylin staining (right). × 80

For the embedding, an *AB* specimen-mount press equipment (Buehler, Ltd., Chicago) was used. The object is placed on a bed of the plastic powder used (vinyl chloride) on the base-plate of the mould assembly, and covered by plastic powder. The mould assembly is inserted into the press; at a temperature of 120–150° C. and a pressure of 3,500–4,000 lb. polymerization takes place. The specimen is now mounted in a short plastic cylinder, 25 mm. in diameter, and about 10 mm. high. If the polar axis or the equatorial diameter of the oospore has been placed parallel to the upper surface of the cylinder, longitudinal or transverse ground sections can be made according to the usual palæobotanical technique. Due to the toughness of this kind of plastic as compared with the object embedded, ground sections down to 10–15 µ are easily prepared.

It has been observed that the sculpture, when faint, will appear comparatively distinct after embedding. Due to the cylindrical mounting, the oospore can be photographed in two lateral aspects only, or in apical and basal view. Efforts to remove segments of the cylinder followed by polishing of the new surface obtained have been unsatisfactory because of the soft plastic used. Irregularities in the surface and remnants of grinding material pressed into the plastic could not be avoided. For those reasons, an additional part of the mould assembly has been constructed, consisting of a circular insertion plate of the same physical properties as the mould cylinder and closely fitting into the latter. In the middle, the plate has a cubical chamber with sides 7 mm. long. The specimen to be embedded is orientated in the plastic powder to get the polar axis parallel to the upper surface of the cube; pressing and polymerization take place in the usual way. The specimen can be observed and photographed in six aspects, as the highly polished steel walls of the chamber prevent any irregularities in the cube surface.

The oospore can be removed from the plastic by various solvents, among which acetone at a temperature of 50° C. has been found preferable. No damage to specimens has been observed on embedding or dissolution. The plastic cube must not be placed in cold acetone, however, as it makes deep fissures in the plastic and may spoil the oospore. The whole procedure of embedding, polymerization and cooling-down takes about twenty minutes.

One advantage of the method described is that on account of the high light transmission of the plastic the faint sculpture is visible. Further, the difficulty is avoided of handling small strongly polar objects which must be inspected or photographed in a certain view, for example, a needle-shaped specimen from the apex. The method can be used for various small objects, where sculpture is essential and orientation difficult.

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## A New Electron Multiplication Process

IF electrons move through a gas in an electric field, their number can increase if they ionize gas molecules by collision—the well-known Townsend avalanche. Recently, it has been shown[1] that in high-frequency electric fields at very low pressures the number of electrons increases, due to the impinging of electrons on the walls of the vessel and the release of secondary electrons. This is a 'wall multiplication' process which can lead to breakdown.

We have investigated the high-frequency breakdown of neon in cylindrical glass vessels with external electrodes. At pressures greater than 50 mm. mercury and frequencies less than, or equal to, $10^7$ c./s., the peak value of the starting field was found to be surprisingly low, corresponding to $X/p = 0\cdot6$ V./cm. per mm. mercury[2]. The energy an electron can acquire is then so small that electron multiplication by collision is negligible. Thus we propose the following mechanism: the first electron which is accelerated by the field will have a much greater number of exciting than ionizing collisions, the more so the lower is $X/p$. Normal excited atoms (emitting resonance quanta within approximately $10^{-8}$ sec.) and metastable atoms will be produced. Only a few of the latter will reach the walls, because they are destroyed by collisions in the gas and also emit resonance quanta. These strike the ends of the vessel either directly or after being absorbed and re-emitted by other atoms. There they release photoelectrons which will be accelerated, etc. We have here what could be termed a 'quantum avalanche), which releases photoelectrons from the wall in increasing numbers.'

In order that an initial electron may be multiplied. it must produce such a number of quanta that more than one electron is released from the wall. Calculations using the meagre data of excitation probabilities[3] and the estimated photoelectric yields[4] make the suggested mechanism likely to occur from $10^7$ to 50 c./s.

After this initial process, once the number of electrons is large, gas ionization can occur by electron collision in stages; that is, fast electrons (> 17 eV.) strike neon atoms to produce excited or metastable atoms, and slow electrons (> 5 eV.) strike metastable atoms to ionize them. With traces of argon a metastable neon atom can ionize an argon atom by a collision of the second kind.

The new avalanche is distinct from multiplication processes in which ionization by electron collision in the gas is accompanied by electron emission at the cathode by ions and quanta, as has been suggested to explain the breakdown of krypton and xenon[5] and recently of atmospheric air and nitrogen[6].

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## Crystal Structure of Barium–Strontium–Calcium Triple Carbonate

IT has already been found that calcium carbonate exists in one stable form, β-$CaCO_3$ (calcite), and two unstable forms, λ-$CaCO_3$ (aragonite) and μ-$CaCO_3$ (or vaterite), in the ordinary temperature range. Aragonite is formed if precipitation is carried out at a temperature approaching the boiling point of water (higher than 85° C.), whereas when precipitation is carried out at room temperature only calcite results. The third form of calcium carbonate, μ-$CaCO_3$, is formed by precipitation at 60° C.[1].

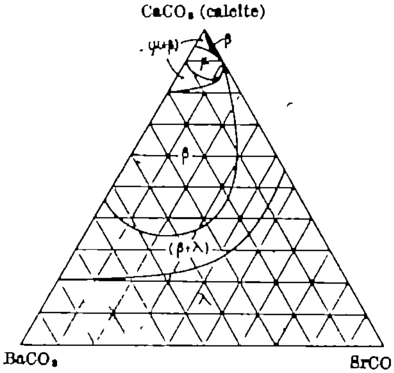

Fig. 1. Co-precipitated at 25–30° C.

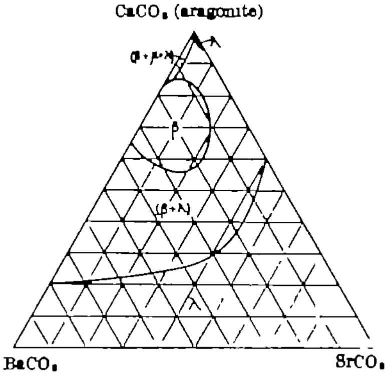

Fig. 2. Co-precipitated at 90–105° C.

Barium carbonate and strontium carbonate have only one stable form (aragonite-type structure) and in both cases temperature of precipitation has no effect on crystal form.

We have co-precipitated the triple carbonate by dropping 1 *N* sodium carbonate solution into a 1 *N* solution of the nitrates of barium, strontium and calcium mixed in the desired proportions and efficiently stirred. These crystalline powders were then examined by an X-ray Geiger counter spectrometer employing copper *K*-radiation.

Figs. 1 and 2 show the variation of crystal structures with molecular composition which we have found at low temperature of precipitation (25° – 30° C.) and at high temperature (90° – 105° C.) respectively. In all, about a hundred and twenty co-precipitated carbonates have been studied, and there have been found three types of solid solutions : aragonite type (λ-carbonate), calcite type (β-carbonate) and vaterite type solid solution (μ-carbonate)[2]. It is noticeable that in the presence of a small amount of isomorphous barium ion, calcium carbonate forms β-carbonate even at a high temperature of precipitation, whereas at low temperature it forms μ-carbonate.

At present no direct correlation between the carbonate structure and the properties of thermionic emission from the BaO–SrO–CaO system obtained by Grey[3] can be offered ; but an investigation of the conversion process of triple carbonate to oxide and other experiments are in progress.

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## Activation of Lithium Iodide by Europium

A SINGLE crystal of lithium iodide activated with an impurity of 0·05 mol. per cent europous chloride has been grown from the melt and found to be a relatively efficient scintillator. The crystal is clear and transparent except for a slight non-uniform purple coloration. Under 2537 A. ultra-violet excitation the luminescence is a strong blue very like that of anthracene. A section of the boule was cut and finished with 320-grit abrasive paper into a cylinder of 2 cm. diameter by 1·5 cm. long. The finished crystal was mounted in an atmosphere of dry nitrogen within a polished aluminium reflecting-cup[1] sealed at the open end with a 'Lucite' light-piper and joined to a 5819 photomultiplier.

The luminescence efficiency for γ-rays was found to be 36 per cent that of sodium iodide (with thallium). The decay time constant of the phosphor is 2·0 μsec. The resolution of the photoelectric line in the pulse height spectrum for cæsium-137 γ-rays was observed to be 14 per cent (full width at half maximum).

Fig. 1 is the pulse height spectrum produced by slow neutrons on lithium iodide (with europium). Neutrons obtained from a polonium–beryllium source were moderated in paraffin ; the γ-rays from the source were shielded from the crystal with 3 in. of lead. The spectrum exhibits a resolution of 6 per cent for the 4·785-MeV. products of the $^6$Li(*n*,α)$^3$H reaction.

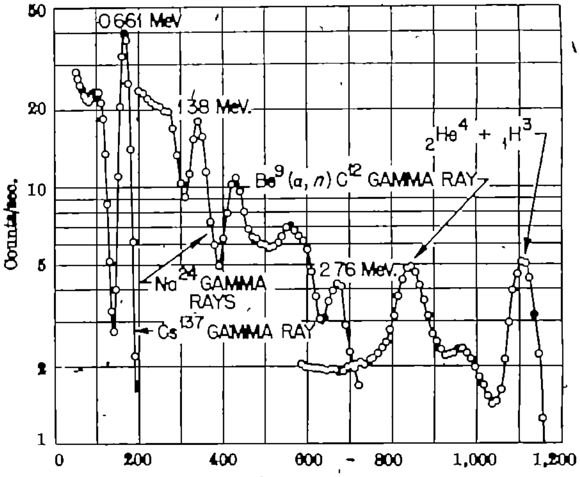

Fig. 1. Pulse height spectrum produced by slow neutrons on lithium iodide (with europium)

Fig. 2 shows the pulse spectra obtained when the crystal was separately irradiated with (*a*) γ-rays from cæsium-137, (*b*) γ-rays from sodium-24, and (*c*) γ-rays and neutrons from a polonium–beryllium source. A partial shield of $B_4C$ was placed between the moderated neutron source and the crystal in order to attenuate the neutron peak so that it would not interfere with the γ-ray peak. The energy calibration was determined from the known values of the sodium-24 γ-rays[2]. A calibrated pulse generator was used to obtain corrections for slight deviations of the apparatus from linearity.

The peak at 843 pulse height divisions (3·40 MeV.) results from the production of electron-positron pairs in the crystal by the γ-rays from the polonium–beryllium source. Previous measurements at this laboratory[3] have indicated a slightly higher value (3·44 MeV.) for this 'pair peak'. The peak at 1,126 divisions (4·55 MeV.) is due to the $^6$Li(*n*,α)$^3$H reaction

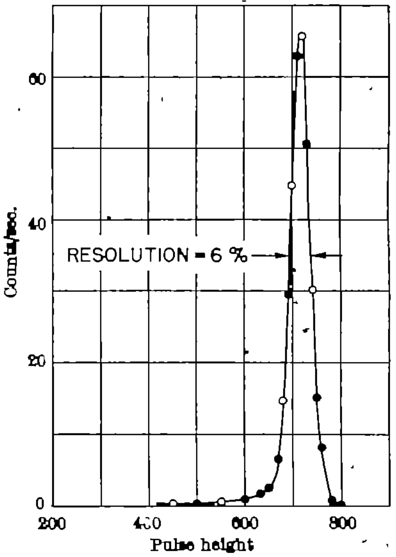

Fig. 2. Spectrum of pulses from lithium iodide (with europium) when exposed to radiations from cæsium-137, sodium-24 and polonium–beryllium neutron source surrounded with paraffin

inside the crystal. Since the $Q$-value of the reaction is 4·785 MeV., it appears that the efficiency of this crystal is somewhat reduced for heavily ionizing particles.

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## Measurement of Activated Diffusion of Adsorbed Molecules

IN continuation of a previous study[1] on the contribution of 'surface diffusion' to the transport of adsorbed molecules within porous adsorbents, rates of adsorption of $n$-butane have been measured.

For this purpose, a small metal beam balance was constructed which could be operated under high vacuum conditions. The weighing was performed with movable riders manipulated by means of external controls through ground joints in the enclosing glass tube. The beam was 5 cm. long and fitted with agate knife edges. A sensitivity of $\tan \alpha = 0{\cdot}022$ per 1 mgm. was achieved. The pan carrying the adsorbent was hung on a thin glass rod 30 cm. below the balance and was surrounded by a glass tube inserted in a temperature bath. In the present investigation, an electronically controlled low-temperature thermostat[2] was used with 'dry ice' as refrigerant. Any given temperature in the range from room temperature to − 80° C. could be maintained within ± 0·1° C. for any desired period.

In order to simplify the mathematical treatment of the diffusion problem, rates of adsorption were measured at constant pressures. These were maintained by adsorbing a certain quantity of butane at a convenient temperature, say, 0° C., on an amount of silica gel 100–500 times greater than that of the adsorbent under investigation on the balance.

After proper degassing, the adsorbent was cooled to the desired temperature and the balance system then connected to the constant-pressure device. The increase in weight of the adsorbent (4–125 mgm.) was followed with time, until equilibrium was reached. At − 14° C. this occurred in about three hours, while at the lowest temperature (− 79·5° C.) experimental periods were as long as 30 hr. From a plot of $w_\tau/w_\infty$ versus time ($w_\tau$ and $w_\infty$ are weight increases at time $\tau$ and at equilibrium), overall diffusion coefficients could be evaluated using a solution of the general differential equation of diffusion for a system of finite length and for the particular boundary conditions. The range $w_\tau/w_\infty = 0{\cdot}4$ to $0{\cdot}6$ was chosen to give representative values for the diffusion coefficient.

Rates of adsorption of $n$-butane in porous silica plugs were measured at various temperatures (− 14° to − 80° C.), porosities ($\epsilon = 0{\cdot}72$ to $0{\cdot}53$) and surface coverages ($y/y_m = 0{\cdot}37$ to $6{\cdot}9$, where $y_m$ is monolayer capacity in millimoles/gm.). The plugs (0·3 gm.) were formed by compressing Linde silica (300 m.$^2$/gm.) into small steel cylinders, thus allowing adsorption to occur only through one plane.

In order to demonstrate the feasibility of the above method and to indicate the bearing of surface diffusion on molecular transport in porous media, some of the results obtained may be quoted. For a plug of porosity 0·53 and a surface coverage of $y/y_m = 0{\cdot}9$, the following overall diffusion coefficients were obtained: $7{\cdot}20$, $2{\cdot}33$ and $0{\cdot}64 \times 10^{-6}$ cm.$^2$/sec. at − 14·4°, − 44·2° and − 79·5° respectively. Following Barrer's[3] calculations for the transient state of gas flow into a porous system, these coefficients are corrected for Knudsen streaming. In this way, the corresponding surface diffusion coefficients are obtained: $5{\cdot}04$, $1{\cdot}87$ and $0{\cdot}60 \times 10^{-6}$ cm.$^2$/sec. This indicates that, under the above conditions, 70, 80 and 94 per cent of the total transport is due to the mobility of adsorbed molecules along the surface. From these diffusion coefficients an activation energy of 3,000 cal./mole results, corresponding to 47 per cent of the adsorption energy.

At the lower temperatures, diffusion coefficients vary only slightly with the porosity of the adsorbent, whereas at higher temperatures there is a considerable increase with porosity. In this range the activation energy is also somewhat greater. Diffusion coefficients depend markedly on the surface coverage. For example, at a coverage $y/y_m = 0{\cdot}37$, $\epsilon = 0{\cdot}72$ and $t = -44{\cdot}5°$ C., an overall diffusion coefficient of $4{\cdot}08 \times 10^{-6}$ cm.$^2$/sec. was obtained. This increased steadily with greater coverage and reached a maximum value of $8{\cdot}56 \times 10^{-6}$ cm.$^2$/sec. in the multilayer region at $y/y_m = 3{\cdot}0$, whereafter it decreased.

As a whole, these results are in agreement with those obtained in experiments based on a steady-state flow method, as recently reported by Carman[4].

I wish to thank Dr. P. C. Carman, who made the permeability data necessary for the calculation of the Knudsen streaming available to me. This communication is published with the permission of the South African Council for Scientific and Industrial Research, Pretoria.

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## Activity Data and the Association of Hydrogen Chloride in Concentrated Solutions

IN some experiments in which concentrated solutions of hydrochloric acid were employed it was necessary to consider the part played by associated hydrogen chloride in determining its properties. Examination of data on the activity of hydrogen chloride[1] showed that the curve relating mean activity ($a$) to concentration ($c$) was continuous throughout, although its slope increased markedly at about 2 $N$.

Up to 4 $N$ the activity coefficient $\gamma$ is given with reasonable accuracy by the semi-empirical relationship:

$$\log \gamma = \frac{-Ac}{1 + Bc} + Dc + Ec^2 - \log (1 + 0{\cdot}036m) \quad (1)$$

| | 0° C. | | | | 20° C. | | | 50° C. | | |
|---|---|---|---|---|---|---|---|---|---|---|
| $c$ ($N$) | log $\gamma$ obsv. | $'c$ | $10^2 \times K$ | $10^2 \times K^1$ | log $\gamma$ obsv. | $'c$ | $10^2 \times K^1$ | log $\gamma$ obsv. | $'c$ | $10^2 \times K^1$ |
| 5 | 0·44 | 4·5 | 3·20 | 2·5 | 0·39 | 4·4 | 3·1 | 0·30 | 4·4 | 3·2 |
| 6 | 0·59 | 5·4 | 1·38 | 2·1 | 0·52 | 5·2 | 3·0 | 0·42 | 5·3 | 3·0 |
| 7 | 0·74 | 6·1 | 0·79 | 2·4 | 0·66 | 5·9 | 3·2 | 0·53 | 6·0 | 2·8 |
| 8 | 0·89 | 6·8 | 0·44 | 2·6 | 0·79 | 6·6 | 3·2 | 0·65 | 6·7 | 3·0 |
| 9 | 1·03 | 7·4 | 0·15 | 2·9 | 0·93 | 7·3 | 3·2 | 0·76 | 7·2 | 3·5 |
| 10 | 1·17 | 8·0 | 0·14 | 3·1 | 1·05 | 8·0 | 3·1 | 0·87 | 7·8 | 3·6 |
| Mean $K^1$ | | | | 2·6 | | | 3·1 | | | 3·2 |

where $c/m = a_1 - b_1 m$, and $A$, $B$, $D$, $E$, $a_1$ and $b_1$ are constants that have been evaluated by Harned and Owen[2].

Above 4 $N$ the observed values of $\gamma$ are less than would be expected from the above relationship. If deviations are due to association into an ion pair or a truly associated type, the values of the concentration interpolated from the curve relating calculated log $\gamma$ and $c$, using log $\gamma_{\text{obsv.}}$, might be assumed to be the actual concentrations of the free ions.

Fig. 1 shows the curves for log $\gamma$ against $c$ calculated from the above relationship for $c = 4 - 10\,N$ at 0°, 20° and 50° C. The experimental values of log $\gamma$ were then interpolated from these curves to give values of $'c$ corresponding to the free ion concentration (see table).

Consider now the equilibrium :

$$H^+ + Cl^- = HCl$$

$$K = \frac{c - 'c}{'c^2} \cdot \frac{\gamma_{HCl}}{\gamma_{Cl^-} \cdot \gamma_{H^+}} = \frac{c - 'c}{'c^2} \cdot \frac{\gamma_{HCl}}{\gamma^2_{\pm HCl}}, \qquad (2)$$

where $c$ is the total hydrogen chloride concentration.

If this association were of the normal type as understood in the case of acetic acid, then $\gamma_{HCl} \sim$ constant $= 1$ at $c = 0$. However, this assumption leads to values of $K$ that are not constant (see table). Making the further assumption that, as for acetic acid in dilute solution, either $\gamma_{H^+} = \gamma_{Cl^-} = \gamma_{HCl} = 1$, or $\gamma_{HCl} = \gamma^2_{\pm HCl}$, a constant $K^1 = \frac{c - c^1}{'c^2}$ (see table) is obtained. The values of $K^1$ are remarkably constant and show little variation with temperature, indicating that $\Delta S_{\text{ass.HCl}} \approx 0$ and $\Delta F_{\text{ass.HCl}} = \Delta H_{\text{ass.HCl}} = 2 \cdot 1$ k.cal./mole.

According to equation (2), $K/\gamma_{HCl}$ can be calculated from the data in the table ; extrapolation to $c = 0$ gives $K$. Theory[3] and experiment[4] demonstrate a linear relationship between log $\gamma$ and $c$ in dilute solutions. The extrapolation was therefore carried out as shown in Fig. 2[5].

Values of $K$ thus obtained were, within extrapolation error, independent of temperature and had a value $K_{c=0} = 0 \cdot 056$, being in reasonable agreement with the value of $K^1$ ; the corresponding value of $\Delta H_{\text{ass.HCl}} = 1 \cdot 7$ k.cal.

The above calculations seem to indicate the validity of the assumption that $\gamma_{HCl} = 1$ and the alternative relationships $\gamma_{Cl^-} = \gamma_{H^+} = \gamma_{HCl}$, or $\gamma^2_{\pm HCl} = \gamma_{HCl}$.

The figures for $K$ and $K^1$ are in accord with that found for nitric acid by light absorption experiments[5], namely, $K_{c=0} = (5 \pm 1) \times 10^{-2}$. The agreement is to be expected, for these two acids have similar strengths.

Available thermochemical data[6] reveal a considerable fall in the heat of formation of solutions of hydrogen chloride at about 2 $N$, becoming much more marked at 5 $N$ onwards. The data for sodium chloride and sodium hydroxide do not show a similar fall until higher concentrations are reached, indicating that at 5 $N$ the association in solutions of these substances is relatively small. It is possible to calculate $\Delta H_{\text{ass.HCl}}$ in an approximate manner from the equations : $Na^+(5\,N) + H_2O + Cl^-(5\,N) = Na^+(5\,N) + OH^-(5\,N) + HCl(H^+,Cl^-, + HCl_{\text{ass.}} = 5\,N) +$ 15·7 k.cal., and $H_2O = H^+ + OH^- +$ 13·7 k.cal.

If there were no association of the hydrogen chloride, the heats of these reactions should be identical. The difference $\Delta H_{\text{ass.HCl}} = 2 \cdot 0$ k.cal. is in good agreement with the above.

I should like to express my thanks to Sir Eric Rideal for his help and advice. The above forms a part of a research pro-

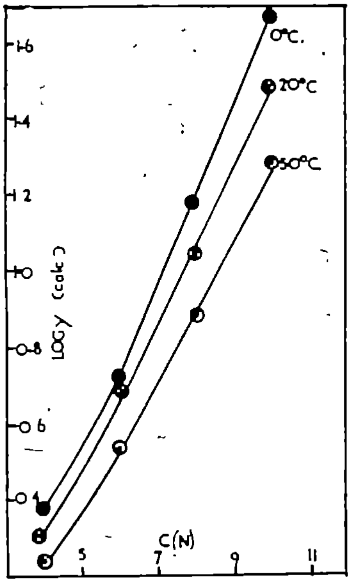

Fig. 1

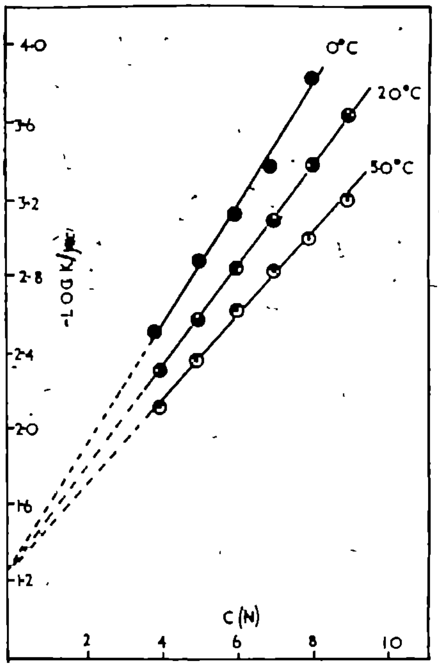

Fig. 2

Fig. 1. log $\gamma_{\text{calc.}}$ plotted against the HCl normality. ●, 0° C. ; ⊗, 20° C. ; ○, 50° C.
Fig. 2. $-\log K/\gamma_{HCl}$ plotted against the HCl normality. ●, 0° C. ; ⊗, 20° C. ; ○, 50° C.

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## Reaction Kinetics of the Cytochrome System

In living wheat roots three cytochromes co-operate, the prosthetic groups of which correspond spectroscopically to the types $a$ (= cytochrome oxidase), $c$ and $b$ of animal preparations. Succinoxidase is the main dehydrogenase system[1]. A factor $X$, characterized by a strong band at 570–575 mμ, is probably linked between succindehydrogenase and cytochrome $b$ [1,2]. Studies of the time-course of oxidation, performed by means of a new automatic spectrophotometric technique[1], show a direct electron transference in the sequence succindehydrogenase $\rightarrow X \rightarrow b \rightarrow c \rightarrow a \rightarrow$ oxygen. The process of oxidation of the reduced cytochromes is a first-order reaction in accordance with the overall formula $Fe^{2+} \rightarrow Fe^{3+} + e$. The molar velocity of oxidation, calculated as $V_e = \frac{1}{\frac{1}{2}t} \cdot c$ ($\frac{1}{2}t$ is time in seconds for the half-way point of oxidation, $c$ is relative molar concentration), shows very similar values for all cytochromes (see table), a fact compatible with a uniform electron transference between the reacting cytochromes, these probably being located in a fairly compact structural unit near the surface of the cells (cf. ref. 1).

At normal anion respiration and 19° C., the cytochromes are predominantly oxidized (64–84 per cent; cf. ref. 1). This means that the electron transference only amounts to a small fraction (c. 1/10 to 1/30) of the full capacity of a nearly reduced system (0–10 per cent oxidation). This damped activity balances the power of reduction of the succindehydrogenase system. The 'over-dimensioned' capacity of the cytochrome system corroborates earlier experiences as to the low oxygen requirement; wheat roots maintain their full anion respiration at an oxygen tension amounting to only 1/10 to 1/20 of normal aeration (cf. ref. 3).

The re-oxidation of a completely reduced cytochrome system (anaerobical conditions) agrees with $\frac{1}{2}t$ = 10–40 sec. It was found that the diffusion of the oxygen from the medium to the respiring cells is not a limiting factor, whereas the continuous delivery of electrons from succindehydrogenase has a general retarding effect. In absence of succindehydrogenase the re-oxidation would be completed in $\frac{1}{2}$–1 sec.

After a rapid shift from aerated to complete anaerobiosis, the cytochrome oxidase is reduced with $\frac{1}{2}t$ = 10 sec. (approx.), or about the same as for re-oxidation. The reduction of $c$ and $b$, however, is

Relative Velocities of Electron Transference ($V_e$) in the Cytochrome System of Living Wheat Roots.
Percentage values in brackets. Relative concentration of $a$, 1; $c$, 2, and $b$, 3·5.

| Cytochrome | $a$ | $c$ | $b$ |
|---|---|---|---|
| Reduction (from aerobic to anaerobic) | 0·090 (100) | 0·032 (35) | 0·011 (12) |
| Re-oxidation (from anaerobic to aerobic) | 0·100 (100) | 0·100 (100) | 0·095 (95) |

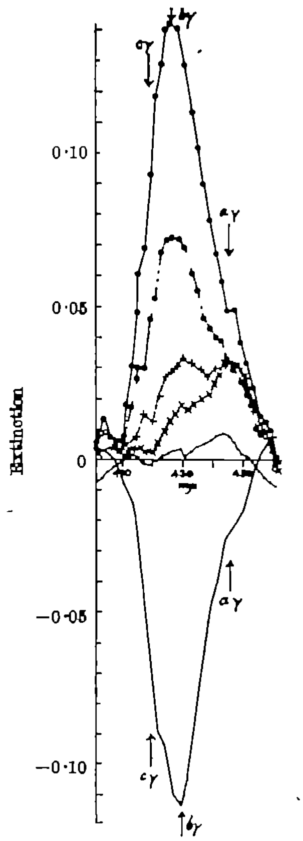

Fig 1. Oxidation–reduction curves ($e$ red.–$e$ ox.; cf. ref. 1) of a 15-mm. thick bundle of wheat roots, exposed to increasing anaerobiosis (oxygen-free succinate) and thereafter re-oxidized. The positive curves illustrate the increasing reduction: ·— after 1 min., ×—× after 4 min., +—+ after 7 min., ○—○ after 18 min., and ●—● after 32 min. The negative curve shows the rapid re-oxidation 1 min. after shifting over to aerated solution. Absorption spectrum automatically recorded in intervals of 2 mμ (cf. ref. 1). The very rapid response of the cytochrome oxidase is clearly shown

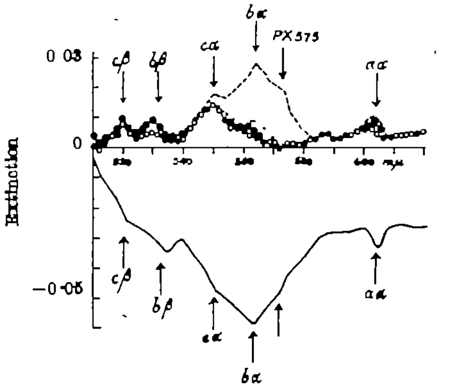

Fig. 2. As in Fig. 1, but comprising the α- and β-bands of the cytochromes. Upper curves, reduction in oxygen-free succinate: ○—○ after 1 min., ●—● after 6 min., - - - - after 16 min., and —·—·— after 32 min. The time order $a > c > b > PX$ 575 is clearly shown. Lower curve shows the re-oxidation in aerated solution

considerably retarded (see table), the molar quantities of these enzymes amounting to five to six times that of *a*. The retarded reduction reflects the much slower rate of the succindehydrogenase system, namely, of the dehydrogenation of the succinate, as compared with the full capacity of the electron transference in the system $X \rightarrow b \rightarrow c \rightarrow a \rightarrow$ oxygen. At re-oxidation the reaction starts with a turnover number of more than 20,000 per min. (which is 10 to 30 times the 'normal' turnover number of about 1,700; cf. ref. 1), whereas at reduction the reaction starts with the moderate speed of the succindehydrogenase system, resulting in the observed retardation of cytochrome *b* with a factor of 9 or 10. The rapid response of the cytochrome oxidase at reduction, on the other hand, reflects the higher velocity of the electron transference, *a* being immediately reduced by *c* and *b*. As previously stated[1] the potential states of *c* and *b* are not so far apart as those of *c* and *a*, as a consequence of which a reversible equilibrium exists between *c* and *b* (and between *b* and the factor *X*).

The interpretation given here of the retarded reduction of the cytochromes *c* and *b* does not support the deductions advanced by Chance as to *b* not lying in the direct path of electron transference from succinoxidase to oxygen[4]. The tissue preparations used by him are obviously less suited for a clear-cut study of the reaction kinetics of the cytochrome system, because the interaction with the systems supplying the succindehydrogenase is broken. It is known that an accumulation of fumarate may reverse the stream of electrons from succindehydrogenase to *b* (and *c*) and completely stop the reduction.

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## Relative Specificity of the Chemically Modified 'Aspergillus niger β-Glucosidase'

The work of Miwa and co-workers[1,2] showed that the relative specificity of β-glucosidase, expressed in terms of the ratio of enzyme activity toward β-glucosides with different aglucons, differs over a wide range depending on the source of the enzyme preparations. These differences are considered to be due to the difference in the structure of enzyme proteins themselves rather than contaminating substances, since they remain almost unchanged upon fractionation of enzyme preparations as well as with preparations of different purity.

In immunochemistry it is well known that the specificity of antigenic proteins can be artificially altered by modifying their chemical structure in various ways. In view of this, it seemed interesting to examine whether or not we are able to modify the relative specificity of the enzyme by chemical means. Such a study might give a clue to the elucidation of the structure of enzyme proteins responsible for relative specificity.

In the present work, β-glucosidase from *Aspergillus niger* was used. This enzyme has been considerably purified in Miwa's laboratory and shown to be a protein with nitrogen content of 15·4 per cent[3]. As chemical reagents capable of modifying the structure of enzyme protein, formalin and nitrous acid were employed.

*Enzyme preparation*. The method of procedure was similar to that applied by Niwa[3]. Specific activity *f* (phenyl-β-glucoside) was about 25 in glycine–hydrochloric acid buffer of *p*H 3 and 10 in citrate. Niwa carried purification further, but in the present work chemical treatment was carried out with this enzyme preparation redissolved in the concentration of about 2 per cent.

*Treatment with nitrous acid*. (*a*) One part of 30 per cent sodium nitrite and 0·2 part of glacial acetic acid were added to four parts of enzyme solution. After keeping in a refrigerator for 48 hr. the enzyme was precipitated, washed with acetone and dried *in vacuo* over calcium chloride. A yellow powder was obtained. (*b*) To 10 ml. of a 2 per cent solution of the yellow enzyme powder a small amount of α-naphthylamine was added and kept at 30° C. for 2 hr. The enzyme was precipitated and washed with acetone and dried *in vacuo*. The resulting preparation was red.

*Treatment with formalin*. (*a*) To seven parts of enzyme solution one part of 30 per cent formalin was added and allowed to stand at 30° C. for 48 hr. Then the enzyme was precipitated with acetone, washed free from formalin and dried *in vacuo*. (*b*) The same procedure as (*a*) was used, except that the ratio of enzyme solution and formalin was 4 : 1 and the duration of incubation was 70 hr. (*c*) The same procedure as (*b*) with incubation of 144 hr.

The accompanying table shows the results thus obtained. It will be seen that relative specificity is affected by the action of nitrous acid or formalin. Changes of the relative specificity of the enzyme treated with nitrous acid are recognizable in *p*-nitrophenyl-, *p*-cresyl- and methyl-β-D-glucosides. This modification of the relative specificity in *p*-nitrophenyl-β-D-glucoside is nearly restored to the original value after treatment with nitrous acid followed by coupling with α-naphthylamine. On the other hand, it has long been postulated that nitrous acid forms nitroso or diazo compounds with protein in addition to deaminizing[4]. Thus, it may be suggested that the modification of the relative specificity is due to the

RELATIVE SPECIFICITY OF CHEMICALLY MODIFIED '*Aspergillus niger* β-GLUCOSIDASE'

| Substrate: β-D-glucoside of | Original enzyme | Treatment with nitrous acid |  | Treatment with formalin |  |  |
|---|---|---|---|---|---|---|
|  |  | (*a*) | (*b*) | (*a*) | (*b*) | (*c*) |
|  | *f** = 9·5 | *f* = 3·4 | — | *f* = 11·5 | *f* = 10·5 | *f* = 11·5 |
|  | Ratio† | Ratio | Ratio | Ratio | Ratio | Ratio |
| Phenyl | 10·0 | 10·0 | 10·0 | 10·0 | 10·0 | 10·0 |
| *o*-Cresyl | 0·6 | 0·7 | — | 0·4 | — | — |
| *p*-Cresyl | 11·8 | 7·8 | 8·9 | 9·3 | 9·9 | 9·7 |
| Saligenin | 4·6 | 4·5 | 4·6 | 1·5 | 1·2 | 1·5 |
| Salicylaldehyde | 12·5 | 14·0 | 12·9 | 7·6 | 6·8 | 7·1 |
| Vanillin | 7·1 | 4·3 | — | 4·4 | 3·5 | 3·9 |
| *p*-Nitrophenyl | 9·7 | 23·7 | 14·7 | 15·0 | 13·0 | 15·0 |
| Methyl | 2·8 | 1·5 | 2·0 | 2·8 | 2·8 | 2·9 |
| *n*-Butyl | 2·5 | 3·4 | 3·8 | 3·2 | 3·7 | 3·7 |

* Specific activity *f* was calculated from $f = K/g \log 2$, where $K$ is a velocity constant of the first-order reaction and $g$ is grams of enzyme in 8 ml. of reaction mixture composed of buffer (*M*/5 citrate, *p*H 3·0), substrate (0·048 *M*) and enzyme solution in the ratio of 1 : 1 : 2. Temperature, 30° C. Phenyl-β-D-glucoside is used as standard substrate for determining β-glucosidase activity.

† The rate of hydrolysis of the phenyl-β-D-glucoside is taken as unity.

change of enzyme structure. On testing formolized enzyme, it is found that the hydrolytic activity against salicin is specifically decreased. Moreover, the relative specificity is affected in the same way and to the same extent with formalin for two, three and six days respectively. These results indicate that chemical reaction is completed at least within two days under these conditions. From the point of view of species specificity of the enzyme, it should be noted that '*Aspergillus niger* β-glucosidase' is resistant to formalin, whereas almond emulsin is very sensitive[5,6]. The reaction of protein with formalin is more complicated than simply the formation of methylene compounds. In any event, free amino groups are blocked in addition to changes in other groups such as indole nuclei and imidazol rings. In the hydrolysis of *n*-alkyl-β-D-glucosides, nearly all the β-glucosidases from different sources exhibit an increase in the ease of hydrolysis with increasing chain-length except in the case of *Aspergillus niger* β-glucosidase[6,7]. In this respect it is significant that, after treatment with nitrous acid or formalin, *Aspergillus niger* β-glucosidase also shows a small increase with increasing chain-length.

There still remains, however, the question whether or not we are able to change greatly the enzymatic properties without losing its activity.

I wish to thank Prof. Tomoo Miwa, of Tokyo Bunrika University, in whose laboratory this work was carried out, for his help and encouragement throughout this investigation.

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## Fate of Sodium 2,4-Dichloro-phenoxy-ethyl-sulphate in the Soil

SOME additional aspects of the "Fate of Sodium 2,4-Dichloro-phenoxy-ethyl-sulphate" which Prof. L. J. Audus has discussed[1] may possibly lend further understanding to this interesting problem.

Research on sodium 2-(2,4-dichloro-phenoxy)ethyl-sulphate for the past three years in this laboratory has indicated that the compound is readily hydrolysed under acid conditions to 2-(2,4-dichloro-phenoxy)-ethanol and sodium acid sulphate[2]. It has also been found that the soil organism, *Bacillus cereus* var. *mycoides* (Flugge) Smith, Gordon and Clark, possesses enzymes which can catalyse this hydrolysis[3,4]. The enzymatic conversion occurs in soil as well as *in vitro*[4].

An important point for consideration is the fact that 2-(2,4-dichloro-phenoxy)ethanol, which is quantitatively generated when sodium 2-(2,4-dichloro-phenoxy)ethyl-sulphate is added to soil[4], is a highly potent root growth inhibitor. It is extremely difficult to distinguish between 2,4-D and 2-(2,4-dichloro-phenoxy)ethanol on the basis of root growth suppression.

Although 2-(2,4-dichloro-phenoxy)ethanol can be oxidized to 2,4-D in soil[4], it is yet impossible to ascribe the herbicidal action of sodium 2-(2,4-di-chloro-phenoxyl)ethyl-sulphate exclusively to one or the other of these compounds. Under field conditions it is most likely that when sodium 2-(2,4-dichloro-phenoxy)ethyl-sulphate is added to soil, the hydrolysis product 2-(2,4-dichloro-phenoxy)ethanol, as well as any 2,4-D which is generated, can suppress the root development of weed seedlings.

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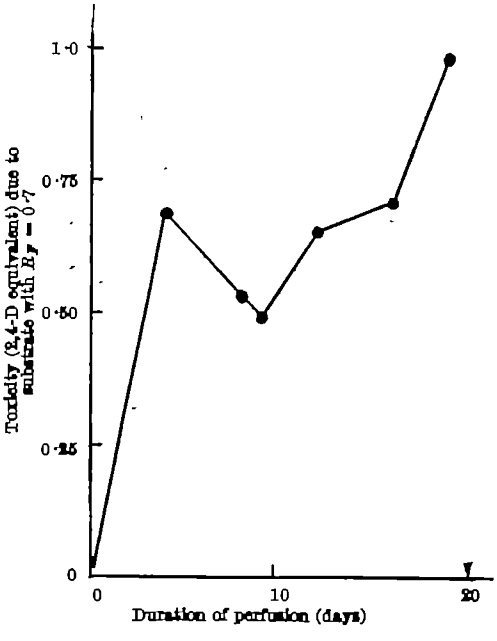
[1] *Nature*, 170, 886 (1952).

[2] Carroll, Robert B., *Contrib. Boyce Thompson Inst.*, 16, 409 (1952).

[3] Vlitos, A. J., *Contrib. Boyce Thompson Inst.*, 16, 435 (1952).

[4] Vlitos, A. J., *Contrib. Boyce Thompson Inst.*, 17 (in the press).

THE possibility that phytotoxicity generated when sodium 2,4-dichloro-phenoxy-ethyl-sulphate is perfused through soil might be due to hydrolysis to a toxic 2,4-dichloro-phenoxy-ethanol has been seriously considered; but I have so far been unable to obtain any evidence that this compound accumulates in the perfusate. The toxicity seems to be due entirely to 2,4-D. Four independent reasons for this conclusion are given in the original paper[1]. The most convincing evidence comes from assays using paper chromatography to separate the toxic compounds in any possible mixture[2]. Only one compound has, as yet, been found in this very sensitive assay, which will detect $10^{-4}$ γ equivalents of 2,4-D, and this has an $R_F$ value (0·7) identical with that of 2,4-D. A graph showing toxicity changes due to this compound in the perfusate is reproduced herewith. It is extremely unlikely that the ethanol has the same $R_F$ value (solvent: butanol–ammonia) as the 2,4-D, but it has not been possible as yet to check this experimentally. The most rational explanation of the results to date is that the hydrolysis of sulphate to ethanol



is the limiting reaction in the soil and that the shape of the toxicity–time curve is a direct reflexion of the activity of the hydrolysing organism. The further conversion to acid, probably by a different organism, takes place so rapidly that the ethanol intermediate can never accumulate in amounts detectable even by the sensitive assay employed.

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[1] Audus, L. J., *Nature*, 170, 886 (1952).

[2] Audus, L. J., and Thresh, Ruth, *Physiologia Plantarum* (in the press).

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## Effect of Cortisone on Tissue Potentials in Man

SINCE a study[1] of the changes produced by cortisone in the decolorization times of oxidation-reduction dyes injected in the skin gave some grounds for believing that this drug caused a change in the electrode potential ($E_h$) of the tissues, it seemed desirable to test the hypothesis by direct electrical measurement. The results show that a change in potential does occur, and the method employed offers a simple clinical means of investigating the peripheral action of cortisone and other substances.

A platinum–iridium needle insulated to within a few millimetres of the tip forms the electrode, which is inserted subcutaneously and connected to one arm of an electrometer-type of potentiometer. The other arm of the potentiometer is connected to a calomel half-cell which is dipped in a beaker of saturated potassium chloride solution; the patient places one finger into the same beaker to complete electrical contact with the skin. The potential difference was found to rise slowly during the period following insertion of the needle, so that for purposes of comparison readings should be made at corresponding times, measured from the moment of insertion. Preliminary investigation showed the errors due to the variables of temperature and body resistance to be negligible.

In a first experiment, two patients were studied over a ten-day period during which cortisone was given intramuscularly in divided doses to a total dosage of 600 mgm. in the three-day period covered by the fifth, sixth and seventh days. On each of the ten days the electrode potential of the subcutaneous tissues was measured in the fasting patient at the same time in the early morning, using three separate sites of needle-electrode insertion. The mean of the potentials for the first four and last two days of the trial was then compared with the mean for the second and third days of the cortisone period. There was a significant fall of potential in both cases.

Case 1. Mean fall = 25 mV. ($n = 23$, $t = 5.4$, $P < 0.001$)
Case 2. Mean fall = 21 mV. ($n = 23$, $t = 4.4$, $P < 0.001$)

In a second experiment, five patients were given cortisone acetate orally in a single dose varying from 125 to 500 mgm., and in every case there was a significant fall of potential during the second hour after administration. The fall ranged between 17 and 23 mV.; $P$ was less than 0·01 in four cases and less than 0·001 in the other case. In a control experiment using the aqueous vehicle in which cortisone acetate is suspended, no significant change was observed.

The fall in electrode potential of the subcutaneous tissues observed by this method is not specific to cortisone, as we have measured a fall after the intravenous administration of both ascorbic acid and glutathione. In fact, the effect of 1 gm. ascorbic acid given by this route may be observed leaving the needle *in situ*, since it is apparent within two minutes of the injection. Our experiences with indicator dyes, together with the observations of Long *et al.*[2] on the effect of cortisone and ascorbic acid on tuberculin sensitivity in guinea pigs, had originally led us to expect that cortisone, by shifting the ascorbic ⇌ dehydroascorbic acid equilibrium in the tissues to the right, would produce a rise in tissue electrode potential. In fact, a fall has been found uniformly to occur. This is in harmony with the work of Stewart *et al.*[3], who have shown that 20 per cent of the plasma ascorbic acid is normally in the dehydro form and that cortisone causes the temporary disappearance of this oxidized fraction without altering the total level. This shift of the equilibrium to the left is consonant with a fall in electrode potential as found in our experiments, and occurred at the same time after oral administration of the drug.

We wish to thank Dr. George Brownlee for advice and criticism; the Cambridge Instrument Co., Ltd., for making the needle electrode to our instructions; the Medical Research Council and Ciba (Basle) for supplies of cortisone and control material; and British Drug Houses, Ltd., for the glutathione.

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DAVID LE VAY

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[1] Loxton, G. E., and Le Vay, D. (in the press).

[2] Long, D. A., Miles, A. A., and Perry, W. L. M., *Lancet*, i, 1085 (1951).

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## Diabetogenic Effect of Nucleic Acid

THE discovery of alloxan diabetes was followed by an examination of the specificity of alloxan. Whether alloxan could be found in biological material and its possible function in the intermediary metabolism were also investigated.

The effect of substances natural to the organism obviously attracted attention. Griffiths[1] found that chronic hyperglycaemia in rabbits could be induced by sufficient doses of uric acid, provided the rabbits lived on a diet lacking cysteine and methionine for a long period. He found that a dose of 1 gm. of uric acid to 1 kgm. body-weight was sufficient. The investigations of J. W. Patterson[2] on the diabetogenic effect of dehydroascorbic and dehydroisoascorbic acids are also of importance.

Nucleic acids as a group are related to uric acid. We have examined whether nucleic acids could have diabetogenic effects under certain conditions.

Ribonucleic acid (Natrium nucleinicum e faece Merck), 1 gm. to 1 kgm. body-weight, dissolved in water was injected intraperitoneally into three rabbits starved for 48 hr. The curve of blood sugar immediately after the injection of nucleic acid was followed by the determination of glucose by Hagedorn–Jensen's method. Then for ten days the urine was collected from metabolic cages and we determined glycosuria at intervals of 24 hr.

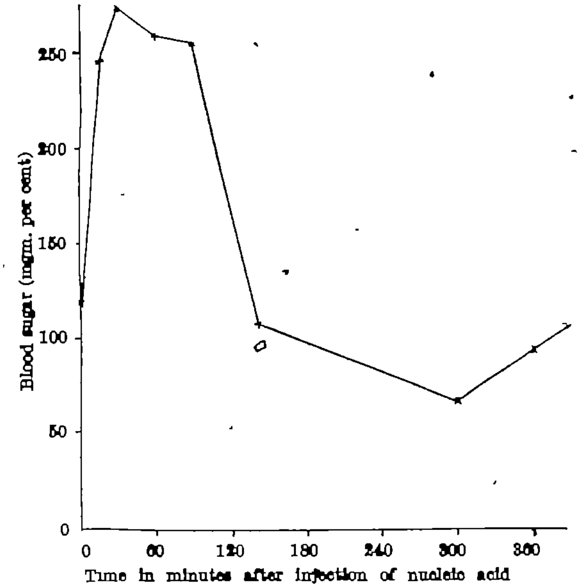

Fig. 1

Nucleic acid was injected in the same doses as in the previous experiment to a group of rats starved for 24 hr. Then the rats were killed at different intervals (30 min., 45 min., 90 min., and 300 min.) after the injection. Immediately after death, we removed some of their organs and determined quantitatively the reduced glutathione in them, employing the modified Kühnau method. Results from this experiment, reproduced in Fig. 2, have been arrived at statistically.

The intraperitoneal injections cause hyperglycaemia in rabbits; later, hyperglycaemia changes into hypoglycaemia, and finally the blood sugar content remains at the level of about 200 mgm. per cent (Fig. 1). Then the rabbits show slight glycosuria for a few days.

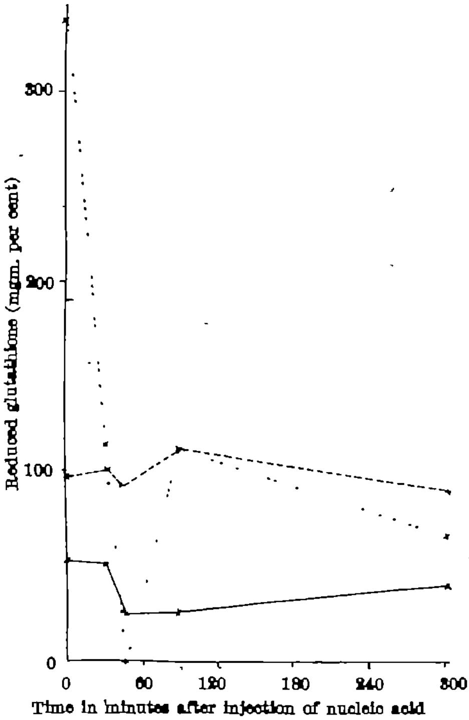

Fig. 2

– – – – –, Liver; . . . . ., adrenals; ————, pancreas

If animals which have lived on a diet lacking cysteine and methionine for several days are used, the symptoms of diabetes are much stronger.

The curve of the contents of reduced glutathione in the livers, pancreas and adrenals is shown in Fig. 2. The courses of the curves are identical with those observed after the injection of alloxan[3].

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Brno. Aug. 30.

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[1] Griffiths, M., *J. Biol. Chem.*, 172, 853 (1948); 184, 289 (1950).

[2] Patterson, J. W., *J. Biol. Chem.*, 183, 81 (1950).

[3] Brada, Z., *Arch. Int. Pharmacodyn.*, 86, 497 (1951).

## Seasonal Variation in the Plankton and Salinity of the Hauraki Gulf, New Zealand

THE seasonal variation of the plankton of the Hauraki Gulf, New Zealand, has not previously been studied. From November 1948 until October 1950, a pilot survey of the plankton of the Gulf was made possible by the courtesy of the Marine Department of the Government of New Zealand, which made available its research vessel *Ikatere*.

It is found that there is an inner coastal population of fairly constant composition, characterized by *Corycaeus aucklandicus* Krämer, and containing also *Temora turbinata* Dana, *Acartia clausii* Giesbrecht and *Euterpina acutifrons* (Dana), all of which are quite common. In summer months only, *Penilia avirostris* Dana[1], *Podon polyphemoides* Leuchart and *Evadne* species are also found in quantity in the coastal population.

The outer region of the Gulf contains an oceanic population which varies according to the season. From November 1948 to April 1949, from October 1949 to May 1950, and in October 1950, the outer region of the Gulf was dominated by salps. These were chiefly *Thalia democratica* (Forskål), but *Salpa fusiformis* Cuvier and *S. cylindrica* Cuvier were also common on occasion. Associated with the salps were the copepods *Rhincalanus cornutus* Dana and *Sapphirina* species, and also stomatopod larvæ.

In the winter months, particularly July, of 1949 and 1950, the oceanic region of the Gulf was dominated by chætognaths, notably *Sagitta planctonis* Steinhaus, *S. serratodentata* Krohn and *S. hexaptera* d'Orbigny. With these the copepod *Oncaea venusta* Philippi was frequently taken.

During July and August 1949, and in July 1950, salps were not recorded at all in the Gulf. In August 1950, they were very infrequent. In view of the known life-history of salps, it is clear that the body of water containing salps in summer cannot be the same as the body of water containing chætognaths in winter. Two other possibilities exist. Either there is a constant invasion of oceanic water from the same source, bearing salps in summer and sagittas in winter; or two distinct oceanic waters invade the Gulf alternately, in summer a salp-bearing water from one source and in winter a sagitta-bearing water from another source.

It is not possible to correlate the occurrence of salps with temperature. Each year salps reappeared in the coldest months—August or September—with a water temperature of 13°–14° C. They persisted through the summer with maximal temperatures of 22° C., and then disappeared in July when the temperature had dropped to 15° C.

In the second year of the survey, salinity observations were made to discover whether the seasonal changes in plankton could be correlated with changes in salinity. It was found that the average salinity of the Gulf rises from 35·30 parts per thousand in November, when salps are dominant, to 35·70 in July, when salps are absent. Salinity then declines to 35·50 parts per thousand in August, when salps are found infrequently, and then to 35·40 in October, when salps are dominant. It will be noted that salps reappear when salinity begins to decrease. Conversely, chætognaths are almost entirely restricted to the months April–August, when salinities are above 35·50.

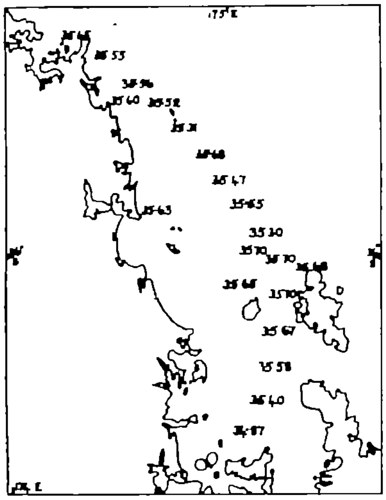

**Fig. 1.** Salinity (parts per thousand) of the Hauraki Gulf and more northern waters in July 1950

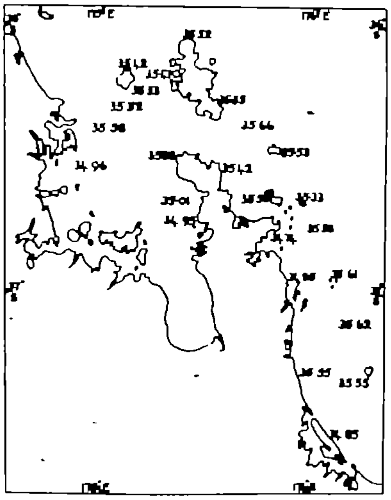

**Fig. 2.** Salinity (parts per thousand) of the Hauraki Gulf and more eastern waters in August 1950

When the salinity of the Gulf is rising, the water of high salinity apparently comes from the north. In July, the bulk of the water in the Gulf is of salinity 35·60–35·70, but there is an outer area of salinity about 35·50 (Fig. 1). In August the Gulf appears to have been diluted from its outer limits inwards (Fig. 2).

These results, by themselves, are not incompatible with either type of oceanic influx suggested above. It is believed, however, that the Notonectian Current from the Tasman Sea varies in its flow around the North Cape of New Zealand, being greatest in summer and least in winter[2]. So it appears possible that the seasonal variation of plankton and salinity described above may be associated with variation in the flow of this current; but this is, of course, not proved.

The observations on which this report is based were made when I was a temporary lecturer at Auckland University College. I am indebted to Prof. W. R. McGregor and the Council of that College for extending the tenure of my appointment so that the survey could be operated over two years.

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[1] Fuller, A. S., *Nature*, 165, 734 (1950).

[2] South Pacific Ocean Currents, M.O.435 (H.M.S.O., 1938).

## Phosphate Content of Mudbanks along the Malabar Coast

The importance of the phosphate content of water masses as a limiting factor in their organic productivity has long been recognized. The investigations of Mortimer[1], Moore[2], Stephenson[3] and Rochford[4] have stressed the importance of the bottom muds in the phosphate cycle.

The inshore sea along the Malabar coast of India has a peculiar environment owing to the formation of extensive banks of very fine mud settling regularly after the rough weather of the south-west monsoon which occurs from the month of June to the beginning of September. The area is also subject to a heavy rainfall (121 in. per annum at Calicut) most of which occurs during these months. This region of the Indian coast is highly productive in respect of fisheries and shows a marked seasonal cycle in its biological features, this being apparently closely related to the south-west monsoon.

In connexion with the study of the fishery and ecology of the inshore area near Calicut, it was considered useful to study the composition of the material forming these mudbanks and to follow the seasonal changes, especially in its phosphate content in relation to the phosphate content of the overlying water and to the seasonal changes in the biology of the area. In view of recent trends in such phosphate studies, it was particularly suggested to me by Dr. N. K. Panikkar that the west coast mudbanks probably form reservoirs of inorganic nutriment playing an important part in the annual cycle, and that their detailed investigation is necessary to understand the fisheries cycles. Work on these lines is in progress, and it is already apparent that these mudbanks contain considerable quantities of phosphates (even if we take only the interstitial inorganic fraction into account) and that the results confirm the above view. The work has also shown that the release of phosphates from the mudbanks takes place largely during the south-west monsoon period, when the waters are continually highly agitated by the strong winds.

The accompanying table shows the values of interstitial and adsorbed phosphates of mud samples taken at two stations near Calicut during the months of January–June 1952. The procedure followed in these estimations was that detailed by Rochford[4] with slight modifications. The mud samples were taken by means of a grab sampler instead of a core sampler.

The individual values of the interstitial phosphate (per gm. of mud) were themselves often higher than the corresponding values of inorganic phosphate (per litre) in the overlying water during the pre-monsoon months, and per unit weight or volume the mud may be said to contain several hundred times as much phosphate as the water-layer above it. The interstitial phosphate is released into the water by agitation. A severe agitation of the sea bottom, noticed during the south-west monsoon of 1950, resulted in a large increase in the phosphate content of the water. During

INTERSTITIAL PHOSPHATE AS PHOSPHATE PHOSPHORUS IN PARTS PER MILLION OF DRY MUD AND ADSORBED PHOSPHATE SIMILARLY IN DRY SILT FROM MUD SAMPLES NEAR CALICUT

| Months | Samples per station | Station I (4 m.) | | | | Station II (19 m.) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Interstitial | | Adsorbed | | Interstitial | | Adsorbed | |
| | | Range | Mean | Range | Mean | Range | Mean | Range | Mean |
| January | 5 | 13 to 35 | 26 | 19 to 80 | 47 | 21 to 27 | 25 | 18 to 68 | 33 |
| February | 4 | 22 to 43 | 35 | 9 to 41 | 21 | 25 to 33 | 29 | 9 to 22 | 16 |
| March | 3 | 19 to 27 | 23 | 13 to 43 | 25 | 17 to 25 | 20 | 16 to 30 | 24 |
| April | 4 | 11 to 25 | 17 | 17 to 28 | 24 | 12 to 19 | 15 | 9 to 33 | 18 |
| May | 3 | 13 to 19 | 15 | 20 to 35 | 27 | 24 to 46 | 33 | 12 to 17 | 14 |
| June | 2 | 7 to 20 | 18 | 22 to 25 | 23 | 9 | 9 | 4 to 10 | 10 |

the pre-monsoon months in 1952 again, the phosphate content of the inshore water was very low, but it increased after the commencement of the monsoon rough weather that disturbed the mudbanks. It appears highly probable that the well-marked seasonal features in the biology of the inshore area along this coast are closely related among other factors to the existence of these extensive mudbanks, the retention by them of relatively large quantities of phosphates (and perhaps other nutrients) and the release of these during the south-west monsoon every year.

The mudbanks have also been found to contain fairly high quantities of adsorbed phosphate. The material of these mudbanks is derived partly from the laterite formation which fringes this coast[5]. An analysis of a sample of laterite has revealed a high 'adsorbed' phosphate content, and since a considerable quantity of laterite silt is washed into the sea during the rainy seasons, this seems to be a constant source to supplement the local turnover of phosphates in the inshore area.

I wish to thank Dr. N. K. Panikkar, Dr. W. R. G. Atkins and Dr. B. S. Bhimachar for helpful criticism.

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[1] Mortimer, C. H., *J. Ecol.*, 29, 280 (1941); 30, 147 (1942).

[2] Moore, H. B., *J. Mar. Biol. Assoc. U.K.*, N.S., 16, (2), 595 (1930); 17, (2), 325 (1931).

[3] Stephenson, W., *J. Mar. Biol. Assoc. U.K.*, N.S., 28, (2), 371 (1949); *Proc. Indo-Pacific Fish. Coun.*, 2nd Meeting 1950, 184 (1951).

[4] Rochford, D. J., *Proc. Indo-Pacific Fish. Coun.*, 2nd Meeting 1950, 157 (1951); *Aust. J. Mar. Freshwater Res.*, 2, (1), 1 (1951).

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## Occurrence of *Puccinia polysora* Underw. in East Africa

Rhind, Waterston and Deighton reported epidemics of *Puccinia polysora* Underw. in West Africa in 1949 and the following years[1]. Fears were expressed that this disease might eventually reach East Africa. Plans were accordingly made for authorities in West Africa to test East African varieties of maize for susceptibility to the fungus, and for the introduction of maize varieties from Central America in the hope that resistant types might be found in an area where the disease is endemic.

The maize rust hitherto recorded in East Africa and generally present throughout the Territories is *Puccinia sorghi* Schw. In June 1952, outbreaks of maize rust, exceeding in severity any previous occurrence, appeared in the Coast Province of Kenya. Collections, which comprised the uredo and teleuto stages, were examined by Dr. G. R. Bisby[2], who stated that the teleuto stage agreed exactly with the original American collections, thus affording final confirmation of an identification which remained uncertain so long as the uredo spores alone were available. This is believed to be the first record of the teleuto stage of *P. polysora* outside America.

Subsequent collections of uredo material were examined from Zanzibar and milder attacks from Uganda and Tanganyika, where both species of rust were found occupying the same leaf. All collections from the Kenya Highland have, so far, been *P. sorghi*; and, in fact, all records of severe attacks of *P. polysora* have been from the warmer, more humid areas. It is hoped that the Kenya Highlands, where maize is the most important food crop of the native population, may remain free.

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Sept. 26.

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[1] Rhind, J., Waterston, J. M., and Deighton, F. C., *Nature*, 169, 631 (1952).

[2] Bisby, G. R., *in litt.*

## *Cerastium arcticum* Lange

RECENT publications containing references to this plant have used the name *C. edmondstonii* (Wats.) Murb. and Ost.[1] in preference to the older name *C. arcticum* Lange[2]. The objection to using the older name is, according to Hylander[3], that "there is no authentic, i.e. chosen by Lange, type specimen". But this in itself is no reason for dismissing the older name since the description is validly published. Moreover, Murbeck and Osterfeld in their description[1] only redescribed Lange's plant. They also took the varietal epithet, var. *edmondstonii*, and gave it specific rank. This is in contradiction to the rules of botanical nomenclature, and therefore the name *C. edmondstonii* is illegitimate.

Recent work on the cytology of this species, using material collected from Snowdon in Wales and Ben Nevis in Scotland, has shown that the chromosome number is $2n = 108$ (Fig. 1). Some seedlings, however, gave higher chromosome numbers, and it is suspected that occasionally this species may be cross-pollinated by *C. holosteoides* Fries (*C. vulgatum* L.), $2n = 144$, which grows in the vicinity. One plant, from Snowdon, showed a highly irregular meiosis with many lagging chromosomes at both first and second anaphase, and it is thought that this may have been a hybrid, although it closely resembled *C. arcticum*. Pollen-mother cells from other plants showed a perfectly regular meiosis with $n = 54$. At first metaphase many multivalents can be seen (Fig. 2), usually in the centre of the cell with the bivalents arranged in a ring outside them. A very similar arrangement has been seen in *C. holosteoides*.

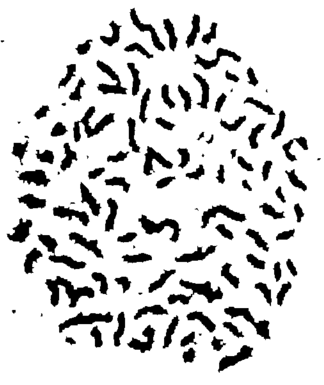

Fig. 1. Root-tip metaphase in *Cerastium arcticum* Lange with 108 chromosomes. × 2,000

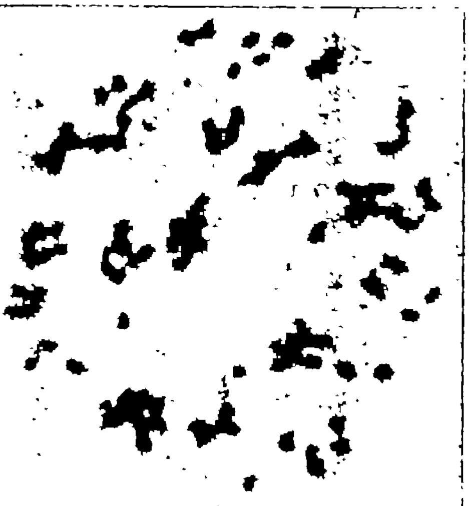

Fig. 2. First metaphase in a pollen mother cell of *Cerastium arcticum* Lange showing many multivalents. × 2,000

Chromosome counts for all the British species of *Cerastium* have now been made. Unpublished counts besides *C. arcticum* $2n = 108$ are *C. cerastoides* (L.) Britton $2n = 38$ and *C. pumilum* Curt. $2n = 90$ and $2n = 95$. The count for *C. cerastoides*, which was also collected on Ben Nevis, agrees with counts made by other workers for material collected in the Alps[4] and in Greenland[5]. The *C. pumilum* material, $2n = 90$, which was collected in Surrey, agrees with the count made by Söllner[6] for Swiss material. In the Surrey material, the higher number $2n = 95$ was more common than $2n = 90$.

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Bot. Not., 246 (1898).

[2] "Flora Danica", 17, Fasc. 50, 7 (1883).

[3] Hylander, N., *Uppsala Univ. Arsskrift*, 7, 148 (1945).

[4] Favarger, C., and Sollner, R., *Bull. Soc. Bot. Suisse*, 59, 87 (1949).

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## A Method of obtaining Phloem Sap via the Mouth-parts of Aphids

Although aphids and coccids are known as 'sucking' insects, suggestions have been made from time to time[1] that forces within the plant, set up by or even independent of the insect, assisted in the feeding process. Yust and Fulton[2] observed fluid exuding from broken-off mouth-parts left embedded in lemons after detachment of the coccids which had been feeding there. The exudate formed pools on the lemon skins from which samples were taken for sugar analyses. When experiments on the feeding preferences of *Aphis fabae* Scopoli[3] were extended to the comparison of turgid and wilting leaves on otherwise similar plants, the wilting leaves proved to be less acceptable to the aphids. The inference that aphids depend less on their own sucking power than on the turgor pressure in the plant tissue, to maintain the flow of plant sap through the exceedingly fine food canal within their maxillary stylets, was checked by severing the mouth-parts of *A. fabae* individuals feeding on beans. Here, too, fluid was observed to exude from the stylet stumps left projecting from the plant surface.

The technique of obtaining sap from severed aphid stylets has been developed since (by T. E. M.) using the lachnid, *Tuberolachnus salignus* (Gmelin), a conveniently large species colonizing the branches of *Salix* spp. That part of the aphid's rostrum which remains outside the plant during feeding can be severed by a clean cut down on to the bark, without dislodging the stylet tips from their normal situation inside a phloem sieve-tube. The operation can be done on living insects on intact growing plants. The exuding sap can be collected continuously by sleeving the projecting stylet stump in the end of a capillary tube. Exudate has been collected in this way at the rate of about 1 cu. mm. per hour uninterruptedly for periods of up to four days. Very similar rates of honey-dew excretion were recorded from adjacent intact aphids, suggesting that the force responsible for moving the sap out of the plant into the normally feeding insect is provided almost entirely by the pressure in the phloem sieve-tubes themselves. The chemical evidence confirms the view that the stylet exudate is the same as the sap ingested by aphids.

This method of obtaining phloem sap is now in routine use in a study of aphid nutrition, and might also be of use to plant physiologists. It is possible that stylet exudate differs somewhat from sieve-tube sap in an aphid-free plant. But the resemblance should be closer than that of extracts of whole phloem tissue, on which past studies of translocation, for example, have so largely been based.

J. S. Kennedy
T. E. Mittler

Agricultural Research Council
Unit of Insect Physiology,
Zoological Laboratory,
Cambridge.
Sept. 26.

[1] Zweigelt, F., *Zbl. Bakt.*, Abt. 2, 42, 265 (1914). Leonhardt, H., *Z. angew. Ent.*, 27, 208 (1940).

[2] Yust, H. R., and Fulton, R. A., *J. Econ. Ent.*, 34, 307 (1943).

[3] Kennedy, J. S., and Booth, C. O., *Ann. App. Biol.*, 38, 25 (1951)

## Shell Regeneration in some British Molluscs

A study of shell regeneration in *Helix aspersa* (Müller)[1] showed that this snail was able to repair its shell with rapidity, chiefly by virtue of the speed with which amoebocytes could transport materials to the damaged area, either from the digestive gland or from other parts of the shell. It was of considerable interest, therefore, to investigate whether a similar process could operate in other Mollusca, and particularly whether there was any distinction between snails in different habitats.

As a result of investigations on a limited number of species, carried out along the same lines as those used for *Helix aspersa*[1], it was established that the following land snails could regenerate their shell as readily as could *Helix aspersa* :

Helicidae
*Helicella itala* (L.)
*Helicella caperata* (Montagu)
*Cochlicella acuta* (Müller)
*Monacha cantiana* (Montagu)
*Monacha cartusiana* (Müller)
*Hygromia striolata* (Pfeiffer)
*Hygromia subrufescens* (Muller)
*Hygromia hispida* (L.)
*Helix hortensis* (Müller)
*Helix nemoralis* (L.)
*Helix pomatia* (L.)
*Arianta arbustorum* (L.)

Clausiliidae
*Balea perversa* (L.)
*Clausilia rugosa* (Draparnaud)
*Marpessa laminata* (Montagu)

Succineidae
*Succinea elegans* (Risso)
*Succinea putris* (L.)

It was of interest that the largest land snail, *Achatina fulica* (Ferssac.), was also able to regenerate its shell.

These terrestrial gastropods similarly stored calcium products within protein spheres in the digestive gland. Removal of pieces of shell in all these species stimulated amœbocytes to withdraw materials from these stores for the repair of the shell. Other amœbocytes, under such conditions, were demonstrated withdrawing calcium carbonate and proteins from small pieces of original shell placed over the damaged area. Possibly all land Pulmonates are similarly able to repair damage to the shell. Certainly any land snail (unless living continuously in a very humid atmosphere) would need to be able to protect its delicate internal organs efficiently to prevent desiccation.

This regenerative ability is not shared by the Prosobranch *Pomatia elegans* (Müller). Similarly, intertidal Prosobranchs do not cover over damaged shell areas as do the Pulmonates during experimental periods of four weeks. Yet, by contrast, those land Pulmonates that were investigated protected a damaged area of 1 sq. cm. within three hours and continued to thicken the regenerating tissues for at least another forty-eight hours.

Shell repair in land Pulmonates is a process comparable with shell thickening, both involving calcification of successive organic membranes. In those intertidal and marine species examined there was a failure to secrete an initial organic membrane over the damaged area. If this is artificially introduced, in the form, for example, of a glass coverslip[2], then repair is possible, although more slowly than in the land Pulmonates. The marine Mollusca that were examined and were unable to regenerate their shell, in the absence of an artificial covering, within a period of four weeks were :

Prosobranchia
*Haliotis tuberculata* (L.)
*Emarginula reticulata mülleri* (Forbes and Hanley)
*Diodora apertura* (Montagu)
*Patella vulgata* (L.)
*Patella depressa* (Pennant)
*Patina pellucida* (L.)
*Patina laevis* (Pennant)
*Calliostoma zizyphinum conuloide* (Lamarck)
*Gibbula cineraria* (L.)
*Gibbula umbilicalis* (da Costa)
*Gibbula magnus tuberculata* (da Costa)
*Osilinus lineatus* (da Costa)
*Lacuna parva* (da Costa)
*Littorina saxatilis rudis* (Maton)
*Littorina saxatilis saxatilis* (Olivi)
*Littorina rudis* (Maton)
*Littorina littorea* (L.)
*Neritoides littoralis* (L.)
*Turritella communis* (Risso)
*Crepidula fornicata* (L.)
*Natica catena* (da Costa)
*Natica montagui* (Forbes)
*Lamellaria latens* (Muller)
*Trivia monacha* (da Costa)
*Nucella lapillus* (L.)
*Ocenebra erinacea* (L.)
*Buccinum undatum undatum* (L.)
*Hinia reticulatus* (L.)

Opisthobranchia
*Acteon tornatilis* (L.)
*Triola punctostriata* (Mighels and Adams)
*Aplysia punctata* (Cuvier)

Lamellibranchiata
*Anomia ephippium* (L.)
*Mytilus edulis* (L.)
*Chlamys varia* (L.)
*Cardium edule edule* (L.)
*Cardium aculeatum* (L.)
*Venus verrucosa* (L.)

The freshwater species *Viviparus viviparus* (L.) has been shown by Heaysman[3] to repair its shell, though rather irregularly and not with the same speed as *Helix aspersa*.

Bevelander[4] and Heaysman[3] have both established that the marine and freshwater species that they examined could absorb calcium directly from their environment. Neither the freshwater nor the marine species are subjected to the possibility of desiccation and, provided their body fluids are isotonic with the water in which they are living, damage to the shell need not be serious to the animal. Spherules containing calcium were not found in the digestive gland of the marine species that were studied. Again, surrounded with a constant supply, the need for the accumulation of calcium reserves is much less important here than for the land molluscs that are usually entirely dependent on very low concentrations of calcium from their foods. Those that live on calcareous soils have a richer calcium supply and consequently have thicker shells.

The amœbocytes that carry the necessary materials for shell repair and shell thickening play a vital part in the preservation of land snails, since damage to the shell under natural conditions is fairly common, judged by the numbers of snails that are found in the wild with repaired shells. Probably, as Heaysman suggests[3], these same amœbocytes play only a minor part in the formation of new shell, since shell-growth and shell-repair are quite different processes, the former associated with the growth of the whole animal, the latter with 'first aid' to an injury. Land Pulmonates may well owe their ability to live away from water to the speed with which these amœbocytes can work, particularly when it is found that none of the land Pulmonates examined failed to produce large numbers of these amœbocytes when they were required.

L. E. WAGGE
T. MITTLER

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London, S.W.7.
Oct. 10.

[1] Wagge, L. E., *Quart. J. Mic. Sci.*, **92**, 307 (1951).
[2] Bevelander, G., and Benzer, P., *Biol. Bull.*, **94**, 176 (1948).
[3] Heaysman, J. E. M., Ph.D. thesis, University of London (1951).
[4] Bevelander, G., *Biol. Bull.*, **102**, 9 (1952).

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## Detection of Phosphate Esters on Paper Chromatograms

PHOSPHATE esters separated on paper chromatograms are usually detected by degrading them on the paper with acid to give *ortho*-phosphoric acid and detecting this by the reaction with molybdate and a reducing reagent. The procedure of Hanes and Isherwood[1] is based upon this and is widely used. This technique suffers from two disadvantages. In the first place, the prolonged initial 'digestion' necessary to break down the more resistant esters frequently leaves the paper in a very fragile state ; and secondly, further analyses cannot be carried out on the spot after treatment. In order to avoid these disadvantages the following technique was developed. It depends upon the fixation of ferric ions by the esters and the reaction of the free ferric ion with salicylsulphonic acid. If the paper is not strongly buffered it is sprayed with 0·1 per cent $FeCl_3.6H_2O$ in 80 per cent alcohol, dried in air at room temperature and then sprayed with 1 per cent salicylsulphonic acid in 80 per cent alcohol. Upon drying, the phosphates appear as white spots on a pale mauve background, *ortho*-phosphate having a band of deeper mauve surrounding it. The colour formation occurs only when the *p*H of the residual moisture in the paper is about 1·5–2·5. This can be checked conveniently with thymol blue, since the colour formation occurs most satisfactorily when the paper just turns this indicator red. Further indications of unsatisfactory *p*H are that below this range no colour is formed, whereas above the range the colour is orange-yellow and definition of the spots is very poor.

When the chromatogram is heavily buffered, modifications to the above reagents are necessary. For example, when there is strong buffering on the alkaline side, it may be necessary to increase the concentration of salicylsulphonic acid to about 10 per cent; when buffering occurs at a low *p*H, the sodium salt may be used.

Other spot indicators of ferric ions have also given good results; but they were either nitrogenous compounds that would interfere with nitrogen determinations or gave colours that faded in light.

Before elution of the chromatogram spots a permanent record of the chromatogram can be made by taking a contact print on a document printing paper such as Ilford No. 50. The colour lends itself well to this, and prints can be obtained that give even better definition of the spots than the original chromatogram.

If a sufficient quantity of ester is present, it can be located on the paper before spraying with salicylsulphonic acid by observing the paper in transmitted daylight or ultra-violet light from a low-pressure mercury lamp incorporating a Wood's filter.

The technique described permits the detection of 1–2 μgm. phosphorus, as phosphate ester, distributed over an area of about 1 sq. cm. The treatment is sufficiently mild not to cause any significant breakdown of adenosine triphosphate providing elution is carried out on the same day as the spraying.

We wish to record our thanks to Major L. H. Kent for his advice and interest. Acknowledgment is made to the Chief Scientist, Ministry of Supply, for permission to publish this communication.

H. E. Wade
D. M. Morgan

Microbiological Research Department,
Ministry of Supply,
Porton, Wilts.
Sept. 23.

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[1] Hanes, C. S., and Isherwood, F. A., *Nature*, **164**, 1107 (1949).

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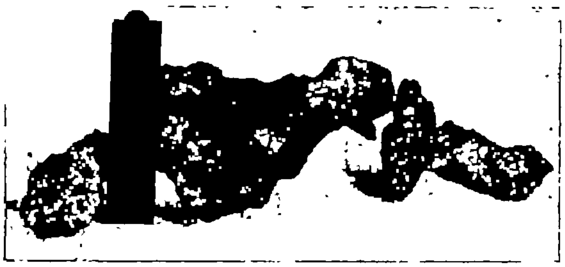
## Vesicular Laterite

The suggestion has been made that the vesicular form of lateritic ironstone owes its characteristic sponge-like structure to termite action, presumably to burrowing by these insects before the material hardened[1].

It is possible that termite action may be responsible in some instances for the perforations; but evidence from the Aripo Savannah in Trinidad (which botanically interesting area receives special mention in Charles Kingsley's "At Last") indicates that vesicles may be a normal morphological feature. The soil profile on this savanna consists of a grey sandy upper layer of about a foot to eighteen inches depth, grading into a material with the consistency of 'Plasticine' with pronounced reddish-yellow mottling. During the wet season, May–December, the water-table lies at or near the surface of the ground, while during the dry season, January–April, it may recede six or more feet. The site is a level one and conditions are correct for the development of a 'ground-water laterite'.

By a fortunate chance during the Second World War, roads were made through this area for military purposes. The area is unfit for agriculture, and had it not been for this chance the present observations might not have been so readily made.

Making of the roads, or more correctly the making of drains at the road-sides, has resulted in the exposure of the mottled horizon. The result, which could scarcely have been predicted by mere inspection of the undisturbed profile, is that 'ironstone' fragments, ranging through all degrees of hardness to completely indurated, have been isolated and stand out on short columns of softer material. They range in size from grain size to more than six inches in length. The larger fragments have the grotesque shapes characteristic of the 'fossil' laterite of Uganda and elsewhere, and which in this case are determined by the irregular shapes of the mottles from which they have been formed. Some of the fragments show smooth-sided perforations, the contents of which have been washed out by rain. The accompanying photograph illustrates one such fragment.



It is suggested that the undisturbed profile represents a stage preceding that which, by progressive enlargement and ultimate contact and fusion of the mottles, would furnish on induration and removal of the softer enclosed material a more or less continuous pavement of vesicular ironstone.

A mound-building termite does occur in the area (*Nasutitermes ephratae*)[2]; but its mounds are infrequent in occurrence and small in size (less than 2 ft. high with a base of about 1½ ft.) There was no sign of termite burrows in the pits examined, and termite action may be excluded in this case as in any way contributing to the whorls and perforations of the indurated material.

The profile will now be studied critically, with the view of tracing the stages of induration, etc., and the findings will be published in due course.

G. ap Griffith

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Imperial College of Tropical Agriculture,
Trinidad, B.W.I.
Sept. 15.

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[1] Russell, E. J., "Soil Conditions and Plant Growth", 508, 8th edit. (Longmans, Green and Co., London).

[2] Adamson, A. M., *Trop. Agric.*, **17**, 12 (1940).

# FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

## Monday, March 23

IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY (in the Main Chemical Lecture Theatre, Royal College of Science, Imperial Institute Road, London, S.W.7), at 4 p.m.—Prof. V. Prelog (Zürich): "Organic Chemistry". (Further Lectures on March 24 and 27.)

ROYAL GEOGRAPHICAL SOCIETY (at 1 Kensington Gore, London, S.W.7), at 5 p.m.—Dr. G. P. Wibberley: "Some Aspects of Problem Rural Areas in Great Britain".

INSTITUTE OF METALS (at the Royal Institution, 21 Albemarle Street, London, W.1), at 6 p.m.—Sir Christopher Hinton: "The Present and Future Requirements of the Chemical Engineer" (Annual May Lecture).

## Tuesday, March 24

CHADWICK PUBLIC LECTURE (in the Lecture Hall, Chadwick Department of Civil and Municipal Engineering, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Mr. H. R. Oakley: "Public Health Engineering—Research and Training".*

INSTITUTE OF PETROLEUM (at Manson House, 26 Portland Place, London, W.1), at 5.30 p.m.—Dr. J. B. Matthews, Mr. J. H. T. Brook, Mr. H. C. Evans, Mr. J. Hughes and Dr. R. P. Taylor: Papers on "The Examination of Used Lubricating Oils".

ROYAL SOCIETY OF MEDICINE, MEDICINE SECTION (at 1 Wimpole Street, London, W.1), at 8 p.m.—Discussion on "The Chemotherapy of the Reticuloses".

## Tuesday, March 24—Thursday, March 26

INSTITUTE OF METALS (at the Park Lane Hotel, Piccadilly, London, W.1).—Annual General Meeting.

**Tuesday, March 24**

Presidential Address.

**Wednesday, March 25**

Symposium on "Control of Quality in the Production of Wrought Non-Ferrous Metals".

## Wednesday, March 25

ROYAL SOCIETY OF ARTS (at John Adam Street, Adelphi, London, W.C.2), at 2.30 p.m.—Mr. Peter Opie: "The Collection of Folklore in England".

PHYSICAL SOCIETY, COLOUR GROUP (in the Physics Department, Imperial College of Science and Technology, Imperial Institute Road, London, S.W.7), at 2.15 p.m.—Annual General Meeting; at 3.30 p.m.—Dr. T. Vickerstaff: "Colour Problems in the Dyeing Industry" (Chairman's Address).

ROYAL STATISTICAL SOCIETY (at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 5.15 p.m.—Miss M. S. Rix: "Construction of an Index Number of Gilt-Edged Values".

EUGENICS SOCIETY (at the Royal Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Dr. Gertrude Willoughby: "Population Problems and Family Policy in France".*

SOCIETY OF CHEMICAL INDUSTRY, NUTRITION PANEL of the FOOD GROUP (at the Chemical Society, Burlington House, Piccadilly, London, W.1), at 6.15 p.m.—Mr. N. W. Pirie, F.R.S., and Dr. A. C. Thaysen: "Newer Sources of Foodstuffs" (Food and the Future, 3).

## Wednesday, March 25—Friday, March 27

INSTITUTION OF NAVAL ARCHITECTS (on board the *Wellington*, Headquarters Ship of the Honourable Company of Master Mariners, Temple Stairs, Victoria Embankment, London, W.C.2), at 10.15 a.m. each day.—Spring Meeting.

INSTITUTE OF PHYSICS (at Bedford College, Regent's Park, London, N.W.1).—Conference on "Static Electrification".

## Thursday, March 26

MINERALOGICAL SOCIETY (at the Geological Society of London, Burlington House, Piccadilly, London, W.1), at 5 p.m.—Scientific Papers.

ROYAL ANTHROPOLOGICAL INSTITUTE (at 21 Bedford Square, London, W.C.1), at 5.30 p.m.—Dr. S. Biobaku: "Egba Traditional Authorities".

## Thursday, March 26—Friday, March 27

FARADAY SOCIETY, COLLOID AND BIOPHYSICS COMMITTEE (in the Wheatstone Physics Laboratory, King's College, Strand, London, W.C.2).—Discussion on "The Nature and Structure of Collagen".

## Friday, March 27

SOCIETY OF CHEMICAL INDUSTRY, CORROSION GROUP (joint meeting with the MANCHESTER SECTION of the S.C.I., and the ROYAL INSTITUTE OF CHEMISTRY, in the Chemistry Lecture Theatre, The University, Manchester), at 10.30 a.m.—Symposium on "Corrosion Inhibitors".

BIOCHEMICAL SOCIETY (in the Department of Biochemistry, University College, Gower Street, London, W.C.1), at 11 a.m.—Annual General Meeting; Scientific Papers.

ROYAL SCOTTISH FORESTRY SOCIETY (in the Large Lecture Hall, Royal Botanic Garden, Inverleith Row, Edinburgh), at 2 p.m.—100th Annual Business Meeting.

ROYAL ASTRONOMICAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.15 p.m.—Geophysical Discussion on "Magmatic Diffusion and the Hot Hydrosphere".

INSTITUTION OF MECHANICAL ENGINEERS (at Storey's Gate, St. James's Park, London, S.W.1), at 5.30 p.m.—Annual General Meeting.

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 9 p.m.—Sir Eric Rideal, F.R.S.: "Count Rumford and the Royal Institution".

ROYAL AERONAUTICAL SOCIETY (in the Chemistry Lecture Theatre, University College, Gower Street, London, W.C.1).—Discussion on "Fatigue".

## Friday, March 27—Saturday, March 28

BRITISH PHARMACOLOGICAL SOCIETY (joint meeting with the FINE CHEMICALS GROUP of the SOCIETY OF CHEMICAL INDUSTRY, at the Wellcome Research Institution, 183 Euston Road, London, N.W.1), at 9.30 a.m. and 2.30 p.m. each day.—Symposium on "Anticholinesterases".

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# APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

ASSISTANT EXPERIMENTAL OFFICER (preferably with experience in biological and/or physical chemistry) IN THE BACTERIOLOGY DEPARTMENT—The Secretary, National Institute for Research in Dairying, Shinfield, Reading (March 28).

LECTURER IN HUMAN PHYSIOLOGY, and a LECTURER IN EXPERIMENTAL (Mammalian) PHYSIOLOGY—The Secretary, St. Mary's Hospital Medical School, Paddington, London, W.2 (March 28).

SCIENTIFIC OFFICERS AT THE NATIONAL AERONAUTICAL ESTABLISHMENT, Bedford, to plan and conduct tests in supersonic wind tunnels and to interpret results—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting C.117/53A (March 28).

ASSISTANT ADVISER (with a degree or the national diploma in horticulture) IN HORTICULTURE—The Secretary, North of Scotland College of Agriculture, 41½ Union Street, Aberdeen (March 31).

ASSISTANT LECTURER (probationary) IN METALLURGY—The Registrar, University College, Singleton Park, Swansea (March 31).

SENIOR RESEARCH STUDENTSHIP IN METALLURGY, and a probationary ASSISTANT LECTURESHIP IN METALLURGY—The Registrar, University College, Singleton Park, Swansea (March 31).

EXPERIMENTAL OFFICER (Grade III) AT THE AERONAUTICAL RESEARCH LABORATORIES, Fishermen's Bend, Melbourne, to carry out wind tunnel investigations related to the development of new aircraft types—The Senior Representative, Department of Supply, Canberra House, 87 Jermyn Street, London, S.W.1, quoting No. 248 (April 2).

RESEARCH ASSISTANT (Grade II) IN THE DEPARTMENT OF TEXTILES, Victoria and Albert Museum—The Secretary, Civil Service Commission, Burlington Gardens, London, W.1, quoting 237/53 (April 2).

LECTURER (Grade II) IN MINING (Coal), and a RESEARCH FELLOW IN COAL TREATMENT—The Registrar, The University, Edgbaston, Birmingham 15 (April 4).

RESEARCH OFFICER TO THE PHYSICAL CHEMISTRY SECTION, Division of Industrial Chemistry, Fishermen's Bend, Melbourne, to investigate the properties of solutions of polyelectrolytes—The Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting No. 4173 (April 4).

LECTURER and an ASSISTANT LECTURER IN (*a*) GAS ENGINEERING AND (*b*) FUEL TECHNOLOGY—The Registrar, The University, Leeds 2 (April 6).

LECTURER (Grade III or II, preferably with interests in pure mathematics) IN MATHEMATICS—The Registrar, The University, Bristol 8 (April 7).

ASSISTANT LECTURER (graduate with qualifications and/or experience in heavy electrical engineering) IN ELECTRICAL ENGINEERING—The Registrar, The University, Manchester 13 (April 10).

ASSISTANT LECTURER IN MATHEMATICS (preferably with special qualifications in algebra or geometry)—The Registrar, Queen Mary College, Mile End Road, London, E.1 (April 10).

CHIEF CHEMIST (with honours degree in chemistry, and with experience in inorganic analysis) IN THE GEOLOGICAL SURVEY, Southern Rhodesia—The Secretary, Rhodesia House, 429 Strand, London, W.C.2 (April 10).

SENIOR LECTURER-IN-CHARGE IN THE DEPARTMENT OF MINING, University of Sydney—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (April 10).

LECTURER OR ASSISTANT LECTURER IN MATHEMATICS at University College, Ibadan, Nigeria—The Secretary, Inter-University Council for Higher Education in the Colonies, 1 Gordon Square, London, W.C.1 (April 11).

RESEARCH CHEMIST to take charge of the Regional Chemical Laboratory of the Division of Soils of the Commonwealth Scientific and Industrial Research Organization, at Canberra—The Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting No. 270/83 (April 11).

RESEARCH OFFICER TO THE MINERALS UTILIZATION SECTION, Division of Industrial Chemistry, Fishermen's Bend, Melbourne, to undertake research work in the field of inorganic and physical chemistry—The Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting No. 4187 (April 11).

SCIENTIFIC OFFICER (with honours degree in botany) for potato breeding with special reference to breeding for resistance to potato root eelworm—The Secretary, Scottish Plant Breeding Station, Craigs House, Corstorphine, Edinburgh 12 (April 11).

SCIENTIST (Grade III) (with a good honours degree in geology or chemistry, and some experience or special interest in preparing scientific papers and reports) on the Coal Survey headquarters in London, mainly to assist in the preparation and editing of Coal Survey publications—The National Coal Board, Establishments (Personnel), Hobart House, Grosvenor Place, London, S.W.1, quoting TT/606 (April 11).

SENIOR RESEARCH OFFICER (Theoretical Physicist) IN THE DIVISION OF ELECTROTECHNOLOGY, National Standards Laboratory, Sydney—The Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting No. 4078 (April 11).

EXCHANGE FELLOWSHIPS IN CANCER RESEARCH offered by the National Cancer Institute of Canada and the American Cancer Society—The Secretary-General, British Empire Cancer Campaign, 11 Grosvenor Crescent, London, S.W.1, endorsed 'Exchange Fellowship' (April 12).

ENGINEERS or CHEMICAL ENGINEERS (Senior Lecturers or Lecturers) with wide practical experience of food processing operations, for example, canning, dehydration—The Registrar, National College of Food Technology, Cranwood Street, London, E.C.1 (April 15).

LECTURER IN PHYSIOLOGY at the University of Otago, Dunedin, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (April 15).

RESEARCH FELLOWSHIPS IN GOVERNMENT SCIENTIFIC ESTABLISHMENTS for research into subjects of importance to H.M. Government—The Civil Service Commission, Scientific Branch, Trinidad House, Old Burlington Street, London, W.1, quoting S.4192/53 (April 15).

ASSISTANT LECTURER (with honours degree in chemistry, and research experience) IN THE DEPARTMENT OF CHEMISTRY—The Secretary, Bedford College, Regent's Park, London, N.W.1 (April 17).

RAMSAY MEMORIAL FELLOWSHIPS FOR ADVANCED STUDENTS OF CHEMISTRY—The Joint Honorary Secretaries, Ramsay Memorial Fellowships Trust, University College, Gower Street, London, W.C.1 (April 17).

I.C.I. RESEARCH FELLOWSHIPS IN CHEMISTRY, PHYSICS and allied subjects, including the biological application of chemistry—The Registrar, University Office, 46 North Bailey, Durham (April 18).

LECTURER IN CHEMICAL ENGINEERING—The Registrar, King's College, Newcastle-upon-Tyne (April 18).

SCIENTIST (Grade II), a SCIENTIST (Grade III) or SCIENTIFIC TECHNICAL OFFICER (Grade I) on the staff of the Director of Scientific Control, to carry out environmental studies at collieries in connexion with a long-term Field Research into the occurrence and causes of pneumoconiosis—The National Coal Board, Establishments (Personnel), Hobart House, Grosvenor Place, London, S.W.1, quoting TT/607 (April 18).

UNDERGRADUATE SCHOLARSHIPS, POST-GRADUATE SCHOLARSHIPS, and RESEARCH FELLOWSHIPS FOR UNIVERSITY STUDY IN MECHANICAL ENGINEERING, TEXTILE ENGINEERING, TEXTILE TECHNOLOGY and certain allied subjects—The Secretary, Sir Walter Preston Scholarship Trust, Textile Machinery Makers, Ltd., 60 Huddersfield Road, Oldham (April 18).

ASSISTANT LECTURERS IN BOTANY, with special interests in either plant ecology and/or plant morphology, or mycology and/or microbiology—The Principal, Royal Holloway College, Englefield Green, Surrey (April 20).

ASSISTANT LECTURERS IN PHILOSOPHY, PHYSICS and GEOLOGY, and a LECTURER or ASSISTANT LECTURER IN GEOGRAPHY—The Registrar, University College of North Staffordshire, Keele, Staffs (April 22).

CHAIR OF PHYSICS in the University of Hong Kong—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (April 30).

DIRECTOR—The Secretary, John Innes Horticultural Institution, Bayfordbury, Hertford (April 30).

INTERMEDIATE and JUNIOR FELLOWSHIPS IN CANCER RESEARCH—The Secretary-General, British Empire Cancer Campaign, 11 Grosvenor Crescent, London, S.W.1, endorsed 'Intermediate' or 'Junior' Fellowship (April 30).

JUNIOR PLANT PHYSIOLOGIST (with good honours degree in botany with special reference to plant physiology, and preferably with some postgraduate experience) under the Colonial Development and Welfare Cocoa Research Scheme—The Secretary, Imperial College of Tropical Agriculture, 40 Norfolk Street, London, W.C.2 (April 30).

LECTURER IN GEOLOGY at the University of Hong Kong—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (April 30).

LECTURER IN THEORETICAL PHYSICS—The Secretary of University Court, The University, Glasgow (April 30).

GRADUATE ELECTRONIC ENGINEER FOR WORK IN THE DEPARTMENT OF ANATOMY on the problem of counting and measuring microscopic particles, for research in television microscopy and its application to central nervous system—The Secretary, University College, Gower Street, London, W.C.1 (May 1).

I.C.I. RESEARCH FELLOWSHIPS IN PHYSICS, CHEMISTRY or related subjects—The Registrar, University Registry, Oxford (May 1).

LECTURER or ASSISTANT LECTURER IN CHEMISTRY at University College of the West Indies—The Secretary, Inter-University Council for Higher Education in the Colonies, 1 Gordon Square, London, W.C.1 (May 1).

RESEARCH SCHOLARSHIPS, GRADUATE SCHOLARSHIPS and STUDENT SCHOLARSHIPS—The Secretary, Institution of Electrical Engineers, Savoy Place, London, W.C.2 (May 1 for Student Scholarships, June 1 for Graduate and Research Scholarships).

HUNTLEY AND PALMER'S AGRICULTURAL RESEARCH FELLOWSHIP—The Registrar, The University, Reading (May 2).

SENIOR LECTURER IN HYDRAULIC ENGINEERING at the University of Melbourne—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (May 18).

BOOTS RESEARCH SCHOLARSHIP at the Long Ashton Agricultural and Horticultural Research Station—The Registrar, The University, Bristol (May 31).

JUNIOR LECTURER IN THE DEPARTMENT OF ENTOMOLOGY—The Assistant Dean, London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1 (May 31).

LECTURER IN THE DEPARTMENT OF LAND SURVEYING, University of Natal, Durban—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (May 31).

BURSARIES IN CONCRETE TECHNOLOGY tenable at the Imperial College of Science and Technology—The Deputy Registrar, City and Guilds College, Exhibition Road, London, S.W.7 (June 1).

ENGLISH ELECTRIC COMPANY'S BURSARIES IN HYDRO-POWER ENGINEERING, tenable in the Civil Engineering Department of the Imperial College of Science and Technology—The Deputy Registrar, City and Guilds College, Exhibition Road, London, S.W.7 (June 1).

NUFFIELD RESEARCH FELLOWSHIP for research on the scientific aspects of ageing—The Secretary, Nuffield Foundation, Nuffield Lodge, Regent's Park, London, N.W.1 (June 1).

UNIVERSITY LECTURER IN ANTHROPOLOGY, and an ASSISTANT CURATOR IN THE MUSEUM OF ARCHÆOLOGY AND ETHNOLOGY—The Secretary of the Appointments Committee, Faculty of Archæology and Anthropology, Museum of Archæology and Ethnology, Downing Street, Cambridge (June 1).

AGRICULTURAL ENGINEER, British Honduras, to organize and control two land clearing units for agricultural developments—The Director of Recruitment, Colonial Office, Great Smith Street, London, S.W.1, quoting CDE.63/31/01.

ENGINEER in the Ministry of Supply at Fort Halstead, to supervise design of test models and equipment, and operation and maintenance of large wind and water tunnels and other installations—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting C.139/53A

MECHANICAL ENGINEER or PHYSICIST (with strong interest in technique of mechanical test creep of materials and instrumentation generally) FOR METALLURGY DEPARTMENT of the Royal Aircraft Establishment, Farnborough—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting C.141/53A.

PRODUCTION CHEMISTS at Royal Ordnance Factories in S.W. Scotland, Lancs, Somerset and South Wales, to assist in technical control or administration for explosives and acids manufacture or ammunition filling, including development work—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting F.77/53A.

RESEARCH ASSISTANT (B.Sc. standard) IN THE CLINICAL RESEARCH LABORATORY, to work in the steroid field—The Secretary, Sheffield No. 1 Hospital Management Committee, Nether Edge Hospital, Sheffield 11.

SENIOR BIOCHEMIST (non-medical) IN THE AREA PATHOLOGICAL LABORATORY—The Secretary, Shotley Bridge General Hospital, Shotley Bridge, Consett, Co. Durham.

SENIOR EXECUTIVE ENGINEER, Public Works Department, Aden—The Director of Recruitment, Colonial Office, Great Smith Street, London, S.W.1, quoting CDE.112/2/01.

SENIOR LECTURER IN PHYSICS, and a LECTURER IN TECHNICAL CHEMISTRY—The Secretary, Royal Technical College, Glasgow, C.1.

STATISTICIAN to help in planning and carrying out technological investigations in mills—The Secretary, British Rayon Research Association, Barton Dock Road, Urmston, Manchester.

TOBACCO OFFICER, Department of Agriculture, Tanganyika, to take charge of the Tobacco Experiment Farm—The Director of Recruitment, Colonial Office, Great Smith Street, London, S.W.1, quoting CDE.63/8/02.

# REPORTS and other PUBLICATIONS

*(not included in the monthly Books Supplement)*

## Great Britain and Ireland

Studies in Conservation: the Journal of the International Institute for the Conservation of Museum Objects. (About 2 Nos. a year.) Vol. 1, No. 1, October 1952. Pp. iv+48. (Edinburgh and London: Thomas Nelson and Sons, Ltd., 1952.) 21s. net. [112

Sight Reduction Tables for Air Navigation. Vol. 1: Selected Stars, Epoch 1955·0. (A.P. 3270.) (Published on behalf of the U.S. Navy Hydrographic Office.) Pp. xi+325. (London: H.M. Stationery Office, 1952.) 21s. net. [112

The Health of the School Child: Report of the Chief Medical Officer of the Ministry of Education for the Years 1950 and 1951. Pp. 144+7 plates. (London: H.M. Stationery Office, 1952.) 5s. net. [912

Proceedings of the Royal Society of Edinburgh. Section A (Mathematical and Physical Sciences.) Vol. 63, Part 4, No. 28: A Molecular Sum Rule. By D. ter Haar. Pp. 381–384. 1s. Vol. 63, Part 4, No. 29: The First Chemical Society, the First Chemical Journal, and the Chemical Revolution (Part 2). By Dr. James Kendall. Pp. 385–400. 2s. 9d. (Edinburgh and London: Oliver and Boyd, Ltd., 1952.) [912

The Registrar General's Statistical Review of England and Wales for the Year 1950. (New Annual Series, No. 30.) Tables, Part 1, Medical. Pp. x+461. (London: H.M. Stationery Office, 1952.) 12s. 6d. net. [1012

## Other Countries

Institut Royal Météorologique de Belgique. Publications, Series B, No. 2. Le temps en Belgique pendant l'année 1951 et ses rapports avec la production agricole. Par A. Vandenplas. Pp. 68. Publications, Serie B, No. 4: Peut-on faire pleuvoir artificiellement? Par Dr. L. Dufour. Pp. 16. (Uccle-Bruxelles: Institut Royal Météorologique de Belgique, 1952.) [1112

New Zealand Forest Service. Annual Report of the Director of Forestry for the Year ended 31 March 1952. Pp. 76. (Wellington: Government Printer, 1952.) 1s. 6d. [1612

Bulletin of the Museum of Comparative Zoology. Vol. 107. No. 4: Revision of the Species currently referred to Alepocephalus, Halisauriceps, Bathytroctes and Bajacalifornia, with Introduction of Two New Species. By A. E. Parr. Pp. 253–270. Vol. 107, No. 5: Geographic Variation in the Red-eyed Towhee of the Eastern United States. By J. C. Dickinson, Jr. Pp. 271–352. (Cambridge, Mass.: Harvard College, 1952.) [1612

University of South Carolina Publications. Series 3: Biology. Vol. 1, No. 1: Distribution and Bibliography of the Amphibians and Reptiles of South Carolina, by James T. Penney; Fishes of Richland County, South Carolina, by Harry W. Freeman. Pp. 41. (Columbia, S.C.: University of South Carolina, 1952.) 75 cents. [1612

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# FUNCTION OF TECHNOLOGICAL EDUCATION

THE collection of essays constituting the preliminary survey of the nature and efficacy of technical education, which the United Nations Educational, Scientific and Cultural Organization has published under the title "Education in a Technological Society"*, emphasizes the need for social foresight in estimating technological needs and in providing suitable education. Much more is intended by this than forecasting future requirements for particular classes of technological or technical experts and attempting to adjust supply to demand. It envisages also the question of flexibility so as to ease transfer from one occupation to another, and the problems which are presented by changing age-structure and elderly workers.

This need for social insight has been well indicated by a number of recent management studies in Great Britain; and it is further stressed in an international study of the "Sense of Belonging in Industry" made by two of the authors of one of these studies, whose services were made available by the British Institute of Management. This study also has been published by the United Nations Educational, Scientific and Cultural Organization under the title "The Community Factor in Modern Technology"†. Following a well-documented review of the discords of industrial society, it presents, first, twelve European studies of organizations which helped to maintain a community and of organizations which fostered the creation of a sense of community where none had existed, and, secondly, two case studies of the process of maintaining and fostering communities. The latter utilize material already reported in Great Britain; but the conclusions drawn regarding satisfactions in industry and on the need and methods for study outlined in the following two chapters are not based simply on this evidence.

The main purpose of the book is to demonstrate the reason for believing that industry can play a major part in maintaining existing, and in fostering the growth of new, communities. This belief has been confirmed whenever the discords of industrial society have been strident enough to demand analysis, and Mr. Scott and Mr. Lynton consider it would be reasonable to expect that attention to the community factor in industry would result in many individuals finding the security and stability which they now lack. This change should greatly reduce neurotic and anti-social behaviour: much psychosomatic illness is traceable to industrial situations. Responsibility can also reasonably be expected to be diffused through an organization, community, region or nation, leading to more equal sharing of burdens and satisfactions. This might revise the growing tendency of society to consist of a few at the centre with too much to do, and many at the periphery with no community responsibilities.

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* Education in a Technological Society: a Preliminary International Survey of the Nature and Efficacy of Technical Education. (Tensions and Technology Series.) Pp. 76. 200 francs; 4s.; 75 cents.

† The Community Factor in Modern Technology: an International Study of the 'Sense of Belonging' in Industry. By Jerome F Scott and R. P. Lynton. (Tensions and Technology Series.) Pp. 170. 300 francs; 6s.; 1 dollar.

(Paris: Unesco; London: H.M Stationery Office, 1952.)

In drawing this conclusion, the report is stating in other words and in a fresh context the importance of genuine local self-government as the basis of a democratic society, and the whole trend of the conclusions of Mr. Scott and Mr. Lynton points to the vital necessity for reform at that level as much as for developments in industry. They suggest that a balance and integration of social classes and economic interests may be expected to replace the cycle of domination of society by successive groups, and that the reconciliation of interests would thus be possible without unmanageable conflicts. It requires an integrated community to enable the various interests to co-operate around the fundamental principle that wealth is increased only through increased productivity, not through strife; and the report suggests that our capacity to communicate with others may be expected to develop greatly, rendering it easier to become adapted to changes of all sorts, since we should have roots in communities, and daily practice of effective communication and adaptation.

In this sense, responsible membership of a real community is training for living in the world community; and as status systems attuned to the needs of the times develop, we may expect really representative institutions to throw up regional and national leaders. Community could thus co-operate with community, region with region, and national policies could be evolved and continuously adapted. Moreover, the growth of many spontaneous and autonomous arrangements between effective social institutions and between communities may be expected to replace some national policies which have been born of the failures of institutions and communities and now hinder their growth.

Mr. Scott and Mr. Lynton in this report provide a reasonable basis for such expectations; although, in their summing up, they give insufficient weight to the obstacles and prejudices which such trends will have to overcome even within any one country. We may perhaps disregard for the present any effect they are likely to have on international co-operation; but in technological development and in both the planning and the content of technological and technical education, due weight must be given to the implications of such factors. They are highly relevant to discussions on modern industrial organization such as Political and Economic Planning has published in two recent broadsheets: No. 348, "New Thinking on Monopoly", and No. 350, "The Structure of Industry and the Technical Revolution".

The first of these broadsheets traces the development of thought on monopoly up to the present time, when it is seen as a problem of power, and, as such, a question for politicians rather than economists. The efficacy or otherwise of the means available for counteracting monopoly obviously can have powerful repercussions on the development of community ideas; but the second broadsheet is concerned essentially with the various technological and other factors affecting the growth of business firms. Efficiency, it is emphasized in the Unesco report, is no longer seen almost as a function of size; on the contrary, even in industries most favourably disposed to mass production, there is a tendency, defended essentially in social terms, to limit the size of each production unit. Managers tend to be regarded as trustees of an institution; and explicit evaluation of human affairs is replacing implicit evaluation.

The PEP broadsheet is emphatic that, while industrial concentration has continued in the past few years, the dominant forces are now technological rather than financial or economic. Over many years such factors as the development of organized research and the advent of synthetic materials, with, as corollary, the huge initial investment demanded by new processes, have broken down traditional barriers between industries and stimulated the development both of the firm making a variety of products and of joint enterprises of several companies, not necessarily from the same industry. Both the inventive and financial resources of the nation are being canalized more and more through the large concern, whether publicly or privately owned.

The prime influence in this expansion across industrial boundaries has been the growing complexity of modern industry, under the influence, first of the chemical revolution in the second half of the nineteenth century, and later the development of synthetic products in the second and third decades of the twentieth. While the technical implications for different industries of such developments as plastics—'Terylene' and nylon, for example—have been adequately discussed, their impact on the industrial structure seems to have been neglected, and in directing attention to this as well as to the implications of such changes for the trade unions and for the human side of industry, the broadsheet does a real service. Moreover, it puts in its true perspective the seriousness of inappropriate taxation policies which discourage enterprise at a time when only the really large firm is in a position to carry the heavy overheads represented by research facilities and development from the laboratory, through the pilot plant, to full-scale production.

The broadsheet quotes sufficient examples of joint enterprise to indicate that the analysis of competition simply in terms of competing against other firms in the same industry is no longer tenable. The corollary that each firm is competing to a greater or less extent against every other firm in the economy holds social as well as economic implications far reaching enough to warrant a comprehensive survey of industrial structure such as the broadsheet suggests. The suggestion is further supported by the trend of Mr. Duncan Sandys's recent statement in the House of Commons on progress in the development of the use of atomic energy for industrial purposes. Nothing in that statement encouraged the view that power obtained in this way is likely to be available on a significant scale for industrial purposes at an early date. Mr. Sandys was more concerned to emphasize the technical difficulties still to be overcome, and the need for much more experience before a considered judgment could be formed on the economic soundness of such proposals. None the less, social as well as workers in the Society. In this volume excellent photographs are reproduced of all the presidents past and present of the Society; some of these are, or were, personally known to their British colleagues both for their activities as chemists and for their participation in the Society's activities; but it is highly likely that the name of Charles L. Parsons is known to more chemists in the world than any other associated with the Society's activities. It is probable that the membership of the American Chemical Society by now exceeds the total membership of all other chemical societies outside the Iron Curtain, and one can look forward with hope and enthusiasm to the first centenary of the Society.

ERIC K. RIDEAL

# THE STERLING AREA IN AMERICAN EYES

The Sterling Area

An American Analysis. Prepared under the direction of John M. Cassels. (Published by the Mutual Security Agency Mission to the United Kingdom.) Pp. 672. (London: H.M. Stationery Office, 1951.) 21s. net.

WHEN the Economic Co-operation Administration mission to the United Kingdom began to function in 1948 it immediately felt the inconvenience of its lack of knowledge, not only of the United Kingdom economy but still more of the economies of other British Commonwealth countries and of that strange and amorphous organization summed up as 'the Sterling Area' with which they are financially linked. The information the mission sought was not easily available anywhere, and it was an excellent idea to get together a fact-finding committee to write an objective report on the various members of the Area, from the point of view both of those who had to administer Marshall Aid and of the American public, who might be expected to contribute more willingly if they understood better to what they were contributing. The result is a handsome volume, sumptuously printed in Amsterdam, with innumerable illustrated statistics, some of which are in colour, and a wealth of tables. It contains 671 double-column pages and weighs 5¼ lb.

The American passion for large publications is very difficult for the British to understand, and this one (as it would no doubt be described in the United States) a 'jumbo' even by American standards. It is divided into three parts, described as books. The first summarizes the main features of Sterling Area countries; one chapter describes briefly the United States and Canadian economies by way of contrast and by showing their relations to the Sterling Area. A brief summary of the extent and progress of post-war recovery is then given, and the book ends with what is effectively a review of the Sterling Area considered as a proposition for American investors.

Book 2 consists of a series of lectures on economic geography at a fairly elementary level, going carefully around the components of the Area and summarizing their economic structure: population (size, growth and racial structure), imports and exports (pre- and post-war, by commodity and by country of origin or destination), external capital position and domestic economic policies. Book 3 consists of thirteen chapters, each of which is devoted to describing the world position in respect of some commodity or group of commodities (primary products) important in world trade. This is done with a considerable degree of detail. For example, the chapter on non-ferrous metals gives first a table for twenty non-ferrous metals of United States consumption as a percentage of world, and of United States production. This is followed by an immense table of the production (by weight of metal content) of each of twenty-five non-ferrous metals in each of sixty countries of the world. This in turn is followed by individual studies of tin, copper, aluminium (including bauxite), lead and diamonds.

It will be evident that Books 2 and 3 contain a great deal of information, some of which is not easily available elsewhere and more of which is conveniently brought together for the first time. Most of the information has, inevitably perhaps, been snipped out of books and legal documents (such as the constitutions of the various countries). This matters less in Book 3 than in Book 2, where this type of second-hand knowledge, although not actually incorrect, can give a distorted impression, in that practice often develops a very different emphasis from that apparent in the legal framework. A short visit by a member of the committee to a few leading Sterling Area countries (such as India) would have served to correct this. Again, an over-concentration on trade statistics not infrequently gives a misleading impression, for example, in the case of Ireland, where invisibles in both directions play such an important part in the balance of payments.

The sub-title of the work is "An American Analysis"; this does it both less and more than justice. There is virtually no analysis in the economic sense. On the few occasions when an economic argument is put forward, it tends to be incomprehensible (as when it is stated that devaluation was favoured because it would make British industry more efficient under increased competition from American exporters). The statistics are all of a very 'bread and butter' type and should not be relied on in too great detail.

On the other hand, the study tries very hard (and on the whole succeeds very well) to attain a strictly fair and objective attitude, and to keep American prejudices against the Sterling Area well in the background; indeed, the book should do much to dispel them. Nevertheless, from the British angle the view is, of course, American. For example, the discussion of the change in the position of South Africa, and hence indirectly of the whole Sterling Area, due to the failure of the price of gold to get adjusted to post-war levels, is delicately skated over. Again, while the Sterling Area restrictions on dollar imports are set out at length, there is much less of dollar restrictions on Sterling Area exports, such as tin.

Nevertheless, the British reader will find in the book much that is new to him and on which he would do well to ponder. Especially important is the demonstration of the increased direct dollar earnings of Sterling Area commodities—by-passing the traditional triangle through the United Kingdom (Australian wool is an important example). Such changes as these are very largely the source of the increasing strains which are all too evident in the rigid organization of the Sterling Area. It is vital that we should have them impressed on us in order that they may be relieved before it is too late.

URSULA K. HICKS

# RUMFORD: A BICENTENARY

By THOMAS MARTIN

BENJAMIN THOMPSON, afterwards Count Rumford, was born two hundred years ago (March 26, 1753) at Woburn in Massachusetts, about fifteen miles from Boston. Distinguished as a soldier, a statesman, a philanthropist and a man of science, it is probably in the last of these characters that he is best remembered to-day. He made experiments and reached conclusions of fundamental importance concerning the nature of heat; he was the author of a series of "Essays" on various subjects in pure and applied science which were well known and widely circulated in their day; he was a pioneer in that field of activity which he himself described as the "application of science to the common purposes of life"; and in the pursuit of this object he founded the Royal Institution in London.

Rumford came of the Puritan stock of the original New England settlers, and widely though he departed, in the course of an active and at times adventurous life, from the ways of his forefathers, there is no doubt that their traditions left their mark on his character. Added to his intellectual gifts were a methodical industriousness and a frugal outlook which caused him to take an intense interest in the practical details of his schemes of welfare, while in his personal relations there was often a harsh disregard for the feelings of individuals which was in marked contrast with the professed object of his plans; and it is probably in these characteristics that we may trace his New England origin.

His early life was lived in those troubled years in the American Colonies which led up to the War of Independence. While working as apprentice to a storekeeper, he showed an interest in science and experiment, and attended lectures at Harvard. Later, as a young schoolmaster at Rumford (later Concord) in New Hampshire, he married the widow, fourteen years his senior, of a considerable citizen of that place. It was here that his daughter Sarah, afterwards Countess Rumford, was born.

His military aspirations were gratified when he was commissioned as major in a local regiment of militia; but he was suspected by the townspeople of sympathies for the royalist cause which were too ardent for their liking, and when the troubles came to a head he was obliged to escape from the town. Later, to avoid persecution, he joined the British in Boston, leaving his wife, whom he was never to see again. Henceforth he was an avowed loyalist.

On the evacuation of Boston, Major Thompson was sent with dispatches to London, and before long, such was his initiative and address, was established in the Colonial Office as an under-secretary to the Minister, Lord George Germain. His promotion was rapid. The United States had declared their independence on July 4, 1776; but the war dragged on, and for a time Thompson returned to America, to serve with some distinction in command of a regiment of cavalry with the British forces. Peace was not finally concluded until 1783, when he found himself again in London, a colonel with half-pay on the British establishment.

Seeking fresh fields to conquer, Thompson visited the Continent, and after a brief return to Britain, during which he was knighted by King George III, there followed that most active and fruitful period of his career when for fourteen years he served the Elector of Bavaria. It was in Munich, where he held high military rank and was Privy Councillor of State to the Elector, that his constructive energy and administrative skill found their full outlet. The country was backward and the administration inefficient and corrupt, and Sir Benjamin Thompson's New England soul must have revolted at the incompetence and neglect he saw around him.

He introduced reforms in the army and in many of the Departments of State; but in none of his measures was he more successful than in those for dealing with the problem of mendicancy. After a period of war and political disturbance, the country was infested with beggars whose menaces and extortions seriously alarmed the law-abiding citizens of Munich. Thompson appointed a day when, with the aid of the military, all the vagrants in the capital were arrested. Houses of Industry having been prepared for their reception, and a charitable organization set up to provide the necessary funds, the genuine poor and infirm were relieved and the able-bodied set to useful work. By his enlightened and humane treatment of the destitute and the originality and success of his methods in the Houses of Industry, he established a new system of philanthropy, and his ideas were afterwards applied, often on his personal advice, in many other countries.

This work in Munich aroused his interest in such matters as economy of fuel, the design of stoves and fireplaces and the economical provision of food for large numbers of people; and many of his "Essays", published later, were devoted to these subjects. Rumford stoves were widely used and Rumford soup kitchens set up in London, Paris, Geneva and elsewhere; the soup tickets could be purchased by the charitable and given to the hungry.

The Elector Karl Theodor rewarded Sir Benjamin Thompson by creating him a Count of the Holy Roman Empire, and the new Count took for his title the name, Rumford, of the place in New Hampshire where, after his marriage, he had first been established as a man of substance.

He returned to England in 1798, expecting to be the Bavarian Minister in London, and was grievously disappointed when he found that the British Government would not accept a subject of the King as the representative of a foreign power. He stayed on in London, however, where his fame had travelled before him: William Wilberforce declared in Parliament that it was "a public blessing in such times as these to have such men as Count Rumford" in the country. The Count became a leading member of a group of practical philanthropists, associated in the Society for Bettering the Condition and Increasing the Comforts of the Poor, who were responsible at this time for a number of new enterprises. One of these, the principal object of which was to be the application of science and invention to the improvement of the lot of the working classes, was the Royal Institution; and to this establishment, founded in 1799, Rumford devoted most of his time for upwards of two years.

Rumford's fame during his life-time rested on his public works, and the special feature of his activities, which distinguished him from other professed reformers, was his determination to apply scientific knowledge to the objects of philanthropy. Much of his scientific work had a strictly utilitarian object in view. Throughout the period of his service in Bavaria, however, and indeed all through his life, he returned, in the intervals of his public labours, to the "more pleasing occupations of science and philosophical experiment". These private researches formed the subject of his periodical communications to the Royal Society and other learned bodies, and it is upon them that his enduring reputation as a man of science really depends.

As early as 1778 he carried out in England a series of experiments with gunpowder and firearms. The paper describing this work shows that he was well acquainted with the work of Benjamin Robins, the inventor of the ballistic pendulum, and he used a Robins pendulum to determine the velocities of projectiles. A chance observation of the greater heating of a gun-barrel with a blank charge than when a projectile was fired led him to investigate the source of the heat, and although his explanation of the observation is not very convincing, it shows that he had already begun to think in terms of the generation of heat by mechanical action and to speculate as to the nature of heat itself.

He had made the acquaintance of Sir Joseph Banks and other men of science soon after his arrival in England; and in 1779 was elected a Fellow of the Royal Society.

On a visit to Mannheim in 1785, he made some experiments on heat at the Academy of Sciences. A thermometer was fixed at the centre of a glass tube having a bulb at the end, the bulb immersed in ice or boiling water, and the times noted for the thermometer to fall or rise through certain intervals of temperature. With this apparatus he obtained measures of the conducting power of the contents of the bulb—water, mercury, air at different pressures —or a vacuum. His discovery of the heat-insulating power of a vacuum, or more accurately the reduced conductivity of the imperfect vacuum he obtained, is of particular interest, for it contains the suggestion of the principle used many years later by Sir James Dewar in his vacuum vessels. Another important observation was that moist air conducts more readily than dry.

The experiments begun in Mannheim were continued in Munich, and a more elaborate apparatus devised, which has been erroneously described as Rumford's calorimeter, but which he called his "cylindrical passage thermometer". It was an instrument for measuring conductivity, and with it he made a great many determinations. One of these instruments is preserved at the Royal Institution. The discovery of the superior conductivity of moist air prompted him to measure the moisture absorbed by the materials of clothing and its effect on their heat transmission; and in his paper to the Royal Society on this subject there are observations on the evils of a damp climate and the dangers of sleeping in a damp bed. He was a firm advocate, too, of woollen clothing worn next to the skin, to absorb the moisture, and had no patience with the idea that it was too warm or too irritating a material for the hot weather.

An observation that, by obstructing the free circulation of air, its power of communicating heat could be reduced, led to a new inquiry. Other fluids were examined. He tells us that he had always been struck by the extraordinary capacity of stewed apples to retain their heat. Like others, he had burned his mouth with hot apple pie; and he found on experiment that stewed apples, containing actually very little solid matter, were a much poorer conductor than pure water. From this it was a simple step to obstruct the circulation of water artificially, with fragments of solid materials, and in this way he discovered the important part played by convection in the transfer of heat. With a suspension of powdered amber in an alkaline solution adjusted to the same specific gravity, he went on to make a systematic study of the convection currents in fluids on heating, and reached important conclusions.

Rumford's investigation of the propagation of heat in fluids, and particularly his discovery in these simple experiments of the important part played by convection, is one of his most valuable contributions to the science of heat. His enthusiasm for his discovery led him, however, to make extravagant claims. He convinced himself that air, water and other fluids were actually non-conductors. All heat transfer was by convection, and there could be no conveyance of heat in a fluid at rest; a conclusion which not unnaturally involved him in controversy.

Being in need of a method of comparing the amounts of light emitted by the lamps in a factory in Munich, Rumford devised an instrument for the purpose in which the positions of two lamps could be adjusted to throw equal shadows of an object on a screen. This device, which proved to be thoroughly effective and practical, was the first shadow photometer, described in Glazebrook's "Dictionary of Applied Physics" as "the earliest form of photometer capable of accurate work".

Rumford also made important observations on radiant heat. He was surprised to find that a vessel of polished brass containing hot water cooled quicker when it had a covering of linen than when it was uncovered, and was led to examine surfaces in relation to their loss of heat by radiation. He discovered that a blackened surface gave off heat far more readily than one of polished metal; and he saw at once the practical bearing of this observation, advocating polished metal dishes for serving hot food and black-painted pipes for steam heating. For the accurate comparison of the radiation from different surfaces he devised another new instrument, a differential thermometer or 'thermoscope', consisting of a glass tube with bulbs at the ends, containing air, with a 'bubble' of spirit in the tube the movement of which could be measured when the radiating bodies were presented to the bulbs.

The best known of all Rumford's experiments, made with a cannon and boring tool in the Arsenal at Munich, is so familiar that it need not be described here in great detail. It resulted in a short paper, on the source of the heat which is excited by friction, which contributed more to his scientific fame than any other part of his work. The blunt boring tool was held fixed, and entered a cavity turned in the end of a casting for a cannon; the end of the casting, separated from the main part by a narrow cylindrical neck, was enclosed in a box containing water. When the cannon was rotated by horses, after two hours and a half the friction of the borer caused the water to boil.

To the onlookers, this was a spectacular demonstration. For Rumford, the measurements and observations he made convinced him that any theory, such as the caloric theory, which attributed material properties to heat, was no longer tenable. To quote from his paper: "It appears to me to be extremely difficult, if not quite impossible, to form any distinct idea of anything capable of being excited or communicated in the manner the heat was excited and communicated in these experiments, except it be motion"; motion, that is, of the constituent particles of the heated body. He claimed no originality for this conception; but the investigation confirmed his views, held in opposition to many of his contemporaries, on the nature of heat and its relation to mechanical action; it had a decisive effect in overthrowing the caloric theory, and it paved the way for the later conception of heat as a form of energy and the measurement of its mechanical equivalent by J. P. Joule.

A good deal of controversy was aroused by Rumford's published researches. Berthollet endeavoured to explain the cannon-boring experiment on a caloric basis. Men of science in Great Britain, while they accepted his demonstration of the part played by convection in the propagation of heat, rejected his view that fluids were non-conductors. John Dalton condemned this theory, and repeated Rumford's experiments in his own way to prove that fluids could conduct. Nevertheless, he expressed high appreciation of the demonstration Rumford had given that convection currents were the main cause of the diffusion of heat in fluids. Others less discerning than Dalton saw nothing but error and even hypocrisy in his writings. A spiteful article in the *Edinburgh Review* accused him of 'borrowing' and claiming as his own the invention of the differential thermometer from Leslie. Rumford was obliged to write a "Historical Review" of his work on heat to defend himself, which is remarkable for its moderation compared with the ill-natured criticism which was levelled at him.

Rumford made mistakes, due in part to his isolation and ignorance of what others were doing at the time he was making his own experiments, and he laid himself open to criticism by the prolixity and repetition of which he was often guilty in his writings. But later generations have endorsed the opinion of Dalton, and given credit to him for what was new in his experiments and valuable in his theories on the nature of heat.

In 1802 he left England again, to settle in Paris, where he married the widow of Lavoisier. The marriage proved unhappy, and he retired to a villa at Auteuil, where he carried on his experiments. Although pressed to do so by friends, he never returned to America. He died in 1814.

# RUMFORD AS A SCIENTIST

In a Friday Evening Discourse delivered at the Royal Institution on March 27, Sir Eric Rideal gave an account of the life and work of Rumford. The Discourse was accompanied by experimental demonstrations of many of Rumford's investigations. The following account indicates the great width of his purely scientific interests.

Rumford's name is generally associated with his experiments on heat. In his day the nature of heat was a subject-matter of controversy. According to one view, heat was a material substance termed 'caloric' which, fluid-like in character, could penetrate all space, was self-repulsive, and was strongly attracted by matter. On the other hand, heat was regarded by Boyle and Hooke as a form of energy, a 'mode of motion'. Rumford's experiments in support of the energy theory were very far-reaching and embracing. The experiments on boring cannon which he carried out in Mannheim are well known.

Later, Rumford devised a simpler apparatus in which by friction between metal plates he was able to heat water surrounding the plates. He showed that the supply of heat generated in this way was inexhaustible, and he could detect not the slightest change in either the weight or specific heat of the system. It is interesting to note that his experiments led to the value of 1,034 ft.-lb. as the amount of work required to raise the temperature of 1 lb. of water by 1°, while Joule's later more precise measurements gave 772 ft.-lb. Rumford himself believed his value to be an over-estimate. He was thus the first to determine the mechanical equivalent of heat.

Rumford was the first to show that heat could travel through a vacuum, that is, in the form of radiation. He showed that radiation could take place more readily from blackened surfaces than from polished metals. He likened this radiation to the acoustic waves given off by a bell when struck, and believed that the radiation of cold or frigorific radiation, although different from the radiation of heat, yet obeyed the same laws. In 1800 Rumford repeated in the Royal Institution the experiments of Pictet on focusing cold by means of mirrors, an experiment shown here repeatedly by Tyndall. To Rumford we are also indebted for the discovery of the transport of heat by convection. He demonstrated the existence of convection currents by suspending powdered amber in dilute caustic soda of the same specific gravity as the amber. When a cylinder containing this suspension was plunged into boiling water, the convection currents rising at the sides and moving downwards at the axis were clearly seen. This experiment was published in his seventh essay in 1797, but it was not until 1834 that Prout gave the name 'convection' to this method of heat transport.

The stoves invented by Rumford for domestic heating have often been mentioned. He observed that only one-fifth of the heat generated by the fuel is radiated into the room: the rest goes up the chimney. He showed that the most effective angle between the sides and the back is 135°, and the width of the back only one-third of the front opening, the back and sides rising perpendicularly until they joined the breast of the fireplace, while the throat of the chimney was to be only about four inches wide. The increase in warmth was found to be one-half to two-thirds as compared with the traditional open fireplace.

Lo every parlour, drawing room I see
Boasts of thy stoves and talks of nought but thee.
Yet not alone my Lady and Young Misses,
The cooks themselves could smother thee with kisses.
Yes, Mistress Cook would spoil a goose, a steak,
To twine her greasy arms around thy neck.

In Paris Rumford devoted himself to improvements of the Argand burner and to the construction of a calorimeter in which the products of combustion passed through a serpentine tube immersed in a known volume of water—indeed, a very modern device. He displayed eccentricity by wearing white clothes in winter, since these radiated less heat than dark ones. In these clothes he drove around Paris in a coach with extra broad rim wheels made to his own design. Here, however, he made himself unpopular with the French scientists, especially with Laplace, with whom he also differed in views regarding surface tension.

In 1782, Argand greatly improved oil lighting by utilizing a hollow cylindrical wick which permitted air to be drawn up on each side of the wick. As in modern paraffin lamps, the burner was situated above the oil reservoir. At that time only colza and similar high-viscosity burning oils were available, and, in consequence, the height of the flame was small owing to the low rate of capillary ascent. Rumford improved the lamp by feeding the oil from a circular reservoir maintained at the same height as the wick. In 1800 the reading and lecture rooms of the Royal Institution were illuminated with the new Rumford–Argand lamps.

For testing the most suitable shade to be made, as Rumford states, "of such substances as disperse light without destroying it", he devised the candle photometer, still in use to this day. Rumford at a later date designed a portable lamp with a flat wick, and several of these are to be found in the museums in Massachusetts.

Rumford published several papers on capillarity and demonstrated for the first time the now well-known experiment of flotation of a needle at an air–water and at an ether–water interface. He concluded that liquids such as water are bounded by a pellicle on which the needle can rest, and that air retention under the needle is not the seat of the mechanism of flotation, as was suggested at the time. We now know that the molecules in the surface layer of a liquid are a little farther distant from one another than those in the bulk phase, and if they are so separated there must be net attractive or cohesive forces operating between them; thus the concept of a pellicle was not so erroneous as Laplace supposed.

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# ORIGIN OF ACQUIRED DRUG RESISTANCE IN BACTERIA

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## Variation in Micro-organisms

It is characteristic of micro-organisms that they readily become adapted to changes in environment. This plasticity shows itself in such ways as the development of highly specific virulence or of the ability to grow in unusual media. In undergoing this adaptation, it is sometimes possible for new strains to arise differing considerably from the original strains.

The problem of the mechanism by which such induced variations are brought about has been the subject of much speculation during the past twenty years or so. Particular attention has been given to the induction of variation by changes in chemical environment, the most notable examples being the induction of specific enzymes ('enzyme adaptation') and the induction of resistance to drugs ('acquired drug resistance'). It was while working in this field of enzyme adaptation that I described and distinguished the two most likely mechanisms of induced variation[1]. One of these was at that time called simply adaptation; a better term would be direct induction. This postulated that the change was directly induced in (potentially) all the cells by an interaction between the cells and the new chemical environment. An example of this is the induction of the ability to ferment galactose in some species of yeast which are normally unable to do this[2,3].

The second mechanism by which induced variation might be brought about was originally referred to as 'training'. This postulated the occurrence in a culture of rare mutants having the character of the new strain; the effect of the new chemical environment was entirely selective, in that the mutant cells, but not the non-mutant cells, were able to grow in it. Likely examples of mutation with selection are the occurrence of lacto-fermenting strains in *Bacterium coli mutabile*[4] and the development of strains of *Staphylococcus aureus* highly resistant to streptomycin[5]; it is still not certain, however, that these are not in fact examples of direct induction[6].

It is, of course, possible that both mechanisms may occur simultaneously, so that the new chemical environment both induces a change and selects it. Apart from this possibility, however, all workers in the field of induced variation in micro-organisms have considered only these two possible mechanisms. This is especially noticeable in the problem of acquired drug resistance in bacteria. Demerec[5,7] considers that the effect of a drug in producing resistant strains is in selecting rare spontaneously arising resistant mutants. On the other hand, Hinshelwood and his co-workers have in a large number of publications taken the view that drug resistance is similar to, and is indeed a form of, enzyme adaptation which can occur in potentially all cells. The drug induces in each cell a change in enzymatic structure which enables it to carry out essential metabolic processes, for example, by producing alternative pathways to those blocked by the drug.

The assumption universally made, that there are only two possible mechanisms by which variations may be induced in bacterial cultures, has led many workers to support one theory by criticism of the other. For example, Hinshelwood frequently points out that the theory of mutation with selection would require a number of assumptions which he considers unlikely; in consequence, the theory of direct induction is preferred as being simpler, more plausible and more economical in unproved assumptions.

The fact that the debate has continued for many years is partly because the technical aspects of the work do not lend themselves to crucial experiments which can decide the issue. In some instances of enzyme adaptation, it has been possible to induce the change in cells that are virtually not dividing, which must imply direct induction. In acquired drug resistance, however, it seems to be necessary to grow organisms for many generations, often with numerous sub-cultures, in order to induce the change. Clearly, it is possible in these circumstances for either mutation with selection, or slow direct induction, to act in producing the change.

In spite of these difficulties, I suggest that there are now sufficient experimental facts to throw doubt on both of the currently accepted theories in so far as each attempts to explain completely acquired drug resistance in bacteria. A third theory is proposed which, it is claimed, is in conformity with existing knowledge, and lends itself in some measure to deductions capable of being tested experimentally. Before, however, describing this new theory of 'clonal variation with selection', it will be profitable to examine in a little more detail some of the facts known about the phenomenon of acquired drug resistance.

## Essential Features of Acquired Drug Resistance

(1) An organism, sensitive to a given concentration of drug, may acquire a resistance to this or to higher concentrations if it is grown in the presence of the drug. Occasionally, maximal resistance is attained by one sub-culture in the presence of drug; more often, increasing resistance is achieved by sub-culturing in increasing concentrations of drug. By limiting the concentration of the drug to a value below the maximal, it is possible to attain resistance to intermediate concentrations.

(2) The apparent resistance of a culture varies with the size of the inoculum used. That is to say, the concentration of drug in which the organisms will grow will be larger if a larger number of organisms is inoculated into it.

(3) The training of the organisms to grow in otherwise lethal concentrations of drug involves not only the mere ability to do so but also an increase in the ease with which they grow. This is shown by a gradual reduction in the mean generation time and in the lag, and an increase in the size of colonies on solid media, as the process of training is continued.

(4) When a resistant culture is grown in the absence of drug, reversion to non-resistance may occur. This may be a complete reversion to a culture as sensitive as the original, or it may be a partial reversion to a lower degree of resistance. In some instances, no reversion occurs, and the degree of acquired resistance is retained. The last possibility is more likely to occur if the trained cells are repeatedly sub-cultured in the presence of the drug very many times.

## Interpretation of Essential Features according to Current Theories

Let us now examine the current explanations of these facts according to the two theories of direct induction and mutation with selection.

(1) *Graded resistance.* The fact that a culture may be made resistant to a chosen concentration of drug is in conformity with the theory of direct induction, since it is known that the degree of enzyme adaptation by direct induction is dependent on the concentration of the inducer[8]. The theory of mutation with selection must here postulate a number of step-wise mutations. Since the degrees of acquired resistance may in some instances vary by very small steps over a wide range, one must postulate many mutational steps. If one adds that such step-wise resistance may be acquired by one organism for a number of known drugs as well as no doubt for a much larger number of drugs which have not yet been examined experimentally, it can be appreciated why Hinshelwood casts doubt on the theory of mutation with selection.

(2) *Size of inoculum.* Direct induction involves the concept of opposing factors simultaneously affecting the bacteria over a period of time. On one hand, the drug stimulates the cells to produce the enzymatic adjustment necessary to by-pass the drug-blocked systems. On the other hand, the drug causes the death of continuously increasing numbers of cells. Thus the larger the number of cells inoculated into the drug-containing medium, the greater will be the chance that some will develop the necessary enzymatic equipment to grow in its presence. The theory of mutation would merely suggest that the chances of a drug-resistant mutant being present is obviously larger in a larger inoculum. It is not easy to see, however, why there should be a continuous apparent increase in the degree of resistance with increasing inocula.

(3) *Rate of growth of trained cultures.* We have seen that, in the presence of drug, cultures at first grow slowly. The rate gradually increases if they are sub-cultured into the same concentration of drug; but it often occurs that, even after prolonged training, they still grow slower in the presence of drug than in its absence. Direct induction would no doubt explain this on the basis of the increased strain put upon the organisms in developing the alternative enzymatic systems. The mutation theory simply states that the resistant mutants are slower-growing variants.

(4) *Reversion.* According to the theory of direct induction, a trained culture will or will not revert to the original sensitive strain depending on whether the induction has or has not been sufficiently 'impressed' upon the cells. After a moderate degree of training, for example, twenty passages in the highest concentration of proflavine, Hinshelwood found a rapid though incomplete reversion when cultures of *Bact. lactis aerogenes* were grown in the absence of drug[9]. However, after eighty passages in the presence of proflavine, resistance persisted during many sub-cultures in the absence of proflavine. Hinshelwood postulates that the earlier stages of direct induction involve some mechanical strain in the organism. When the strain is released by growing the cells in the absence of drug, the new enzyme systems partly regress to reach a stable level associated with the mild resistance of an equilibrium state. The later stages in prolonged induction, however, gradually produce more complex changes which stabilize the new enzyme systems, and so permit the retention of full resistance, even in the absence of drug.

The theory of mutation with selection explains reversion as being due to back mutation or the incomplete elimination of non-mutant cells, together with the selection of non-resistant cells when they are assumed to grow faster than the resistant strains. That prolonged training may result in cultures which do not easily revert is to be explained by a parallel selection of faster growing mutants with selection of the resistant mutants[9,10].

## Theory of Clonal Variation with Selection

The theory of clonal variation with selection is based on one assumption. This is that a bacterial cell, of whatever resistance, may give on division two cells with different and unequal resistance. For

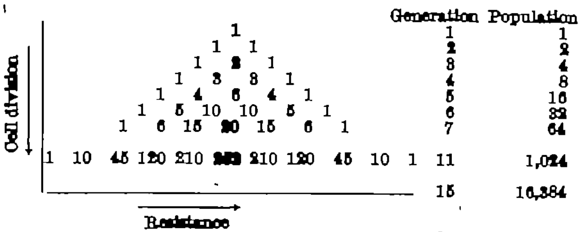

Fig. 1. Distribution of resistance in the progeny of a single cell in absence of drug

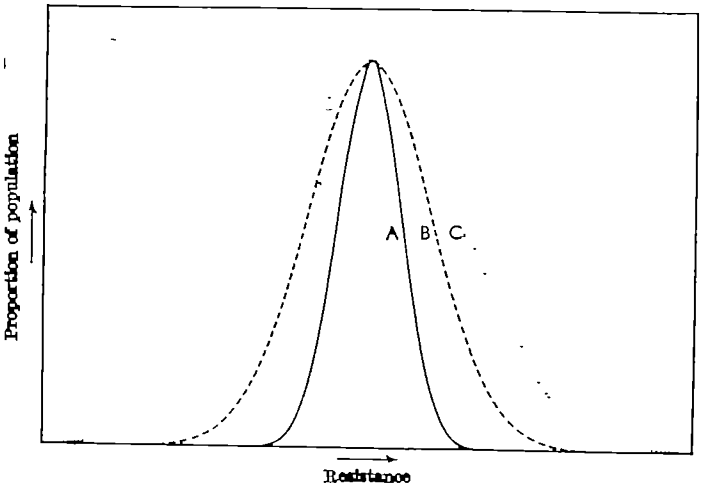

Fig. 2. Distribution of resistance in populations of bacteria grown in *absence* of drug. *A*, culture from single cell; *B*, after a few sub-cultures; *C*, after several sub-cultures—'permanent' form of distribution curve

this to occur, it is only necessary to imagine that at division the systems responsible for drug resistance are not necessarily distributed in equal amounts between the daughter cells. Within limits which will be defined later, the result is a clone of cells the average resistance of which is that of the parent cell, but with a distribution of resistance of the members of the clone around that of the parent cell.

## Model of Acquired Drug Resistance by Clonal Variation and Selection

It is reasonable to suppose that the probability of an unequal distribution of resistance in daughter cells on division is inversely proportional to the size of the inequality. That is, the dividing cell is most likely to give two equally resistant cells, less likely to give cells of slightly different resistance, and least likely to give cells of very different resistance. The resultant clone from a single cell would thus have a resistance in its members which would be of a Gaussian or similar distribution. For our simple model, however, we shall assume that division always occurs with balanced asymmetry, one daughter cell having a higher resistance by a fixed small amount, the other having a lower resistance by the same amount. Repetition of this process produces a family of cells with binomial distribution of resistance (Fig. 1).

With given conditions of composition and volume of medium and of time of incubation, the population from a single cell will be composed of cells of varying resistance, the proportions of which are distributed according to the curve *A* in Fig. 2. A small volume taken from this for inoculating into a fresh amount of medium would be likely to contain cells of the 'peak' of this curve, and not contain the rarer cells of high or low resistance. Thus an inoculum the volume of which is one-thousandth of the whole medium is not likely to contain cells the frequency of which is much less than one-thousandth of the total population. Nevertheless, the inoculum will contain some cells of higher and some of lower resistance than that of the original single cell. The population arising from this in the second volume of medium will therefore have a wider spread of resistance, something like curve *B* of Fig. 2.

During further sub-cultures, the spread will increase until it reaches a degree which we may represent by curve *C*. If we assume that we have used standard conditions of inoculum, volume of medium, time of incubation and the like in our sub-culturing, we now find that no further spread of distribution in resistance occurs in later cultures. The spread among the cells of our inoculum increases during growth to give curve *C*, but no further; it is cut short when growth ceases in the limited medium, or when the culture is discarded after an inoculum is taken. Thus the standard inoculum for subsequent cultures will contain cells of the same degree of spread. Curve *C* thus represents the sort of distribution that will exist in a culture normally being used in the laboratory.

When an inoculum is made into medium containing drug, of a concentration in which only the more resistant cells from the inoculum can grow, a situation will arise of which the earliest stages are represented in Fig. 3. In this, we see what occurs in a cell with a resistance just greater than that represented by the concentration of drug present. The drug acts as a 'bar', killing or at least preventing the growth of those cells which, because of 'clonal variation', have a resistance below that represented by the concentration of drug. As a result, only those cells to the right of the bar are able to grow, and a continuation of the process indicated in Fig. 3 can be shown to give a population of cells with a distribution of resistance shifted to the right. Eventually, after very many generations involving many sub-cultures, the shifted distribution curve will be similar in form to that of the original culture (Fig. 4).

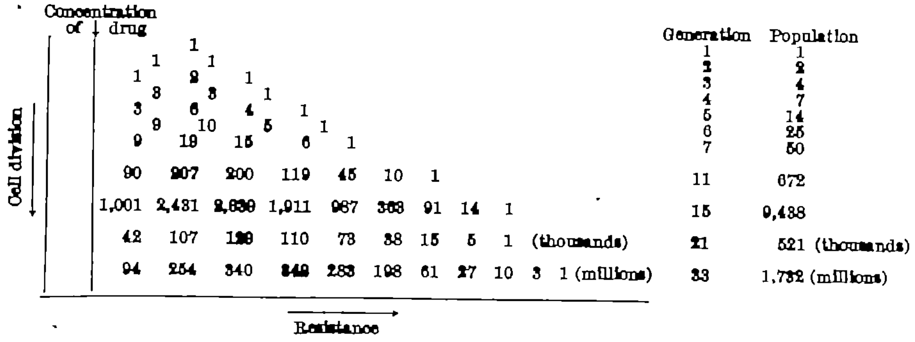

Fig. 3. Distribution of resistance in the progeny of a single cell in *presence* of drug with concentration just below resistance of the cell. Comparison with Fig. 1 shows three effects produced by the drug: (1) for a given number of generations the population is less; (2) for the same population, more generations are required, thus producing a greater spread to the right, (3) there is a very gradual shift of the peak of distribution to the right, that is, towards higher resistance

The magnitude of these effects will depend on how close the resistance of the parent cell is to the 'bar' of drug concentration

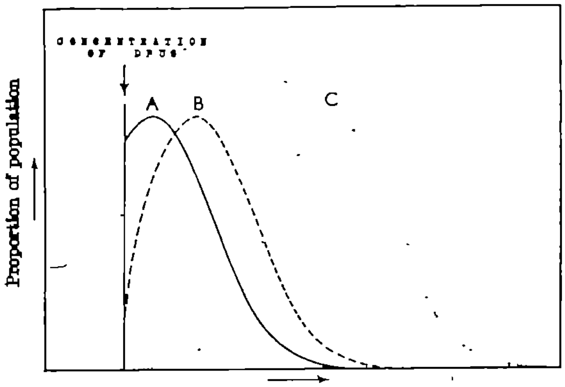

Fig. 4. Distribution of resistance for populations of bacteria grown in presence of *moderate* concentrations of drug. *A*, after a short period of growth; *B*, after a few sub-cultures; *C*, after many sub-cultures

Even the slight shift to the right in the first culture, however, will mean that an inoculum from it will contain cells of higher resistance than an inoculum from the original culture. These cells from the culture grown in drug will therefore grow in higher concentrations of drug. The culture has thus been 'trained'.

Growth in these higher concentrations of drug may perhaps give the same sort of effect as the first concentration used, and a further shift to the right may occur. With some organisms, trained to some drugs, it may be possible to repeat the process a number of times, and produce progressive 'training'.

Sooner or later a limit will be reached, beyond which 'training' cannot be induced. This represents the limit of possible clonal variation, the maximal degree of resistance possible for cells of the given strain in the given drug.

Here a new situation arises. Growth in the highest possible concentrations of drug will be limited on two sides. As well as the 'bar' to the left of the resistance curve, representing the concentration of drug, there will be a 'bar' to the right, representing the maximal possible resistance. Since cells which have maximal resistance cannot on division give cells of higher resistance, we may assume that they give either two cells of maximal resistance or one with maximal resistance and one with slightly lower resistance. In either event, there will be a tendency for cultures repeatedly grown in maximal concentrations of drug to give an increasing proportion of cells with maximal resistance, and a decreasing proportion of other cells. It can be shown that the distribution curves of cells grown in the highest concentrations of drug will have the forms shown in Fig. 5.

## Basis of the New Theory

The theory rests on the assumption that a bacterial cell might divide asymmetrically in respect of drug resistance, giving one daughter cell with less and one with more resistance than the parent cell. This is not a difficult assumption to make. It is indeed more difficult to imagine that the material upon which resistance depends, probably a system of enzymes, is always and inevitably distributed in exactly equal amounts between the two cells arising from division.

It is known that the cells of a pure culture of bacteria do not show identical resistance to a drug. All workers in this field are familiar with survivor curves in which are represented the number of cells surviving with increasing concentrations of drug. Such a curve could readily be reconstructed in the form of a distribution curve, in which would be plotted the number of cells killed rather than the number of cells surviving at each concentration of drug. We have moreover shown, in confirmation of Hughes[11], that single cells of an original culture may give populations having slightly but measurably different survivor curves. This supports the view that these single cells themselves had different degrees of resistance.

## Interpretation of Essential Features according to the New Theory

Let us now see how this hypothesis would explain the features of acquired drug resistance which were discussed earlier.

(1) *Graded resistance.* That resistance can be induced in a culture to a predetermined level, by growing the organisms in a predetermined concentration of drug, follows directly from the conception of a continuously graded resistance arising by unequal distribution at cell division.

(2) *Size of inoculum.* The dependence of the concentration of drug in which a culture will grow on the size of inoculum also follows directly from the theory, since the larger the inoculum the greater the 'spread' of resistance within the cells.

(3) *Rate of growth.* When an inoculum from an untrained culture is placed in medium containing drug, there exist two factors which result in a diminished rate of growth. The first is that only the more resistant cells in the inoculum will be able to grow. If only one in a hundred cells in the inoculum can survive the concentration of drug, it will in effect increase the number of generations to reach a given number of cells by six or seven. The second factor decreasing the growth-rate of the culture is the division of those cells of the inoculum the resistance of which is only just above that for the existing concentration of drug. When these divide, they would each give, according to the model, one cell of higher resistance and one of lower resistance. The latter or one of its early progeny would not be able to divide further, so that the result of the first few divisions of cells with 'marginal' resistance would be to give a low rate of increase of cells (see Fig. 3). If the inoculum contains a high proportion of such cells,

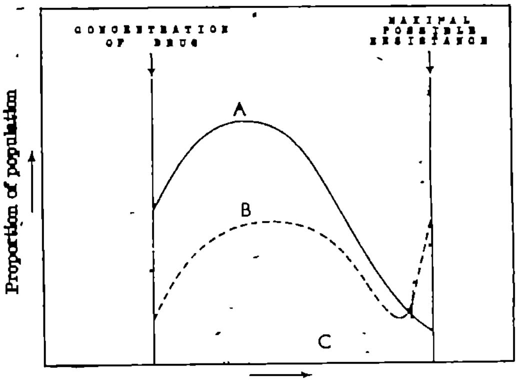

Fig. 5. Distribution of resistance for populations in bacteria grown in the presence of *high* concentrations of drug: *A*, after a short period of growth; *B*, after a few sub-cultures; *C*, after many sub-cultures

the increase in the number of cells in the culture would be smaller than in a normal culture and the *apparent* mean generation time would be increased. This point is discussed in more detail below.

As a result of these two factors, an untrained culture inoculated into medium containing drug would show a longer lag and mean generation time. If this culture is repeatedly inoculated into the same concentration of drug, there is a gradual building up of a distribution curve similar to that of the original culture, though displaced to the right. An inoculum from this will then have fewer cells which are sensitive to the concentration of drug being used, and fewer of 'marginal' resistance. Growth will therefore not be retarded so much by these two factors and 'training' will have occurred in the sense of a decrease in lag and mean generation time towards the normal.

When 'training' is complete and the organism is grown in the highest possible concentration of drug, we have the situation we described as involving the existence of two 'bars'. The distribution curve will be a narrow one, bounded on the left by the concentration of drug and on the right by the maximal possible resistance. It was suggested earlier that the latter bar might exert its effect by increasing the proportion of cells with maximal resistance. The existence of the 'bar' of drug concentration so close to that of maximal resistance must mean that cells with less than maximal resistance can very easily give rise to cells sensitive to the concentration of drug.

One would therefore expect that, for the first few sub-cultures at least, there would always be a fairly large proportion of cells which cross the 'bar' of drug concentration and do not divide further. This would mean both a prolonged lag period and an increase in apparent mean generation time. As the proportion of cells with maximal resistance increases in the cultures and in the inoculum, the lag becomes shorter and eventually normal. However, so long as a fair number of cells arise with resistance low enough to cross the 'bar', the apparent mean generation time continues to be abnormally high. Whether the mean generation time ever becomes normal will depend on the relationship between the spread of resistance at each cell division and the nearness of the existing drug concentration to that representing maximal resistance. For example, the mean generation time is more likely to continue to be prolonged if the cells of maximal resistance give on division cells of unequal rather than of equal resistance.

(4) *Reversion*. When training has occurred for a relatively short time, the distribution of resistance may not yet have reached its final form. It will be such that the proportion of cells with resistance less than the mode will be higher than the proportion with resistance greater than the mode. This proportion will be represented in an inoculum, so that a culture from it in the absence of drug will give a distribution curve which spreads farther to the left than to the right, and with a mode to the left of that of the distribution curve of the cells from which the inoculum has been taken. Depending on the organism, the drug and other factors, this shift to the left might be sufficient to make the culture measurably lower in resistance than that grown in the presence of drug. The culture would then have shown reversion.

We have seen that it may require many sub-cultures in the presence of drug for the change in the distribution curve to be completed. When this stage has been reached, there is only a small proportion of cells with a resistance to just the concentration of drug used. This is particularly true when high concentrations of drug are used, which we have suggested lead to a gradual accumulation of cells of the highest possible resistance.

Thus, the longer the cells are trained, the more permanent is the resistance acquired. This is in conformity with experimental findings.

## Some Consequences of the New Theory

A series of experiments has been planned to test some of the possible consequences of the theory of clonal variation with selection. So far as these experiments have been carried out, we have obtained results with *Bact. coli* and proflavine which conform to theoretical predictions[18].

(1) *Differences between recently isolated and older cultures from a single cell.* The theory predicts that the 'spread' of the distribution curve of resistance in a culture derived from a single cell should reach its maximum only after several sub-cultures. The first culture from the single cell, that is, should have a narrow range of resistance and should consequently not be so easily trained. Our experiments have shown that the curve of a recently isolated culture is indeed narrow and widens during a few sub-cultures, and that it is usually not possible to train the culture, except perhaps to a slight extent, until it has been sub-cultured a few times in the absence of drug. The fact that a newly isolated culture may be incapable of being trained and thus differ qualitatively from an older culture has, so far as I know, not previously been recorded. It may obviously have led to erroneous conclusions being drawn by investigators who have examined only recently isolated cultures for their ability to acquire drug resistance.

(2) *Rate of growth in the presence of drug.* One of the reasons offered by the theory for a decreased rate of growth in the presence of drug is that organisms of resistance close to the concentration of the drug used may give rise to cells of lower resistance which will then not divide further. From the distribution curve, one can determine a concentration of drug at which a high proportion of cells would have this 'marginal' resistance. If serial dilutions of the culture are made into this concentration of drug, one should find that at first only the lower dilutions, which are likely to contain some of the rarer cells of higher resistance, will show growth. The higher dilutions are likely to contain only cells of marginal resistance, and so are likely to give a considerably reduced rate of growth. The result would be that the apparent count is at first small, say after the usual 18–24 hours; later, the apparent count would be very much greater. This difference would not occur when either somewhat lower or somewhat higher concentrations of drug are used, since the proportion of cells of this 'marginal' resistance is in these instances relatively small.

Our experimental results are in conformity with these predictions.

## Discussion

The model of the method by which drug resistance may be acquired by micro-organisms has deliberately been kept as simple as possible. Nevertheless, it is suggested that the elaboration of this model in more realistic terms does not undermine its essential claim to provide a satisfactory explanation of the phenomenon.

We have seen that the assumption in the model of a fixed asymmetrical division of a cell in respect to its resistance to a drug is in fact less likely than a variable asymmetrical division, with a decreasing probability of daughter cells arising with increasingly different resistance from that of the parent cell. From a statistical point of view, however, the simpler assumption, which lends itself more easily to the construction of the model, leads to much the same conclusions.

It has also been implied that the resistance of a cell, once it has arisen from division of a parent cell, is constant. It has, however, been suggested that resistance varies throughout the life-cycle of a cell[12]. This again would not alter in any significant way the deductions from the theory. It would, however, mean that, with a given concentration of drug, cells of 'marginal' resistance would be more likely to be affected by the drug as their resistance varied during their growth. This would have two effects. First, there would be a rather more rapid shift to the right in the distribution curves of cells grown in the presence of drug than is suggested by Figs. 3 and 4. Second, those concentrations of drug which coincide with a high proportion of cells of 'marginal' resistance would affect more cells than we have suggested, and cause an even greater effect on lag and on mean generation time.

It may be argued that the theory of clonal variation has no advantages over that of mutation, and indeed that the variations in resistance which we have described are due to mutational changes in the genetic constitution of the organism. It is true that one may take the view that the difference between these two theories is only one of terminology. But it is suggested that the insistence on the use of the term mutation to describe the continuous variations of resistance which exist in a culture distorts the meaning of this word. Mutation is normally used for describing a discrete discontinuous quantum-like change occurring in a small—usually a very small—proportion of organisms. Not only are the variations we described as clonal so small as to be capable of being regarded as continuous, but also they occur in a very large proportion of the cells. Indeed, the type of distribution of resistance occurring in a culture is such that there are almost as many cells of slightly higher or slightly lower resistance than the mode, as there are cells with modal resistance; there are altogether many more cells of resistance different from the modal than cells with modal resistance. As we have said earlier, it is most improbable that there could occur the vast number of small mutations which would account for the many degrees of resistance which cells may develop for many drugs.

There is, of course, no doubt that many of the properties of micro-organisms are genetically controlled, and that these may include the capacity to undergo variation such as enzyme adaptation and perhaps the capacity to become resistant to a drug. Nevertheless, the essential feature of reproduction in micro-organisms is that the reproductive material and the somatic material are identical. The whole of the dividing cell is represented in the two daughter cells. It is therefore quite conceivable—we have earlier said it is even quite probable—that division may not be completely symmetrical and the distribution of material from the parent cell to the daughter cells not exactly equal. In so far as this material includes the enzymatic systems or other mechanisms which constitute drug resistance, the daughter cells may therefore have a somewhat different resistance from that of the parent cell.

Finally, it should be reiterated that the hypothesis of clonal variation with selection does not imply that mutation or direct induction do not play a part in producing variations in cultures grown in specific chemical or other environments. It is suggested only that this mechanism might more readily explain some of the examples of acquired drug resistance. It is tempting to suppose that the easily induced changes in bacteria and especially viruses grown in specific hosts or specific tissues are also brought about by clonal variation with selection; but it remains to be seen whether the same mechanisms underlie these and other examples of induced variation.

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I am grateful to Dr. S. E. Jacobs and Dr. J. Mandelstam for much helpful discussion during the formulation of the views here set out, and to Miss Joan Fleming for technical assistance in the experiments. I am especially indebted to Mr. L. Bihaly, who has given me invaluable help in the statistical aspects of this work and without whose constant advice and criticism this paper could not have been written.

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# NEW FELLOWS OF THE ROYAL SOCIETY

AT the meeting of the Royal Society on March 19, the following were elected to fellowship:

**Dr. J. S. Anderson**, deputy chief scientific officer, Atomic Energy Research Establishment, Harwell, distinguished for his contributions to inorganic chemistry, particularly in connexion with the chemistry of the metal carbonyls, complex salts, and non-stoichiometric compounds.

**Dr. Kenneth Bailey**, assistant director of research in the Department of Biochemistry and Fellow of Trinity College, Cambridge, distinguished for his biochemical researches on the proteins of muscle.

**Prof. H. Barcroft**, professor of physiology, Sherrington School of Physiology, St. Thomas's Hospital, London, S.E.1, distinguished for investigations respecting the blood supply to human muscles.

**Dr. J. Barker**, reader in plant physiology, University of Cambridge, distinguished for investigations on the carbohydrate metabolism of plant storage tissues.

**Dr. J. C. Burkill**, university lecturer in mathematics, University of Cambridge, distinguished for his researches in analysis, especially in the theory of integration, also for his contributions to the theory of trigonometrical series.

Dr. J. W. Cornforth, research chemist, National Institute for Medical Research, distinguished for his fundamental contributions to the chemistry of penicillin and its degradation products and to the chemistry of the oxazole group, and for the total synthesis of the androgenic hormones.

Dr. S. C. Curran, senior lecturer, Department of Natural Philosophy, University of Glasgow, distinguished for his contributions to electronic counting techniques, and for his researches upon the emission of β- and γ-rays by atomic nuclei.

C. S. Elton, director of the Bureau of Animal Population, Oxford, distinguished for his pioneer work in the field of animal ecology as founder of the Bureau of Animal Population and of the *Journal of Animal Ecology*.

Dr. O. H. Frankel, chief of the Division of Plant Industry, Commonwealth Scientific and Industrial Research Organization, Australia, distinguished for his combined genetical and cytological studies on economic plants.

Dr. E. F. Gale, reader in chemical microbiology, University of Cambridge, distinguished especially for his work on the amino-acid metabolism of bacteria and the effect thereon of penicillin and other chemotherapeutic agents.

Dr. A. G. Gaydon, Warren Research Fellow of the Royal Society, Imperial College of Science and Technology, London, distinguished for his researches on the spectra of flames, which have gone far in elucidating the mechanism of flame reactions under the most varied conditions.

Dr. A. A. Hall, director of the Royal Aircraft Establishment, Farnborough, distinguished for his contributions to the theory and design of aircraft and their equipment.

Prof. G. W. Harris, Fitzmary professor of physiology, Institute of Psychiatry, University of London, distinguished for his contributions to the physiology of the hypothalamus and pituitary body.

Sir Claude Inglis, director of hydraulics research, Department of Scientific and Industrial Research, distinguished for his pioneer work in studying hydraulics by the use of scale models, and for the application of these techniques to hydraulic problems in India.

Prof. Willis Jackson, professor of electrical engineering, Imperial College of Science and Technology, London, distinguished for his studies of the electrical behaviour of dielectrics and of the performance of transmission lines and wave-guides.

Prof. M. J. Lighthill, Beyer professor of applied mathematics, University of Manchester, distinguished for his researches in fluid dynamics, especially in non-linear problems of compressible flow, in supersonic boundary layer theory and in shock wave theory.

Dr. G. H. Mitchell, a principal scientific officer, Geological Survey of Great Britain, distinguished for his researches in palæozoic stratigraphy.

Prof. L. S. Penrose, Galton professor of eugenics, University of London, distinguished especially for his study of the factors responsible for mental deficiency and for inheritance studies in man.

A. R. Powell, research manager, Johnson Matthey and Co., Ltd., distinguished for his contribution to analytical chemistry and the chemistry and metallurgy of the rarer metals, which has led to important developments in methods for the extraction of platinum ores and the production of very pure metals.

Dr. H. M. Powell, reader in chemical crystallography, University of Oxford, distinguished for his elucidation of problems of chemical constitution by X-ray methods, especially of organo-metallic and clathrate compounds.

Lord Rothschild, assistant director of research in the Department of Zoology, University of Cambridge, distinguished for his investigations into the process of fertilization and the physiology of reproduction.

Dr. D. Shoenberg, reader in physics, University of Cambridge, distinguished for his researches in the field of low temperatures, especially upon superconductivity and the magnetic properties of metals.

Prof. T. Wallace, professor of horticultural chemistry, University of Bristol, and director of the Horticultural Research Station, Long Ashton, distinguished for his studies of mineral nutrition of horticultural crops especially in respect to diagnosis of deficiencies.

Prof. D. Whitteridge, professor of physiology, University of Edinburgh, distinguished especially for his studies of the nerves of thoracic viscera and of the external muscles of the eye.

Dr. R. van der R. Woolley, director of the Commonwealth Observatory, Australia, distinguished for his work on the formation of absorption lines and on convective processes in the solar atmosphere.

# NEWS and VIEWS

## Elihu Thomson (1853–1937)

Born in Manchester a century ago, on March 29, 1853, the son of a skilled mechanic, Elihu Thomson, pioneer in the practical applications of electricity, emigrated with his family to the United States at the age of five. After finishing his education at the Central High School, Philadelphia, he was appointed professor of mechanics and chemistry at that institution in 1876. Four years later he became chief electrician to the American Electric Company, and with Edward J. Houston founded the Thomson–Houston Company at Lynn, Massachusetts. By its merger with the Edison General Electric Company in 1892, the General Electric Company of America was formed—the largest manufacturing company of electric equipment in the world, which was to operate more than six hundred patents connected with Thomson's inventions. As director of the firm's research laboratories, Thomson discovered that the resistance of the electric arc is inversely proportional to the current passing through it, constructed the first arc-light dynamo with an automatic regulator, and was the first to use a magnetic field to move an electric arc—the principle on which magnetic blow-out switches operate. He also invented the incandescent method of electric welding, the electric watt-hour meter, and a system of colour photography. His name is given to the repulsion of a metal ring from the poles of an alternating-field electromagnet. Radiology owes to his ingenuity the first stereoscopic X-ray pictures. Thomson received medals from most of the learned societies of the world: the Rumford

Medal of the American Academy of Arts and Sciences in 1902, the Hughes Medal of the Royal Society in 1916, the Kelvin Medal of British engineering institutions in 1924, the Franklin Medal of the Franklin Institute in 1925, and the Faraday Medal of the Institution of Electrical Engineers in 1927. He died on March 13, 1937.

### Sir Isaac Bayley Balfour (1853–1922)

One of the greatest botanists of his day, Isaac Bayley Balfour was born in Edinburgh a century ago, on March 31, 1853, the second son of John Hutton Balfour. Educated at the Edinburgh Academy and University, he graduated B.Sc. in 1873, D.Sc. in 1875, M.B. in 1877, and M.D. in 1883. His medical training was interrupted by his appointment in 1874 as botanist to the Royal Society's expedition to Rodriguez Island to observe the transit of Venus, and by a visit five years later to the oceanic island of Socotra to collect plants. After studying with Julius von Sachs at Würzburg and with Anton de Bary at Strassburg, he was appointed professor of botany in the University of Glasgow in 1879, and in 1884 Sherardian professor of botany at Oxford. In 1888 he was called to Edinburgh to fill the three posts which his father, 'Woody Fibre', had held—professor of botany in the University, keeper of the Royal Botanic Garden, and Queen's botanist in Scotland—and by a remarkable coincidence he occupied these positions for the same length of time as his father had done, namely, thirty-four years. In each of the universities which he served he was destined to find a department sadly in need of reorganization. At Glasgow he introduced the practical laboratory teaching initiated by his father at Edinburgh a generation earlier. He made Edinburgh an important horticultural centre. No man knew Scotland botanically as well as he did. His most substantial published work, "Botany of Socotra" (1888), includes descriptions of some three hundred new species found in that island. While at Oxford, he persuaded the Clarendon Press to publish the ***Annals of Botany*** and also a series of translations of foreign botanical works, under his editorship. Recipient of many honours, he was elected Fellow of the Royal Society in 1884, received the Linnean Medal in 1919, and was created K.B.E. in 1920. He died at Haslemere on November 30, 1922.

### Adult Education at Leeds: Dr. S. G. Raybould

A new chair, that of adult education, has been instituted in the University of Leeds, and Dr. S. G. Raybould, at present head of the Department of Adult Education and Extra-Mural Studies and director of extra-mural studies in the University, has been appointed to fill it, with effect from October 1 next. Dr. Raybould graduated from the University of London in 1933, taking his Ph.D. in 1951, and until the end of 1935 was engaged in teaching in schools and part-time work in adult education. He then obtained an appointment in the University of Leeds as staff tutor, and in 1946 was promoted to be director of extra-mural studies, becoming head of the Adult Education Department five years later. He is at present a member of the Joint Advisory Council of the B.B.C. and of the Central Advisory Council for Education (England), as well as being vice-president of the Workers' Educational Association and deputy chairman of the Central Committee for Adult Education in H.M. Forces. Dr. Raybould's publications include a book on "The English Universities and Adult Education", a Unesco publication, and a number of articles on education.

### British Steel Castings Research Association

A new research association has been recently formed in place of the Research and Development Division of the British Steel Founders' Association, and it will be known as the British Steel Castings Research Association. Mr. J. F. B. Jackson, who, as director of research to the British Steel Founders' Association, has had the responsibility for organizing and building up its Research and Development Division since its formation in 1949, has been appointed director of the new Association. The chairman of council is Mr. F. N. Lloyd, and Mr. R. Barber is the secretary. Being derived from an organization that is already three years old and has an active programme of research in hand, the new Association starts off on a good footing. Besides the investigations being carried out at its own research station, work is being done in conjunction with the many well-equipped research laboratories and plant of industrial concerns, and it is also being sponsored in the universities. Thus during the past three years research has ranged over a wide field of steel-casting science and foundry technology, and has included an important series of projects relating to industrial health and to foundry dust suppression; in this latter connexion, work at the Dust Research Station in Sheffield, which has been in operation since mid-1951, is of particular importance. At the University of Durham and at the Imperial College of Science and Technology, London, essential basic results relating to the mechanism of the freezing of steel in refractory moulds are being obtained, and at the University of Cambridge work on the metal penetration problem and towards the improvement of surface finish in steel castings has continued since 1950. Thus, in general, the formation of this new Research Association represents an important development for a country which is renowned for its steel-making, and we may expect results which will be of vital use to the engineering industry as a whole.

### Transliteration of Cyrillic Script

The policy of ***laissez faire*** in the transliteration of Cyrillic script leads to the same name being spelt *Yachevskii* and *Jačevskij* and *Yachevsky*. This sort of thing obviously causes confusion in bibliographies, and the Royal Society has done a good service by publishing a pamphlet on "The Transliteration of Russian, Serbian and Bulgarian for Bibliographical Purposes" (from the Royal Society, Burlington House, Piccadilly, London, W.1; pp. 16; 1*s*.). The pamphlet contains tables with the recommended transliteration of Cyrillic to English and English to Cyrillic. The recommendations are agreed by the British Academy and the Royal Society and they are carefully annotated. The only disappointment (and it is an inevitable one) is that the alphabet used in English-speaking countries is not flexible enough to imitate all the sounds of the Cyrillic alphabets; and so we have to fall back on ė, ĕ, ı, ĭ, and so on. One hopes that other countries which use the same alphabet as in English will adopt the recommendations.

### Harwell Isotope School

Owing to the continually growing use of radioactive isotopes throughout the world—British sales abroad are now at the rate of four thousand consignments a year—the Isotope School at Harwell has had to introduce an additional course this year. The School was started at the Atomic Energy Research Establishment two years ago to teach the techniques of using and handling radioactive materials to scientists, medical men and industrial research workers. There has been such a heavy demand for places that an extra course will be held during July 6–31. Applications to be considered for this course should be sent to the Isotope School, A.E.R.E., Harwell, Berkshire, not later than June 8. Lectures and instruction at this School are given by members of the Atomic Energy Research Establishment staff. The school building, which is equipped with the latest apparatus, is just outside the security fence at Harwell. Students pay a fee of £40 for the course, and accommodation may be arranged for them, at an additional charge of £7 7*s.* a week, in a senior staff hostel near Faringdon.

## Decennial Supplement for 1931 for the Census of England and Wales

The Registrar General has recently published Part 3 of the "Decennial Supplement for 1931" (pp. 574. London: H.M.S.O., 1952; 70*s.* net). The tabulations for this volume were completed before the Second World War, but publication had to be postponed. The volume contains the aggregation of vital statistics (estimates of population, statistics of marriages, and births and deaths) for England and Wales during the period 1921–30. Most of the figures have already been published in the *Statistical Review*; but there are some tabulations of the less common causes of death for which annual figures are not sufficiently stable. For economy reasons no further volumes will be issued in this series.

## The Night Sky in April

New moon occurs on April 13d. 20h. 09m., U.T., and full moon on April 29d. 04h. 20m. The following conjunctions with the moon take place: April 1d. 01h., Saturn 8° N.; April 12d. 02h., Mercury 6° S.; April 15d. 16h., Mars 5° S.; April 16d. 02h., Jupiter 6° S.; April 28d. 04h., Saturn 8° N. In addition to these conjunctions with the moon, Mars is in conjunction with Jupiter on April 27d. 16h., Mars 1·1° N., and Mercury is in conjunction with Venus on April 27d. 21h., Mercury 7·2° S. Mercury is too close to the sun during April for favourable observation. On April 1 Venus sets at 20h. 40m. and is conspicuous in the western sky; it becomes a morning star after inferior conjunction on April 13, but is too close to the sun to be easily observed until near the end of the month, when it rises an hour before sunrise. Throughout April Mars sets at about 21h. and is visible for some time after sunset; towards the middle of the month it lies a little south of δ Arietis, and at the end of the month is about 4° south of the Pleiades. Jupiter sets at 22h. 10m., 21h. 35m. and 20h. 55m. on April 1, 15 and 30, respectively; it lies fairly close to Mars during the month and, as is mentioned above, there is a conjunction between the planets on April 27. Saturn rises at 19h. 35m., 18h. 30m. and 17h. 25m. at the beginning, middle and end of the month, respectively, and can be seen until the morning hours; the planet is in opposition on April 14, and throughout the month lies a little north of Spica. Occultations of stars brighter than magnitude 6 are as follows, observations being made at Greenwich: April 24d. 20h. 13·6m., $p^4$ Leon. (*D*); April 26d. 21h. 18·2m., *q* Virg. (*D*); April 30d. 23h. 58·0m., $\pi$ Scor. (*D*); *D* refers to disappearance. The Lyrids meteor shower will attain a maximum about April 21.

## Announcements

The Council of the Linnean Society of London has awarded the Linnean Medal for 1953 to Prof. P. A. Buxton, director of the Department of Entomology, London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1.

The title of reader in plant biochemistry in the University of Birmingham has been conferred on Dr. F. W. Norris, lecturer in the Department of Applied Biochemistry.

The following appointments have been made in the University of Leeds: Dr. (Mrs.) Edith Robinson, lecturer in the Department of Botany; Dr. G. Dixon-Lewis, research chemist in the Department of Coal Gas and Fuel Industries. Dr. R. Brown, reader in plant physiology in the Department of Botany, has resigned his post.

Mr. G. R. H. Nugent, Parliamentary Secretary to the Ministry of Agriculture and Fisheries, will inaugurate open days at the Electrical Research Association's Field Station at Shinfield on May 4. The Station will be open to members of the Association and other invited guests during May 6–8. Opportunity will be given of seeing work sponsored by the Association at the Poultry Research Department of the University of Reading and other adjoining stations.

The regional weather services of the Western German Republic have been grouped into a central organization, to be known as the "Deutscher Wetterdienst", with Dr. Rudolf Benkendorff as director. The address of the headquarters of the organization is Bockenheimer Landstrasse 55, Frankfurt am Main.

The Cecil Peace Prize of the Association of Universities of the British Commonwealth has been awarded for 1952 to K. H. Dawson, of the London School of Economics (at present at the Graduate School, Princeton University). The subject for the competition for 1953 is "Has the United Nations Organization been successful in carrying out the objects for which it was formed as defined in the Preamble and Chapter 1 of the Charter? Do you recommend any, and if so, what amendments in the terms of the Charter?" Essays must be sent before November 1 to the Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1, from whom further details can be obtained.

The Association of Agriculture, the Institute of Rural Life at Home and Overseas, and Seale-Hayne Agricultural College are organizing a course on "The Countryside—a Medium for Teaching", to be held at Seale-Hayne Agricultural College, Newton Abbot, Devon, during April 8–13. The course, which is designed to impart to teachers and other interested persons a better knowledge and enjoyment of the countryside, is residential and costs £5 10*s.* inclusive. Application forms and further information can be obtained from the General Secretary, Association of Agriculture, 238–240 Abbey House, 2 Victoria Street, London, S.W.1.

# THE DEPARTMENT OF PHYSIOLOGY, UNIVERSITY COLLEGE OF THE WEST INDIES

By Prof. I. F. S. MACKAY, Dr. S. J. PATRICK and Dr. P. C. FENG

THE University College of the West Indies was founded as the result of a Commission on Higher Education in the Colonies. The West Indies Committee of this Commission published a report in June 1945 and it was on the basis of this that the University College of the West Indies was planned.

For the first time in the British Caribbean, in October 1949, medical students were accepted for physiological studies. The Department of Physiology was then housed in temporary wooden buildings, where it remained until March 1952, when all the divisions of the Department were moved into new buildings. The new buildings are well lighted and ventilated and, although of simple construction, comfortable and adequate for research and teaching (Fig. 1). The detailed interior planning of the buildings and the design of the furniture and fixtures were carried out by the staff. The University has a magnificent setting of 700 acres in a valley surrounded by delightful mountain scenery.

The Department has three divisions: physiology (Prof. I. F. S. Mackay), pharmacology (Dr. P. C. Feng, lecturer in charge) and biochemistry (Dr. S. J. Patrick, senior lecturer in charge). There is a close integration both in teaching and research. The facilities of the Department, such as the animal house and workshop, are available for the three divisions. Fig. 2 shows the layout of the buildings. There is a block set aside for physiology with an extension for pharmacology, and a separate block for biochemistry. The animal house is separated from the main buildings. The lecture theatre shown in the plan is shared by the other science departments of the College, which adjoin the physiology buildings.

The Physiology Division contains a laboratory with adequate facilities for teaching forty medical students and is used both for physiology and pharmacology teaching. The usual services are provided. Each pair of students is allocated a space on the bench, which is furnished with a set of outlets for A.C., D.C., 'time', and taps for compressed air and gas (propane). There are two main research laboratories, one especially equipped for human work and one for animal work. All the necessary electrical supplies and compressed air are laid on throughout the whole Department. The extension for pharmacology houses an office and a research laboratory. There is a special dark room set aside for optical registration as well as a photographic dark room. In addition, there are the usual offices for staff which in themselves are equipped as small laboratories. The workshop is equipped to make the usual physiological equipment. The animal house, besides housing dogs and small animals, has a special research laboratory equipped for animal surgery.

The Biochemistry Division houses the departmental seminar room, which is adequate for the teaching of forty students and contains the usual projection equipment and will contain the departmental library. In this building is situated a glass and chemical store. Research facilities are provided in three main laboratories and there is a teaching laboratory to accommodate forty students.

Students are prepared for the degrees of the University of London on a "special relationship scheme". The course follows the requirements of the University of London, but as a period of six terms of study has been adhered to instead of the usual five, it has been possible to organize a more extensive practical course. The emphasis of teaching in the practical classes has been on the human aspects of physiology and biochemistry. The basic pharmacology is taught with animal experiments. The teaching of the three divisions of the Department is closely integrated, and a tutorial system where students are divided into groups of four or five is in operation. Each term these groups are re-allocated to different teachers in the Department. As the number of students in each year is small (approximately twenty) it has been possible to maintain close individual contact and supervision of their work. Science students have not yet been accepted; but teaching for applied pharmacology has already commenced.

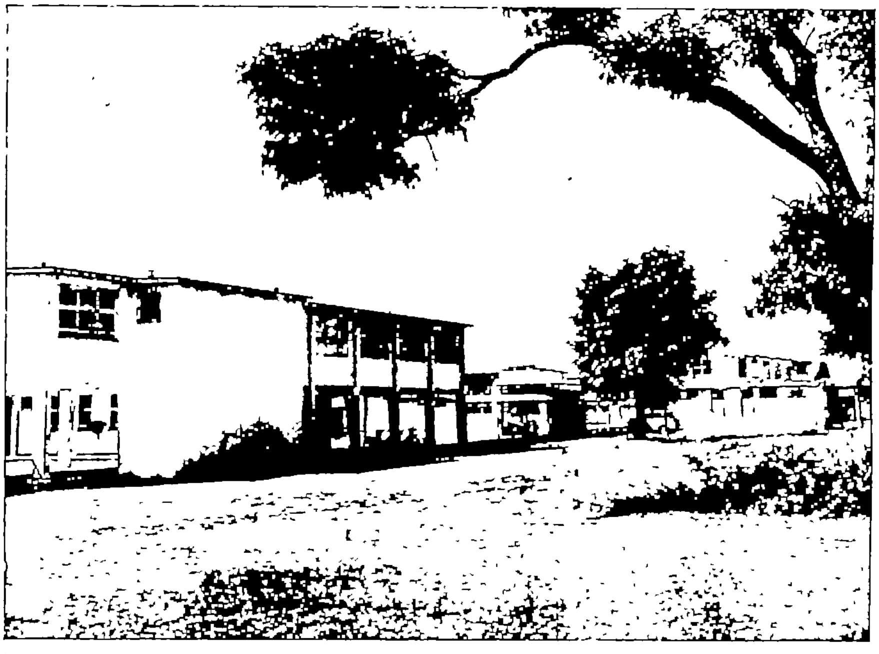

Fig. 1 Foreground left, part of the Biochemistry Division; middle distance right, part of the Physiology Division

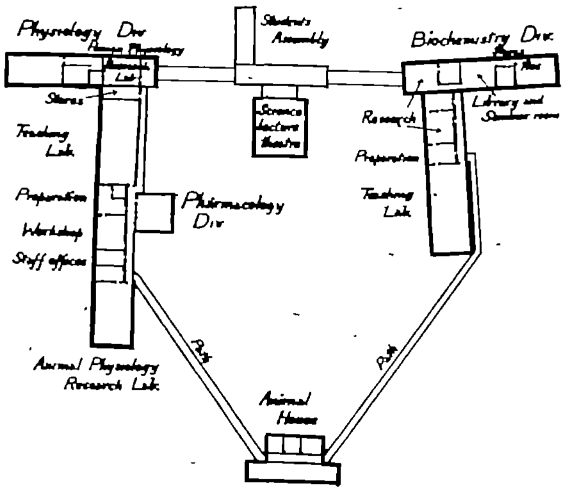

Fig. 2

The teaching of applied physiology will be undertaken when the staffing establishment has been completed.

Because of the location of the new Department in the Caribbean, it was natural that the research interests of its staff would develop in a direction where these territories offer special opportunities. Thus the over-all plan in departmental research has tended largely towards nutritional studies. Several members of the staff, in co-operation with a group from the Department of Pædiatrics from the University of Pennsylvania, are carrying out a basic nutritional survey on children and studying factors influencing nutritional status. We are pleased to report very generous assistance from the American Cyanamid Corporation, Merck and Co. and the Medical Research Council. The nutritional studies have meant an extension of the activities of the Department into relatively inaccessible parts of the island, where villages and communities are only reached after covering long distances, bad roads and surmounting such obstacles as mountain streams, etc. Those of us who have spent most of our time working in the laboratory find this field-work an interesting change. This work has provided material for biochemical studies involving an examination of the metabolism of vitamin $B_{12}$ and a study of the relationship between various enzyme systems and malnutrition. A member of the staff seconded by the Medical Research Council has been studying the intracellular enzymes of the liver and their relation to nutritional deficiencies. Another member of the staff with biochemical interests is now studying the metabolism of the coral reef and carrying out a survey of the zooplankton distribution in these tropical waters.

Jamaica is well supplied with material for the pharmacological and toxicological studies of natural products. Some work has been done on the pharmacological principles in the 'parotid' glands of the local toad (*Bufo marinus*). Studies have also been carried out on the toxicological principles of a local fruit called the ackee (*Blighia sapida*), which is a very common item in the Jamaican diet, and is supposed to be responsible for a seasonal disease called 'vomiting sickness'. This problem is under investigation with the financial assistance of the Government of Jamaica and in co-ordination with other Departments in the University. Apart from these 'Caribbean' interests, work is continuing on more fundamental physiological problems such as cardiovascular, endocrinological and intra-cellular enzyme studies. One of the pleasing factors of the University College as a whole has been the intimate and close co-operation that exists between the new Department of Physiology and those of other science and medical departments.

All the members of staff live in a housing community close to the laboratories, and a very valuable form of social life has developed in which the staff of the Department meet one evening a week on one another's verandas to read journals and discuss their current research problems. To this club are invited members from other departments with similar interests and any scientists visiting Jamaica.

In its short history the Department has been through fire and water. About sixteen months ago a fire destroyed the temporary animal house. Fortunately nuclei of the various imported animal colonies were saved and in the new permanent buildings we are returning to normal. Very anxious moments arose when flames were sufficiently close to the temporary biochemistry laboratories to cause charring of the external walls. Valuable equipment was moved to a safe distance by many willing hands. Our passage through water occurred one night when 25 in. of rain were blown horizontally by a hurricane through the laboratories. Although the roof of the biochemistry building was torn off, the damage to equipment was surprisingly small and was soon made good.

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# THE THYROID GLAND

THE Society for Endocrinology and the Endocrinological Section of the Royal Society of Medicine held a joint symposium on "The Thyroid Gland" in London at the Royal Society of Medicine on February 25. This was well attended and covered a wide range of interests. Among the distinguished foreign visitors were Prof. Jean Roche and colleagues from the Collège de France, Paris.

The morning session was opened by the chairman, Sir Charles Harington, who gave a brief review on the development of thyroid research during the past twenty-five years. He recognized a chemical period dating from the characterization of thyroxine, which was followed by a more biological approach resulting from work on the anterior pituitary and its thyrotropic hormone. He referred briefly to recent work on the nature of the thyroid hormone and its biosynthesis. This has depended on the skilful application of chromatography and auto-radiography, particularly by Leblond, Gross, Pitt Rivers and the French team under Prof. Roche. He also dealt briefly with anti-thyroid substances. Although the goitrogens represent at present the only successful therapeutic application in this field, the theoretical importance of thyroxine analogues was mentioned.

Prof. Roche then described in some detail work carried out in collaboration with S. Lissitzky and R. Michel on the mechanisms involved in the biosynthesis of the thyroid hormone. The view was expressed that the iodination of tyrosine occurs after the incorporation of iodine in the thyroglobulin molecule. The circulating blood contains mainly thyroxine with small amounts of L-triiodothyronine; the absence of mono- and di-iodotyrosine, which occur only in the thyroid, was explained by the operation of a dehalogenase in the gland. Thyroxine is probably converted to triiodothyronine mainly in the peripheral tissues. However, the relative scarcity of triiodothyronine in the blood might also be accounted for by its more rapid excretion.

Mrs. R. Pitt Rivers outlined briefly the methods which she has recently used in collaboration with Dr. J. Gross in the identification of triiodothyronine as a significant part of the thyroid secretion. She then dealt in detail with the physiological activity of triiodothyronine, which possesses all the actions of thyroxine but appears to be about five times as active on a molar weight basis. The same ratio is obtained by different methods of assay such as goitre prevention in rats, the growth-rate of thyroidectomized rats and the minimum dose required for the control of symptoms in patients with myxœdema. The D-isomer of triiodothyronine is, however, almost inactive. Mrs. Pitt Rivers felt that L-triiodothyronine is the substance responsible for the peripheral actions of the thyroid hormone. In the discussion, Dr. G. H. Deltour reported similar results on twelve patients with myxœdema treated with triiodothyronine, and Dr. J. C. Gilliland said that triiodothyronine is more effective than thyroxine in depressing thyrotropic hormone output in the chick. Dr. S. J. Folley, on the other hand, said that he has failed to find any influence of triiodothyronine on the milk yield of cows whereas thyroxine is effective in this connexion. In reply to Mrs. Pitt Rivers, he agreed that the more rapid excretion of triiodothyronine might be of importance here.

The occurrence of post-operative myxœdema in a group of 570 patients, followed over a three-year period, has been studied by Dr. Raymond Greene. The results have been correlated with the histological appearance of the glands, and a strong correlation appears to exist between the presence of lymphoid nodules and the subsequent development of myxœdema. He said that he has formed the opinion that in the absence of lymphoid nodules no ordinary sub-total thyroidectomy will produce myxœdema, and that this complication depends almost entirely upon the state of the gland before operation. The series includes a substantial number of cases of Hashimoto's disease, but even excluding these the relationship still holds. In the discussion Prof. J. M. Yoffey stressed the possible influence of the adrenals in relation to lymphoid hyperplasia.

Mr. S. L. Hignett described a syndrome in cows consisting of thyroid enlargement and a tendency of masculinization as shown by the development of the neck muscles and the attitude of the tail. This is associated with diminished fertility and appears to present a certain analogy with the adreno-genital syndrome in man.

The last speaker in the morning session, Prof. N. F. Maclagan, gave a short account of recent work on the anti-thyroxine compounds. Most of these compounds are iodinated phenols resembling portions of the thyroxine molecule, and have aroused interest since 1946, when Woolley showed that the effects of thyroxine on tadpole metamorphosis could be antagonized by compounds of this type. The most active compound synthesized in his department was *n*-butyl 4-hydroxy-3 : 5-diiodobenzoate. This is an effective thyroxine antagonist in animals and has been tried clinically in association with Dr. Russell Fraser. It cannot, however, be administered to patients in dosages high enough to produce unequivocal anti-thyroxine effects. Results obtained in collaboration with Dr. Wilkinson and Mr. Sprott were then reported, showing that it augments the metabolic action of triiodothyronine in mice and inhibits the deiodination of L-diiodotyrosine in rats. These results support the hypothesis that the compound acts by inhibiting the deiodination of thyroxine and of triiodothyronine. Exact information about this deiodination is not, however, at present available. In the discussion, Mrs. Pitt Rivers and Prof. Roche agreed that these compounds probably are deiodinated in the animal body, although the site of this process is uncertain.

In the afternoon the chair was taken by Dr. S. Leonard Simpson, and Dr. W. R. Trotter opened with some observations on the natural history of Graves's disease as revealed by treatment with anti-thyroid drugs of the thiouracil type. He has found a significantly greater relapse-rate in patients treated for less than one year as compared with those treated for more than one year. He thought that patients who have relatively brief episodes of thyrotoxicosis are particularly liable to have one or more subsequent episodes. A further study of the patients has shown that relapses under treatment are significantly more frequent in winter and spring than at other seasons in the year. The factors concerned in this seasonal relationship are obscure, and Dr. Trotter is not impressed with the influence of psychological stress. In the discussion the influence of hot weather and of sunburn were mentioned; but no clue to this seasonal variation was forthcoming.

The next paper, on thyroid activity in the rabbit, by G. W. Harris, C. von Euler, J. Brown-Grant and S. Reichlin, was read by Prof. Harris. He described a technique employing iodine-131 which he thought gives a measure of the output of hormone by the gland over a period of some weeks. The exposure to cold and administration of thyrotropic hormone increase the rate of output, whereas confinement in the dark, thyroxine, and adrenocorticotropic hormone diminish the rate of output. This hormone is thought to produce its effect via the output of the thyrotropic hormone by the pituitary. In the discussion Dr. Russell Fraser directed attention to the need for a further analysis of emotional factors. He thought that, while fear does not cause thyroid stimulation, other emotional stimuli may do so. Dr. M. Reiss described the inhibitory effect of adrenalin on thyroid function, and Dr. Trotter expressed some doubts as to the interpretation of the release curves shown.

Dr. A. Stuart Mason reviewed methods for assaying the thyroid-stimulating hormone and presented some results on uptake of phosphorus-32 by the thyroid. He thought that this method is complementary to those involving iodine-131, as it is dependent upon hyperplasia rather than hyperfunction. Experiments with iodide suggest that its effect is produced by inhibiting pituitary secretion of thyroid-stimulating hormone rather than by action on the thyroid gland. Prof. Roche expressed his interest in the method and speculated upon its possible relation to mechanisms involving energy-rich phosphate bonds and the biosynthesis of thyroglobulin.

Dr. Russell Fraser spoke of the need for laboratory tests for thyrotoxicosis. While the diagnosis is obvious in perhaps 30 per cent of cases, more frequently it is to some extent a matter of opinion, and objective evidence of hyperfunction is of great value. He thought that measurements involving iodine-131 probably include the best single tests at present available, and, while methods involving the output of hormone as described by Prof. Harris are useful in animals, for clinical work all successful tests depend upon uptake of iodine-131 by the gland. Fortunately the uptake is usually equal to the output in the untreated patient. The method employed at the Postgraduate Medical School of London depends upon measurement of urinary radioactivity and the calculation of a *T* factor. Dr. Fraser's results show that this test is highly efficient in the diagnosis of thyrotoxicosis. It is not quite so good in cases of doubtful myxœdema, although classical cases always give low values. After treatment with goitrogens, the intake is no longer equal to the output, and the position is complicated by iodine deficiency. The test can usefully be employed three months after therapeutic doses of iodine-131.

Results illustrating the diagnostic value of serum protein-bound iodine estimation in the diagnosis of thyroid disorders were described by Dr. R. R. de Mowbray, who said that he cannot agree with some previous claims and has found high values in only 62 per cent of patients with hyperthyroidism. In hypothyroidism, results are below normal in 85 per cent of cases. High levels are seen in normal pregnancy. The overlap with normal values is a definite limitation to the usefulness of this test, but it nevertheless has its value, particularly in the case of patients intolerant of the estimation of basal metabolic rate. Mr. A. Tickner, who joined Dr. de Mowbray in this paper, then described some of the laboratory hazards of the estimation. He also reported some results with serum cholinesterase estimation in thyrotoxicosis. Although high values are frequently obtained, the estimations are of little diagnostic value.

The chairman, Dr. Leonard Simpson, wound up the symposium with a short summary, in which he said that he was particularly impressed with the application of chromatography and the use of radioisotopes in this field. As a clinician he thought that the relationship of the thyroid with other endocrine glands would repay much further study, and he gave a number of examples illustrating these relationships. He hoped that a later symposium might help to explore these other endocrine relationships.

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# METHODS OF PLANT PEST AND DISEASE ASSESSMENT

THE meeting of the Association of Applied Biologists at Imperial College, London, on February 27 was devoted to a symposium on the assessment of plant pests and diseases. In the opening paper, Mr. E. C. Large, of the Ministry of Agriculture's Plant Pathology Laboratory at Harpenden, referred to the wealth of information[1] on plant diseases in England and Wales that had been extracted from monthly reports sent to the Laboratory since 1917, and gave an account of some of the recent surveys, undertaken jointly by the Laboratory and the National Agricultural Advisory Service, to supplement the reporting service and obtain more quantitative information on the losses caused by plant diseases throughout the country. Mr. Large described the way in which an investigation on potato blight forecasting[2], begun in 1950 in collaboration with the Agricultural Branch of the Meteorological Office, had been developed into a comprehensive survey for both outbreak dates and progress of blight. From the survey-maps and curves for the progress of blight on the foliage, taken in conjunction with the results of spraying trials at key centres, it would be possible within a few years to give reliable estimates of the mean gain, or loss, to be expected from routine protective spraying in each region of the country[3]. Disease-assessment (or, as Mr. Large now calls them, 'plant pathometric') methods applied in potato haulm destruction trials at twelve centres over a period of three years were also clearly revealing the blight conditions under which haulm destruction was, and was not, of value for the prevention of the disease in the tubers[4]. Other investigations in progress included a survey of *Epichloe typhina* attack on cocksfoot seed crops[5], now in its third year; a survey of common scab in potatoes, begun in 1952 in collaboration with the Potato Division of the Ministry of Food; and a survey of clover rot in crops of broad red and late-flowering clover, begun in 1953.

The second paper, by Dr. H. E. Croxall (N.A.A.S. Provincial Headquarters, Newcastle upon Tyne), described joint work with D. C. Gwynne and J. E. E. Jenkins in devising rapid methods for assessing the damage caused by apple diseases, particularly apple scab (*Venturia inaequalis*) and brown rot (*Sclerotinia fructigena*). Apple scab damage on the foliage might be conveniently expressed in terms of mean percentage area of the leaves covered by lesions. This could be calculated by comparing leaf samples with standard diagrams showing the appearance of individual leaves with known percentage areas covered by scab. This method was too time-consuming for rapid survey work, and from it had been derived a word-picture key in which brief descriptions were given of the appearance of branches on which the leaves had a known amount of scab damage. In a limited number of tests this method had given results of the same order as those obtained by the standard diagram method.

Similar keys had been drawn up for assessing the amount of scab blemishes on the fruit before picking and also the loss in crop due to brown rot. The results achieved so far were reasonably in agreement with those obtained by a sampling technique using standard diagrams. The possibility of correlating the mean percentage area of fruit covered by scab lesions with the grading of fruit according to the recommended grades of the Ministry of Agriculture Marketing Division was now being investigated. Methods were also being developed for giving a direct estimate of loss of value due to scab in samples of apples after picking.

Dr. R. Hull, of the Rothamsted staff (Dunholme Field Station), dealt with the records of sugar beet diseases made each year by the agricultural staff of the British Sugar Corporation under a scheme organized at Dunholme. Counts of virus yellows in sample fields were checked against yearly estimates of the acreage affected at the end of August. The disease had built up from low levels over four-year periods to peak infections in 1945 and 1949 when more than 50 per cent of the crop was infected. The weather in 1952 had been very favourable for aphid development and movement, and a severe attack of the disease developed late in the season. The losses caused by the disease were assessed by allocating an experimentally determined loss of 4–5 per cent of sugar yield for each week during which plants showed symptoms until harvest. In a bad year, such as 1949, this amounted to about 20 per cent of the sugar yield, or some 900,000 tons of sugar beet. This figure was checked by calculating a regression coefficient of yield on percentage of plants with yellows for the various factory areas. Surveys were also made of the incidence of yellows in sugar beet seed crops and of aphids in clamped mangolds in spring, as these virus and aphid sources were of importance in the initiation of outbreaks of yellows in the root crop.

In opening the discussion on the plant disease assessment papers, Mr. L. P. Smith (Meteorological Office Agricultural Branch) emphasized the need to establish the relationships between the microclimate on the plant surface and the macroclimate as defined by the recording instruments of the meteorologist. Meteorological records could already be used for forecasting potato blight, since it appeared that 75 per cent relative humidity in the air was indicative of saturation on the potato leaf surface. Advances in the application of meteorology to plant disease forecasting depended on exact definition by the plant pathologist of the meteorological factors permitting infection and on the provision of accurate means of disease assessment.

Mr. W. C. Moore (director, Ministry of Agriculture Plant Pathology Laboratory), in concluding the morning session, paid tribute to the pioneer work of Mr. Buddin. He pointed out that the United Kingdom was the only country in which full-time appointments had been made for the development and co-ordination of work on pest and disease assessment. The successful prosecution of this work depended on the co-operation of all those concerned in crop protection who were willing to give time to the surveys necessary to obtain accurate information.

The afternoon session opened with a paper on field technique in pest assessment by Mr. A. H. Strickland, also of the Plant Pathology Laboratory. Mr. Strickland recorded that routine quantitative survey work was started on some twelve pest species by entomologists in the National Agricultural Advisory Service in 1946. Initially the approach had been somewhat arbitrary—necessarily so in view of the almost complete lack of information on pest population variability within and between fields or provinces.

In 1950 four seasons work on the cabbage aphid was critically reviewed and it was realized that a much more intensive approach was needed to give reliable results on aphid abundance and crop damage. Since that time, work had been directed to assessing cabbage aphid damage accurately on an experimental plot scale and in overcoming some of the difficulties met. Two examples were given of the way in which seemingly straightforward population and yield or damage data could be misinterpreted.

It had become increasingly clear that a full interpretation of results in terms of biological activity was not in general possible on present knowledge. In view of the importance of assessing the significance of major ecological factors in relation to pest population build-up, a new pest incidence report scheme had been drawn up and was being given a trial.

Mr. F. G. W. Jones (School of Agriculture, University of Cambridge) classified the seedling pests of beet into three groups: those causing loss of stand only, those causing defoliation only, and those causing both defoliation and loss of stand. Injury caused by these pests could be assessed in terms of money, yield or, occasionally, plant population. Normally, an excess of 'seed' was sown, from which only 25 per cent of potential seedlings appeared above ground, 10 per cent having succumbed to fungal disease, 5 per cent to insect attack and 60 per cent to other causes, mainly arising from the physical properties of the soil. The cost of insecticidal seed dressings applied to beet on arable land had to be regarded as an insurance against unexpected attacks, especially where reduced seed rates were used to ease the labour problems of singling.

Field experiments had been made in which defoliation and loss of stand were produced artificially. The results of five such experiments showed clearly that beet was capable of withstanding up to 75 per cent defoliation at the four- and eight-leaf stages without suffering more than 10–15 per cent loss of yield. Re-drilling was undesirable so long as even one-half of the intended plant population remained, provided the surviving plants were fairly evenly distributed. The use of insecticides against pest attacks of moderate severity was likely to be uneconomical if the cost exceeded £3–£5 per acre.

Mr. D. W. Wright (National Vegetable Research Station, Wellesbourne) described two methods of assessing damage caused by larvæ of the cabbage root fly. The first was an estimation on the tap root of the proportion of the area injured by the larvæ; the second was by recording crop yield. These two methods showed little agreement, as the effect of a given level of root fly infestation on crop yield varied from year to year. This appeared to be correlated with the rainfall during the main period of crop growth and infestation. When the rainfall over this period was at or below average, very considerable increases in yield occurred following control of the pest. When the rainfall was well above average at this time, however, no visible or significant improvement followed control. It would thus seem that under dry soil conditions a damaged root system was unable to provide the plant with an adequate supply of water.

Losses due to this insect appeared to be greatest on crops transplanted early in the year. Crops transplanted later, and harvested in autumn and winter, were usually less affected, but with these also marked increases in yield had been obtained when the root fly was controlled.

Dr. M. Cohen (N.A.A.S., Newcastle), opening the discussion on pest assessment, stressed the need for long-term records and for relating insect attack to the physiology of the host plants. Hitherto the only records that had permitted forecasting of pest attacks had been those on leatherjacket populations. Accurate figures on losses due to pests could help to guide the intensification of control measures into those channels that would increase agricultural production most rapidly.

Prof. H. W. Miles (Wye College, University of London) considered that many lines of field work would be promoted as a result of the symposium. He directed attention to the potentialities of plants to compensate for insect injury, and pointed out that the grower must be shown by realistic figures the amount of crop loss due to pests. The need to combine economy with efficiency in pest control was specially apparent at the present time.

Dr. W. F. Jepson (Imperial College Field Station), and other speakers, referred to work on varietal susceptibility to pest damage, and pressed for a clear discrimination between degree of attack and loss of yield.

Dr. I. Thomas (Plant Pathology Laboratory, Harpenden) noted that methods of assessing plant disease loss had been initiated by research workers, but in assessing losses due to pests, methods had had to be improvised. It was essential to avoid the pitfall of ascribing losses to pests when nutrition and soil factors were primarily responsible. Dr. Thomas again stressed the need for a generous measure of co-operation and goodwill to ensure the successful development and application of methods of assessment.

R. W. MARSH

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[1] Moore, W. C., *Bull. Min. Agric.*, No. 126 (1948) and No. 139 (1948), and earlier bulletins.

[2] Large, E. C., *Plant Path.*, 2, 1, in the press (1953).

[3] Large, E. C., *Plant Path.*, 1, 109 (1952).

[4] Large, E. C., *Plant Path.*, 1, 2, 56 (1952).

[5] Large, E. C., *Plant Path.*, 1, 23 (1952).

# RECENT GEGENSCHEIN STUDIES IN THE SOVIET UNION

A GOOD deal of work has recently been done, in the Soviet Union, on the Gegenschein or 'counterglow', as a result of which a fairly definite point of view has developed. In particular, the Glydén–Moulton theory is regarded as quite overthrown by mathematical analysis (Moiseyev). The Seeliger reflexion theory may account for some portion of the counterglow luminescence, but not for the main effect. Taking advantage of the extraordinarily good seeing conditions in Central Asia, Soviet astronomers have shown both by visual and by photometric observation that the counterglow is variable in shape, in intensity, and in the spatial distribution of its luminescence; that it has an emission spectrum; and that it has a parallax which places it at a distance of about twenty earth radii. This has resulted in the revival of the theory of a gaseous tail extending from the earth's atmosphere. It is thought that the tail is excited to luminescence by the solar 'corpuscular radiation' at some distance from the earth, presumably after it crosses the boundary of the 'forbidden region' (of Chapman, Martyn, Alfvén).

Some of the Russian papers on this subject[1–4] have now been translated and issued in full[5]. A short account also appears in the 1952 edition of Mitra's "Upper Atmosphere"[6], which has just become available.

According to Fesenkov[2], the tenuous exterior atmosphere of the earth may have the form of a paraboloid of revolution, convex toward the sun. Nothing is said about the mechanism by which this form is maintained; but presumably it is a combination of radiation pressure, actual escape, and very high 'bounces' of colliding molecules. The density of the gas is halved every 4·7 earth radii; but apparently, in Fesenkov's view, is uniform over any cross-section of the tail (see ref. 2, p. 500). Astapovich[1], on the other hand, describes the tail as a hollow sleeve of gas, driven off from the twilight rim of the earth by radiation pressure, like the tail of a comet.

To the recognized description of the counterglow, a completely new detail has been added by Divari[3] and Fesenkov[4], who independently discovered that, as the counterglow descends to the west of the meridian, there appears a broad pyramid of fainter luminescence connecting it to the horizon. To this phenomenon Fesenkov gave the name "false zodiacal light" (see ref. 6, p. 492).

The false zodiacal light is confined to the western side of the night sky; it does not appear in the east when the counterglow is rising. No satisfactory explanation is given for this remarkable fact. Obviously it cannot be any ordinary atmospheric distortion or superimposed luminescence, at least so long as our model of the atmosphere is symmetrical. It is necessary to postulate some atmospheric asymmetry in the evening twilight zone, and if we accept the gaseous tail hypothesis at all, we are led to suspect that the asymmetry can only be the tail itself.

In a prefatory note to his translation[5], Mr. Hope has suggested (assuming the gaseous tail really to exist) that the false zodiacal light may be explained by invoking a hitherto unconsidered fact, namely, that the earth's rotation will assist the radiant pressure of the sunlight over the evening twilight zone, but will oppose it on the morning side. The result may be that the gaseous stream is driven off mainly, if not entirely, from the evening side; Astapovich's 'gaseous sleeve' is not complete. If this incomplete sleeve is itself faintly luminous (below the actual counterglow), it will be seen against the western night sky, but not in the east.

A further suggestion is made to account for the fact that the false zodiacal light does not make its appearance before about two o'clock in the morning. This suggestion involves the idea that the fainter luminescence in the incomplete sleeve is generated by atoms or molecules, excited or dissociated in the sunlight, dropping to a lower level of excitation or recombining when they pass into the terrestrial umbra high above the earth. (Incidentally, it seems that the long cone of the earth's shadow, as a possible generator of radiation in the remote exosphere, has been little considered.)

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[1] Astapovich, I. S., *Priroda*, No. 1, 25 (1950).

[2] Fesenkov, V. G., *Priroda*, No. 11, 5 (1950).

[3] Divari, N. B., *Astro. Zhur. SSSR.*, 26, No. 6, 355 (1949).

[4] Fesenkov, V. G., *Astro. Zhur. SSSR.*, 27, No. 2, 89 (1950).

[5] Hope, H. R., 305 Wilbrod Street, Ottawa 2, Ontario.

[6] Mitra, S. K., "The Upper Atmosphere" (Calcutta, 1952).

# ABSTRACTING AND LIBRARY WORK IN THE U.S.S.R.

THREE articles on the organization of scientific information and abstracting in the Soviet Union have appeared in recent issues of *Vestnik Akad. Nauk SSSR* (22 (8, 9), 41, 46 and 80; 1952). The first of these is by A. V. Kremenetskaya and E. V. Vasilyeva, dealing specifically with abstracting (referata) and the work of the State Scientific Library. This is the largest in the Soviet Union, with about three and a half million books and other publications. Among its main objects are publicity on advanced experimental work in industry and on the achievements of Soviet science and technology, and also information on the work of other countries, especially those of Eastern Europe. Special attention is given to the provision of information in suitable form to students. In fact, the library is under the direct control of the Ministry of Higher Education; but it also has a wider range, and its services are available through two hundred and sixty industrial centres throughout the Union.

It is not clearly stated in what precise form the information is supplied—though leaflets are mentioned later—but apparently more than twelve thousand 'informations' are issued annually, manifolded and distributed to the extent of three hundred and fifty thousand copies.

Up to 1948 'subscribers' filled in questionnaires on matters in which they were interested; but this proved unsatisfactory and was replaced by subject lists and abstracts prepared by the Library. Extreme subdivision of subject-matter is not considered desirable, and many fields that were previously thus divided have now been reconsolidated. At present there are seventeen main classes in the industrial field, including nuclear physics, ultra-short-wave radio technique, tele-mechanics, etc., subdivided into more than a thousand subjects. Methods of scanning both books and journals in the library are described at some length, with special reference to the needs of technical and scientific workers, and to the relative value of so-called popular works on science and technology. 'Capitalist' publications must, of course, be carefully examined, but with a somewhat more critically selective acumen, for which various reasons are given.

More than fifty specialists are employed under an editorial staff to examine books and journals and to prepare abstracts. Nothing is said in this first article of the distinction attempted in the third article between abstracts, annotations and reviews, nor of a critical function discussed therein (see below). Up to 1941 the material collected by the Library was in the form of short 'annotations' printed on the usual library index cards, but to increase efficiency and save the time of specialists "there was a constant urge towards more detailed abstract annotations". Length of abstract naturally depended on a number of factors: material in a foreign language not readily accessible would have to be more detailed; literature from a large central publishing-house in the Soviet Union need have little more than title and date. The abstract is usually in the form of single leaflets, for which various advantages are claimed. Co-operation with other libraries and institutes, a call for suggestions and comments, and a few notes about binding, etc., conclude this first article.

The second article, by Dr. L. I. Gutenmakher, is on the mechanical aspects of information work, though it is a little indefinite. It emphasizes the rapidly accumulating and enormous dimensions of modern scientific literature, and notes the various difficult and complex problems involved.

The president of the Academy of Sciences of the U.S.S.R., A. N. Nesmeyanov, has recently suggested a study of mechanical methods for dealing with information work (*Vestnik Akad. Nauk SSSR*, 22 (2), 16; 1952), so that Stalin's doctrine—only by mechanization can Russian industry hold its place—can be applied here also. No actual machine is described; but certain general principles on which its design might be based are suggested by the author. Information in an abstract should be presented in simplest terms or elements, compressed and uniformly formulated. From one to two hundred such elements may constitute the average abstract. Analysis of material, formulation and record (abstracting) might be done through suitable rules and instructions to authors, or by special staff in one or more institutes; but the selection of information relevant to a given subject or problem should be achieved by mechanical means. Some necessary conditions are discussed; including the use of auto-cameras (photo-automatas), with examples drawn from chemical kinetics and reactions. Brief and precise systems of record are essential, with the maximum use of mathematical and other symbols and formulæ. Russian patent specifications are said to be a step in the right direction of formulation. Another problem briefly considered is that of classification, though here again the proposals are a little vague and indefinite, including a suggested use of 'addresses' and the modern technique of commutation.

The third article runs to twelve pages and deals in greater detail with abstracting (referata). The authors are K. R. Simon and G. G. Krichevskiya. The former is a well-known writer on the subject in the U.S.S.R., with numerous articles in the *Sovetskaya Bibliografiya* and other journals. A few statistics are presented to begin with. Figures for 1949 show that, in natural science, medicine and technology (engineering) only, published articles in all countries had reached 1,850,000 a year. In chemistry alone they exceeded fifty thousand a year. In the Soviet Union scientific printed publications, including books and official documents, in 1951 amounted to more than a hundred thousand. In the Russian view it is necessary to distinguish abstracts (referata) from annotations, the purpose of which is to disclose in more or less detail the subject-matter (thematics), and from reviews or criticisms. The distinctions appear a little arbitrary: it is shown later that an abstract must, of course, disclose the subject-matter, and also include a critical function.

The importance of a preliminary general survey (*obzor*) is emphasized—a summary or outline, which may also be informative or critical, although its precise nature, purpose and realization are not very clearly given. A short historical survey relates to abstracting in the Western countries (*Chem. Abst.*, *Brit. Chem. Abst.*, *Centralbl.*) and to the work of Unesco, with various points of criticism, such as the neglect of social sciences, absence of critical acumen, the complete omission of books from the general scope and, it is stated, neglect of material other than English, French and German; also a lot of unnecessary duplication. This matter of a critical function has been considered in some detail by K. R. Simon (*Sov. Bib.*, 1–3, 341; 1933).

A detailed account is given of Soviet progress in abstracting, starting with the decree of January 9, 1928, under which a Commission was established to look after "Indexes of Scientific Literature", including abstracts of all Soviet scientific publications. The original grandiose scheme, as the authors term it, of large annual volumes, could not be properly realized, and there were several defects. Many Soviet abstract publications are noted. The real requirements of an efficient abstract service are described in detail. For example, it must be a true organic system, established on a uniform plan, in accordance with a logical classification of the whole field of human knowledge, of which the main classes are indicated, including philosophy—an inclusion which may possibly be questioned.

For each division of knowledge the question arises as to its appropriate independent abstract medium, having regard to its various aspects, sub-divisions, rate of development, relevant literature, etc. It is clear that some of the main divisions cannot be provided for within the limits of one abstract publication—for example, in the sciences of philology and comparative literature—in view "of the brilliant publications of I. V. Stalin in these fields". But as regards chemistry, long experience with abstract journals has convinced the authors of the paramount need for some single but authoritative and comprehensive chemical abstract journal in the U.S.S.R., for both the theoretical and practical domains.

There is only space here to indicate the other points discussed—for example, choice of material to be abstracted, which should include not only periodicals and patents but also books, etc. (even the general press and popular magazines); linguistic scope of abstracts (what countries and languages, for there are already ten different languages in the Soviet Union itself); nature and value of the information provided, with critical evaluation; what the abstract should contain; and one or two miscellaneous considerations. W. G. Cass

# THE TURKISH EARTHQUAKE OF MARCH 18

THE recent earthquake in Turkey was not one of the greatest of that region, but it happened in a moderately well populated area and consequently the casualties have been relatively great.

Provisional readings of the Edinburgh east–west component seismogram indicate the initial time for the earthquake as 20 hr. 06 m. 16 s. G.M.T. The epicentre appears to have been near Çan in the province of Çanakkale, Western Anatolia (lat. 40° N., long. 27° E.), and the depth of focus normal. The Edinburgh Milne–Shaw seismograph has a magnification of 250, and the maximum surface waves, which are pronounced in this shock, measure 7·1 cm. amplitude (mean to extreme) on the record.

The earthquake was experienced chiefly in the Provinces of Çanakkale and Balikesir, bordering the Ægean Sea, and south of the Dardanelles. The area between Yenice and Gonen suffered severely. In this district more than six hundred houses were destroyed and many more were damaged; fire added to the damage. Çan is a centre of routes in the area, the railway lines from Çan going respectively south-east to Baya, north-north-east to Biga and Karabiga and west-north-west to Çanakkale. All these communications were interrupted and telephone and telegraph lines were down. Reports from fifty-seven villages in the epicentral area were still awaited two days after the earthquake. The shock was felt in Istanbul as strongly as any earthquake since 1906, and some apprehension was felt. Some buildings were damaged in Istanbul, including the Dolmabagtche Palace, where walls cracked and plaster fell off the ceiling of the famous reception hall. Damage has been reported from the Ægean Islands of Chios and Lesbos and the tremor was felt throughout northern Greece. The full list of damage and casualties cannot yet be assessed, but reported damage two days after the event is estimated at a quarter of a million pounds sterling, deaths at more than five hundred and injured at more than a thousand. Ankara observatory reported sixty-five aftershocks on March 19 and fourteen more to noon on March 20.

In Turkey there are annually some hundred to hundred and fifty earthquakes which are felt but which do no damage. Some others do damage only in the immediate vicinity of their epicentres; but since 1938, excluding the present shock, there have been thirteen disastrous earthquakes. These have been: (*a*) in Central Anatolia—Kirsehir-Yerköy, 1938 (19 Nisan 1938 Orta Anadolu yer deprenmesi. Ed. Paréjas and Hamit N. Pamir. Istanbul Ūniversitesi Jeoloji Enstitüsü Neşriyati, No. 5, 1940); (*b*) in Septrionale Anatolia—Erzincan (magnitude 8), December 27, 1939 (27 Birinci Kânun 1939 Erzincan yerdepremi. Ed. Parejas, I. H. Akyol, E. Altinlı. I.U.J.E.N., No. 10, 1942, also *Nature*, January 6, 1940), Erbaa-Osmancik (magnitude 7·5) 1942, Adapazari 1943, Amasya-Tosya (magnitude 7·5) 1943, Bolu-Gerede (magnitude 7·5) 1944, (*c*) in south-east Anatolia, Ceyhan-Misis 1945, Van 1945, Varto 1946, Bingöl 1949; and (*d*) in the Ægean area in which the present epicentre is situated, Dıkili 1939, Ayvacik 1944 and Çesme-Karaburun 1949. In the course of these thirteen earthquakes, fifty thousand people have been killed and a hundred thousand houses destroyed or seriously damaged. Since 1938 earthquake damage has probably cost the Turkish people 100 millions of Turkish pounds.

Tectonically, the area around the Marmara basin consists of faulted synclines, and the area adjoining the Ægean Sea consists of faulted depressions. In between these synclines or depressions there are anticlines with palaeozoic cores, 'plis de fond' or 'massifs'. The elements have been orogenically active throughout geological time, but since the end of the Néogène the general movement has been an upward (epirogenic) one. This rise is shown by the altitude of Néogène lacustrine deposits and by the quaternary terraces. To-day it is still continuing and is evidenced by the sudden changes of equilibrium between sections with faulted contact. Earthquakes accompany the faulting. Ernest Tillotson

# THORNTHWAITE FOREST, CUMBERLAND

THORNTHWAITE was one of the first forests to be established by the Forestry Commission in Cumberland, which took over eleven hundred acres of land around the Whinlatter Pass in 1920 and began planting the same year. Other land has been added from time to time, the latest acquisition being in 1947, and, since planting has proceeded continually, all ages of trees up to thirty-two years are represented. A short record of this forest has now been published by the Forestry Commission in a booklet entitled "Britain's Forests—Thornthwaite"*. The bulk of the work on the larger sections—Whinlatter, Wythrop and Dodd—was finished by 1931, and thus most of the plantations are more than twenty years old. Formerly, the young trees for planting were raised at a small forest nursery near Thornthwaite village; but nowadays they are brought from larger nurseries near the Scottish border. The forest lies three miles from Keswick, two and a half miles from Cockermouth, and twenty-three miles from Carlisle. Its greatest length from north to south is seven miles, and its greatest breadth six miles, including outlying plantations. The distance around Bassenthwaite Lake by road, which touches on most of the plantations, is eighteen miles.

Soon after the Commission commenced planting in the beautiful Lake District, there was a considerable outcry—almost inevitable, since the objectives of forestry are little appreciated in Britain. Such forestry as existed in the country a couple of centuries ago was confined to hardwoods; for many reasons, much of the Cumberland hills were only suitable for conifers.

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* Forestry Commission. Britain's Forests—Thornthwaite. Pp. 20. (London: H.M.S.O., 1952.) 1s. net.

There are many aspects from which Thornthwaite may be examined. Perhaps one of the best known is from the south. As one approaches the well-known town of Keswick by way of the main road from Ambleside, a beautiful panorama is unfolded which includes the young forest, now covering five thousand acres. About two and a half miles short of Keswick, Bassenthwaite is seen below with the young plantations of spruce, pine and larch on the hills on either side with, at the back on the far side, Skiddaw rising to 3,053 ft.

The forest is divided into several sections bearing the local names of the areas concerned, the latest plantations dating from 1948 and 1950. The kinds of trees used are the spruces, Sitka and Norway, Scots pine, and, in small amount, *Pinus contorta* and *P. mugo*, with Douglas fir, Lawson's cypress and western red cedar. On the bottom soils and in sheltered places Japanese larch is planted. Curiously enough, the European larch does not do well in this region. More latterly, the Commission has been planting amenity belts along the Bassenthwaite roads to break the monotony of the dark conifers. The belts include the American red oak, beech, wild cherry, western red cedar, ash, birch and maple, which are seen at their best in the spring and autumn. Thinnings are being made in the older woods, from the poles of which pitprops and finer stakes are yielded, providing a return from the forest and providing work for a considerable labour force.

E. P. STEBBING

# NATIONAL PARKS IN GREAT BRITAIN

THE third annual report of the National Parks Commission* covers the year ended September 30, 1952, and notes the confirmation of the Designation Orders for Snowdonia, Dartmoor and Pembrokeshire coast national parks, and the designation, on February 12, 1952, of a sixth area, the North York moors, as well as consultations with local authorities concerning a proposed Cornish National Park. It records the view that, in spite of unpropitious economic circumstances, the design of the National Parks Act is taking shape. The claim that substantial advance has been made, however, scarcely seems to be justified by the contents of the report, although it appears that, with the exception of Snowdonia, the park authorities, in spite of handicaps due to economic circumstances, have been working with some promise and that the problems of each park are being studied by each authority with a full and proper appreciation of the intentions of the National Parks Act. The tale of administrative difficulty due to ministerial faithlessness, and the persistence of misconceptions as to the effect of designation of areas as national parks on access, is repeated from the previous report; and although the references to financial difficulties are more oblique than in the second report of the Commission there is no substantial evidence in the present report of the disappearance of the parsimony which was last year reported as hindering its educational work through the distribution of the proposed leaflet on the Country Code.

Nothing is said about that leaflet in the present report, and, although the education authorities have rendered much assistance in making the Country Code widely known to the youth of the country, it may be inferred that the Commission's own proposal is still frustrated. The most hopeful features of the report are, in fact, to be found, first, in the evidence it provides of widespread co-operation and goodwill, and, second, in the determination with which the Commission has maintained its position in the face of official indifference.

On the first, directors of education, the Railway Executive, the London Transport Executive and the Central Office of Information have helped to make the Country Code widely known, while much help has been received from local authorities, the Peak Planning Board, the Youth Hostels Association, the Ramblers' Association, the County Councils of Cornwall, Devon, Dorset and Somerset, and individual ramblers at one or more of the numerous stages—from preliminary survey to the erection of cairns and stakes or the provision of hostel accommodation involved in the establishment of the projects for long-distance routes, such as the Pennine Way, now at an advanced stage, the Cornish North Coast Path, the Pembrokeshire Coastal Path, the Thames Riverside Walk, the South Downs route and the Pilgrim's Way. The extent of such co-operation fully justifies the Commission's claim that "the designation, progressively, of the finest areas of England and Wales as National Parks signifies public recognition of the supreme quality of our landscape and of its permanent importance as a factor in the moral and physical welfare of our people, and of the need on that account to ensure that it passes inviolate to future generations". Nevertheless, such public recognition is incomplete, and whether, in fact, the long-term ideal, of which the National Parks and Access to the Countryside Act is the practical expression, is to be realized depends largely on the success of the Commission's stand in regard to administration, and the extent to which the Commission is supported in a matter which, the Commission reiterates, "is of pivotal importance not only to each individual Park but to National Parks policy as a whole".

For this reason the Commission has appended to the present report details of the administrative arrangements for the Peak District, the Lake District, the Dartmoor and the Pembrokeshire Coast National Parks. Closer acquaintance with the practical problems has only confirmed the Commission in the view it has held most strongly from the start, and which has been held by all others before it who have studied this problem—namely, that, short of an organization such as was contemplated by the Hobhouse Committee, the joint planning board, with its own whole-time planning staff, is the most appropriate and serviceable administrative instrument. Such a joint planning board should have at least a whole-time planning officer, who should be a servant of the board and independent of any of the component local authorities. The Commission regards this as a corollary to the principle that a national park should be treated as an integral unit, planned by a single authority with distinct principles and purposes in view, and it sticks to this point; although it admits that the existing arrangements, with one exception, have worked fairly satisfactorily.

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* National Parks and Access to the Countryside Act, 1949. Third Report of the National Parks Commission for the Year ending 30th September, 1952. Pp. iv+30. (London: H.M.S.O., 1952.) 2s. 6d. net.

With regard to the exception, namely, Snowdonia, the Commission records great disappointment that no administrative system has yet been established and therefore no progress whatever made in carrying out the purposes for which the Park was designated. The course of the opposition of the three county councils to a joint board down to the statement by Mr. Harold Macmillan, the Minister of Housing and Local Government, in a letter to the County Councils dated April 25, 1952, saying that he could not doubt that the National Parks Commission was right in believing that a national park ought to be administered by one authority, has already received comment in these columns (see *Nature*, 170, 333; 1952). It would appear from the report, however, that the Minister did not receive from the Councils, in their reply of August 5, 1952, the detailed assurances which he requested as a condition of accepting, for an experimental three years, the joint advisory committee they proposed, and that they did not satisfy him that their proposed arrangements would secure the efficient administration of the Park during that period. When consulted on the replies, the Commission again had occasion to say that it could not advise the joint advisory committee method and that in its opinion the only satisfactory machinery is a Joint Planning Board; the Commission's report indicates that the Minister is again corresponding with the three Councils.

A first task of the Park Planning Authorities already appointed is the preparation of a development plan, and Mr. Macmillan has extended until December this year the period allowed to the Planning Boards of the Peak Park and the Lake District for submitting their plans. The National Parks Commission has already received from the Peak Park Planning Board a comprehensive statement of its general proposals: surveys for the development plan will be conducted so as to marshal information for future action for the preservation of the area and the promotion of facilities for open-air recreation, and particular attention will be paid to the survey of existing defacements and of advertisements, of woodland areas for preservation and of areas for planting or afforestation, of historic and interesting buildings, and of areas suitable for camp sites and parking places. The Lake District Planning Board has also outlined the main considerations on which its development plan will be based and its approach to the problems of development control in the National Park.

The National Parks Commission has been consulted upon a large and urgent volume of projected developments, principally relating to electrical development, forestry and mineral workings. Several important safeguards were included in the British Electricity Authority's Hydroelectricity Bill following discussions between the Commission and representatives of the Ministry of Housing and Local Government, the Ministry of Fuel and Power and the British Electricity Authority. In regard to overhead lines, the Commission indicates in an appendix the conditions under which it considers that capital restrictions should not be allowed to exclude relatively short lengths of underground line which is strongly desirable on amenity grounds. Consultation with the Forestry Commission has usually resulted in mutually satisfactory decisions, but a proposal to acquire and afforest about a thousand acres of one of the finest stretches of moorland scenery at Saltersgate in the area designated as the North York Moors National Park was opposed and submitted to the Minister of Housing and Local Government. The Commission records its full agreement with the policy of the Peak Park Planning Board in regard to mineral workings and endorses the view that, while quarrying in the Peak cannot be excluded, the demands of the industry should receive the closest scrutiny and that any additional areas required for limestone quarrying, over and above those already worked, should, wherever possible, be found outside the National Park. The Commission also indicates its approval of the policy adopted by the Peak Park Planning Board to ensure the protection of the amenities of the Park against unsightly and sporadic growth of camping sites, without discouraging legitimate camping for recreational purposes.

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# FORMATION OF FIBRES FROM PROTEIN MONOLAYERS

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When a monomolecular film of protein at an air/water interface is compressed beyond a certain critical surface pressure it can no longer be re-expanded to its original area, due to the formation of intermolecular linkages by the unfolded film protein. As the film is further compressed, more such linkages occur, and the film 'buckles', or folds up on itself, parallel to the compressing surface (normal to the direction of compression). These regions of folding soon become visible as tiny striations running across the width of the trough[1]; continuing the compression results in the approximation and adlineation of these folds until nothing remains of the film but a solid, fibrous thread which can be picked up entire from the aqueous substratum. This process was first described by the Bordelaisian botanist, Henri Devaux[2], and is commonly called the Devaux effect[3]. It was mentioned somewhat later by Cockbain and Schulman[4].

The use of these fibres in the study of the biological properties of proteins has been demonstrated by Mazia[5], Hayashi, and the latter's collaborators[6-7]; fibres of pepsin, catalase and rabbit actomyosin have been shown to retain the specific biological activities of the unspread protein. The fibres have been shown to consist of microscopically visible 'fibrils' which appear as discrete birefringent units parallel to the fibre axis[6]. It is to these 'structural units' that Hayashi attributes the ability of his actomyosin fibres to contract against a load in the presence of adenosine triphosphate[7], despite the fact that these fibrils merely represent regions where the original film has buckled during the compression, as shown by his own electron microscopic studies[8].

In our experiments on the effect of ultra-violet irradiation of monolayers[8] and dilute solutions[9] of crystalline ovalbumin, we have reported that during the irradiation the fibres formed become increasingly thin and fragile, until finally the irradiated protein loses entirely its ability to form such a fibre. We have shown that the effect of ultra-violet light on this protein is first a non-proteolytic alteration in molecular structure, followed by a photochemical rupture of peptide linkages (proteolysis). A re-examination of our results shows that the protein has lost its ability to form a strong fibre before any appreciable proteolysis has occurred; we have thus been led to the hypothesis that a non-proteolytic structural modification causes either loss of ability to form fibres, or to the formation of fibres of altered appearance and properties. We have re-opened this question and have recorded the following qualitative observations on the effect of pre-treating ovalbumin with typical 'denaturing' agents. It should be noted that none of these agents prevents film formation; indeed, an aliquot of protein will spread to a larger area following ultra-violet irradiation[8,9], and Stallberg has found[10] that treatment in the boiling water-bath increases slightly the area to which an aliquot will spread, provided, of course, that coagulation is prevented.

If 0·01 per cent ovalbumin solutions at $pH$ 2·25 are treated in the boiling water-bath, or by ultra-violet radiation, and then spread at $pH$ 4·8 as described[8], fibres are difficult or impossible to obtain, unless a great excess of protein is allowed to become adsorbed at the interface; in this case, the fibres recovered are easy to distinguish from the controls by their fragility and thinness, and, microscopically, by the presence of short, disoriented broken fibrils interspersed in disordered granular regions in which fibrils are absent altogether. Treatment of a 0·01 per cent protein solution with concentrated urea abolished fibre-forming ability; urea treatment of a 1 per cent solution, on the other hand, led to recovery of thick, continuous, but quite fragile, fibres of totally different appearance from the controls. The former resembled a dense, white granular gel and upon drying were usually devoid of any microscopically recognizable structure and were largely non-birefringent when viewed between crossed nicols. Dialysis of the excess urea prior to spreading does not change the appearance of the fibres eventually formed, which are likewise devoid of any fibrillar substructure and after drying are unable to alter the ellipticity of polarized light.

Fibres formed from untreated protein are tough and, when wet, intensely birefringent at the 45° position between crossed nicols. Extinction occurs when the fibre axis is at right-angles to, or parallel to, the plane of the polarized light. After prolonged dehydration, birefringence is still present, but is of reduced magnitude. In this respect, these fibres are similar to those prepared by the crystal method of White and Elmes[11].

It is interesting to note that certain untreated proteins are evidently unable to form fibres at all, despite the formation of perfectly good films. We have not been able to induce insulin films to form fibres, thus confirming a remark by Wrinch[12]. Gliadin films can be made to form fibres only with the greatest difficulty and then by spreading an excess of a 1 per cent solution.

Egg albumin, although known as a difficult protein to spread[10], will unfold after eight hours on $M/15$ sodium chloride into a film the thickness of which, calculated from our results (ref. 8, Table IV), is 8 A.; these films yielded tough, elastic fibres. Urea, ultra-violet radiation, ozone and heat—agents which modify the structure of the intact molecules and eliminate many of their specific properties—either abolish their capacity to combine into fibres after adsorption at the air/water interface or cause the formation of fibres lacking the characteristic regular fibrillar substructure. Hayashi is thus correct in attributing structural significance to these so-called fibrils, since they are absent or much changed in fibres formed from protein previously treated with the usual 'denaturing' agents. The prevalent view[13] that interfacial unfolding of protein is the same sort of process as that caused by other forms of 'denaturation', differing only in that it is a more drastic form of structural modification, seems to be inconsistent with these facts. Our results rather suggest that interfacial unfolding leaves the protein molecule with a measure of two-dimensional specificity not to be found following modification with other agents. The large literature (cited in ref. 6) showing retention of biological (enzymatic, hormonal, antigenic) activity by fully unfolded protein molecules would seem to reinforce this interpretation. It is supported likewise by the work of Schaefer[14], showing definite changes in indicator oil expansion patterns in films spread from previously 'denatured' protein; it may be significant that insulin and gliadin showed expansion patterns indistinguishable from those of other proteins which had been previously modified by treatment with heat or ultra-violet radiation.

Full experimental details of the work of which this is a part are to be published elsewhere. [Sept. 2.

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# OPTICAL DESIGN OF DOUBLE-BEAM SPECTROMETERS

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As a result of recent work on a fast-scanning double-beam spectrometer[1], which gave opportunities of examining beam balance over a range of wave-lengths while adjustments were being made to the optical system, two fundamental and rather obvious conditions were proposed which should be fulfilled by any adequate design. These were: (i) that in any plane in which the source or monochromator slits form an image the light distribution should be the same for both beams; and (ii) that in any plane in which the collimator or field forms an image the light distribution should be the same for both beams.

Non-fulfilment of the former may lead to an effect by which a displacement in wave-length occurs between the spectra of the two beams. Equality of the beams is therefore more difficult to obtain the more rapid the rate of change of energy with wave-length in the spectrum. In place of strict equality of the beams at all wave-lengths, a difference spectrum appears which resembles a differentiated version of the energy – wave-length relation for one of the beams alone.

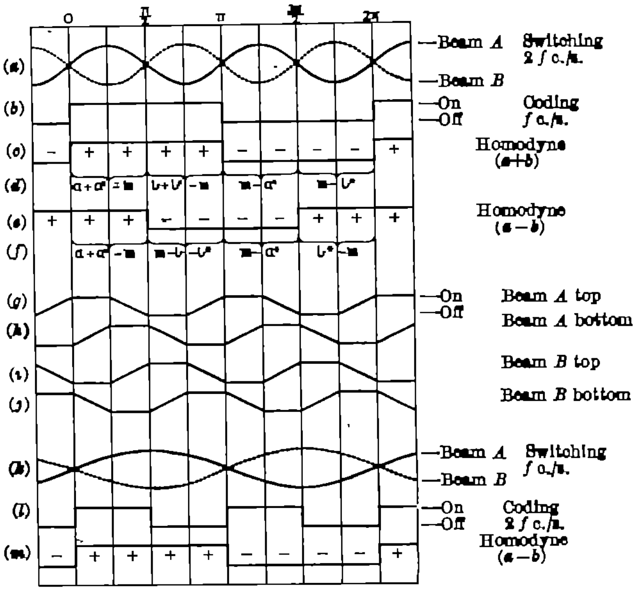
When the second condition is not fulfilled, any variations, within the radiation field, of transmission of prism and windows or of reflexion of mirrors may lead again to an inequality of the beams which varies with wave-length. This effect exhibits a rather slow change with wave-length and tends to become more pronounced as a prism transmission limit is approached.

These conditions are of fairly general application and have been used, as indicated by the following examples, in the design of a conventional recording infra-red spectrometer.

In obtaining a percentage transmission plot in a double-beam infra-red spectrometer, the null-balance method described by Lehrer[2], Wright and Herscher[3] and many others is convenient and widely used. In this, a comb-like shutter is introduced into one beam with the object of reducing the intensity of this beam until it is equal to that of the other beam containing the absorbing sample. From the position of this comb along its line of motion normal to the beam, the percentage transmission of the sample is read off. If such a comb is placed at the focus of the beam, it is clear that the first condition cannot be fulfilled, except at 100 per cent transmission, which in practice might be used for beam balancing adjustments and so conceal the effect. If the comb is used near but not at a focus, neither condition will be fulfilled. It may be noted that imperfection in the slits, in the quality of image or curvature compensation, or in uniformity of the radiation detector surface, make it possible for equal radiation powers entering different elements of the slit to produce very unequal effects.

Thus it appears that only a time-sharing type of shutter may fulfil the two conditions perfectly. We have accordingly examined the possibility of using a rotating star wheel to take the place of the comb shutter and to operate at a focus. This shutter has been designed as a wheel having twenty-four approximately triangular teeth disposed around its circumference, the depth of the teeth being 50 mm., which is thus the traverse required to cover the 0–100 per cent transmission range. It is necessary that the rotation of this wheel should be synchronized with the beam-switching mechanism, and also that several complete revolutions of the wheel should take place during one beam-switching cycle, to avoid errors arising from eccentricity or imperfections of the teeth. Such a shutter, of correct tooth form, will have negligible error on small slit-widths but will be subject to the averaging and end errors, arising at large slit-widths, which are common to both the space-sharing and time-sharing types of shutter.

A second application of the conditions arises in the adaptation of the principle of the multiple-pass monochromator described by Walsh and others[4-6] to a double-beam spectrometer. The design which we have adopted is based on a beam-switching mechanism consisting of continuously rotating sector disks giving a switching frequency of $2f$ c./s. and a coding shutter (the equivalent of the chopper used in Walsh's arrangement) operating at $f$ c./s. and synchronized with the beam switch. Two homodyne detectors, one synchronized with the coding shutter and one $\pi/2$ out of phase with it, give outputs from which the stray light components have been eliminated and which correspond to the sum and difference of the two beams respectively, the sum output being used to control recording speed and the difference output to control the null-balancing and recording servo-mechanism.



Phasing relations between beam switch, coding shutter and homodyne gates are indicated by the accompanying chart. For mechanical reasons the beam switch gives a gradual change-over from beam $A$ to beam $B$ and back, as shown at ($a$), while the coding shutter gives a rather rapid change-over indicated at ($b$). Homodyne detector gating signals are shown in ($c$) and ($e$), + indicating passage unchanged and − inversion of the signal. Using a notation in which $a$ represents the intensity of the wanted component of beam $A$ and $a^*$ the stray component, $b$ the wanted component of beam $B$ and $b^*$ the stray component, and $m$ the mean intensity over the cycle, the homodyne outputs are shown by ($d$) and ($f$), the D.C. output-level being proportional to the algebraic sum of these over one complete cycle.

It is necessary, in order to fulfil the optical conditions, that the duration of irradiation of each element of the collimator should be the same for beams $A$ and $B$. That this is the case may be inferred from ($g$) to ($j$), in which the intensities of illumination of the top and bottom halves of the collimator are indicated diagrammatically for both beams. When the illuminated portions occurring in the second quadrant are subtracted from those occurring in the first quadrant, it is seen that those parts during which the illumination is changing cancel out, leaving full illumination of the collimator by beam $B$ for $\frac{1}{4}$ cycle to be subtracted from full illumination of the collimator by beam $A$ for $\frac{1}{4}$ cycle. It is evident that the cancellation of stray light will be efficient, since the beam switch is in the same phase during the two quadrants for which signals are subtracted in the homodyne detector.

Mechanical considerations might suggest that operation of the beam switch at $f$ c./s. and the coding shutter at $2f$ c./s. would be preferable; but it will be seen that such a system, though otherwise practicable (see ($k$) to ($m$)), does not fulfil the optical conditions, the net effect being that in the $a-b$ homodyne case the top half of the collimator is used for one beam and the bottom half for the other. A system similar to this but using a reciprocating beam switch mechanism has been described by Rochester.

I am indebted to the directors of Unicam Instruments (Cambridge), Ltd., for permission to publish this communication. [Sept. 18.

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# CLASSIFICATION OF MYXOMA AND FIBROMA VIRUSES

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INTEREST in the classification and nomenclature of the animal viruses has been stimulated by the discussions at the Fifth International Congress of Microbiology at Rio de Janeiro[1]. The occurrence in Australia during the summer seasons of 1951 and 1952 of severe and widespread epizootics of myxomatosis among the wild rabbits[2] has redirected attention to this virus, and it is appropriate to consider the question of its classification, that is, its relationship to other animal viruses.

Eight criteria to be applied in classifying animal viruses were laid down by the virus sub-committee at Rio de Janeiro. We will discuss these in turn, and see if light can be thrown on the classification of myxoma virus in this way.

(1) *Morphology and method of reproduction.* There is general agreement that morphology and size are among the most important features in the determination of the broad (generic) relationships of the animal viruses. Stained smears of the elementary bodies of myxoma virus[3] and fibroma virus[4] showed that they resembled vaccinia virus in their size and shape.

Only one study[5] of myxoma virus with the electron microscope has been published, and no electron micrographs of fibroma virus have been printed. However, recent work[6] extends our knowledge of the morphology of these viruses. The elementary bodies of myxoma virus were found to measure 286 μμ × 230 μμ by Farrant and Fenner[6], and 287 μμ × 233 μμ by Ruska and Kausche[5], dimensions almost the same as those of vaccinia virus elementary bodies photographed under the same conditions. More careful examination of metal-shadowed elementary bodies of myxoma virus revealed the central 'condensation' observed also in vaccinia and fowlpox viruses. Treatment with pepsin produced the appearance of a clearly defined central body which resisted peptic digestion[6]. Similar results have been obtained after pepsin treatment of vaccinia[7] and fowlpox[8] viruses. Bang[9] found that, in electron micrographs of sections of chick chorio-allantoic membrane, elementary bodies of myxoma virus were indistinguishable from those of vaccinia virus[10].

It is clear that myxoma is almost the same size, and has the same external shape and internal architecture, as vaccinia and fowlpox viruses.

A few exploratory investigations have been made of the mode of reproduction of vaccinia virus. Infectivity titrations at frequent intervals during the first forty-eight hours, using the chorio-allantoic membrane of developing chick embryos[11] and tissue cultures of the rabbit skin[12], have been interpreted as demonstrating that the same sequence of events occurred as had been found with bacterial viruses[13] and influenza virus[14]. There was a sharp reduction in the amount of infective virus immediately after infection, and no increase could be detected for about eight hours[11] or ten hours[12]. Briody and Stannard[11] observed another sharp rise sixteen hours after the initiation of infection. Preliminary experiments[15] with myxoma virus grown on the chorio-allantoic membrane gave results very similar to those obtained with vaccinia virus. Less than 1 per cent of the inoculated virus could be recovered from the membrane during the first six hours after inoculation. Demonstrable unabsorbed virus and losses during the preparation of the membrane suspension accounted for only 8 per cent of the 'lost' infectivity, so that with myxoma virus also there is an unexplained disappearance of infective virus during the first few hours after inoculation. Eight hours after inoculation there was a slight increase in the infective titres of the membrane suspension, of doubtful significance, and between the sixteenth and twentieth hours the titre increased a hundredfold. The results with both vaccinia and myxoma are too fragmentary to allow any definite conclusions to be drawn concerning their mode of reproduction, but so far no inconsistencies in the behaviour of the two viruses have become apparent.

Studies have also been made of the life-cycle of vaccinia virus in the chorio-allantoic membrane of the chicken embryo with the electron microscope[10,15,16]. The most important conclusion derived from these investigations is that the nucleus probably plays an important part, for the earliest virus particles appear to form at the nuclear wall. No reports have been published of the appearances of cells infected with myxoma virus.

(2) *Chemical composition and physical properties.* The only chemical study made of myxoma virus is that of Balls *et al.*[17]. They found a peculiar lipoid (not cholesterol) in the centrifuged deposit of an elementary body preparation. The nitrogen, phosphorus and lipoid content of this sediment were much the same as the corresponding figures for vaccinia virus and the Rous sarcoma virus.

Schlesinger and Andrewes[18] carried out filtration and centrifugation experiments with fibroma virus. They found that the diameter of the virus, estimated by filtration through graded membranes, was about the same as that of vaccinia (125–175 μμ) and by centrifugation 126–141 μμ. The specific gravity of the virus was estimated at 1·3.

(3) *Immunological properties.* Myxoma and fibroma viruses are closely related antigenically[19], and myxoma virus, which has been investigated in some detail[20], is antigenically complex, having at least two soluble antigens. Neither virus appears to be capable of agglutinating red blood cells[21].

There is no immunological relationship between myxoma virus and vaccinia virus, and no antigenic comparisons have been made with other viruses of the same size and shape.

(4) *Susceptibility to physical and chemical agents.* One of the few satisfactory studies of heat-inactivation of animal viruses is that of Bronson and Parker[22] with myxoma virus. Because no comparable data were available on other viruses of the same size and shape, similar investigations were carried out with a number of viruses of the pox group[23]. Some of the results are summarized in the accompanying table. They are expressed as the time required to inactivate,

TIME (IN MINUTES) REQUIRED TO REDUCE THE INFECTIVE TITRE OF SUSPENSIONS OF VIRUS IN NORMAL RABBIT SERUM FROM $10^7$ TO ZERO, BY HEATING AT 55° C. THE RESULTS OF DUPLICATE EXPERIMENTS ARE SHOWN

| Myxoma | Fibroma *O.A.* | Vaccinia | | Cowpox | Ectromelia | Fowlpox |
|---|---|---|---|---|---|---|
| | | Gillard | Mill Hill | | | |
| 24, 25 | 11 | 82, 74 | 125, 155 | 62, 53 | 48, 42 | 54, 45 |

by heating at 55° C., suspensions of a number of viruses in normal rabbit serum, the initial concentration in all cases being $10^7$ infective particles/ml. The figures shown were determined by extrapolation of the straight lines obtained when the infectivity (on a $\log_{10}$ scale) was plotted against the time of heating. There was some variation between different strains of vaccinia virus; but myxoma and fibroma viruses appeared to be more susceptible to inactivation by heat than any of the other viruses tested.

Andrewes and Horstmann[24] regard resistance to ethyl ether as a property which might be useful in the classification of viruses, since in many cases it runs parallel with distinctions made on other bases. We[25] were able to confirm their observations of the sensitivity of myxoma and fibroma viruses, and the resistance of vaccinia, fowlpox and ectromelia viruses to ethyl ether. However, when a number of viruses were tested for inactivation by certain surface-active agents (sodium lauryl sulphate, sodium deoxycholate, and saponin)[26], myxoma virus was found to resemble fowlpox, vaccinia and ectromelia viruses and to differ from a number of other viruses in the high degree of resistance it showed to these chemicals.

(5) *Natural methods of transmission*. The natural method of transmission of fibroma virus is not known, though it may well be mechanical carriage by insect vectors[27]. Myxomatosis may be transferred by contact[28] or by exposing rabbits to a virus-containing mist[29]; but in Nature transmission is effected principally by insect vectors[2] and, at least in the most important vector, the mosquito, is purely mechanical in nature, being due to contamination of the mouthparts by virus in the skin lesions[30]. The modes of transmission of myxomatosis are quite similar to those of fowlpox[31].

(6) *Host, tissue and cell tropisms*. Both myxoma and fibroma have a limited host-range, rabbits of the genus *Sylvilagus*[32,33] and *Oryctolagus*[32,34], the developing chick embryo[35,36] and the developing duck embryo[37] being the only susceptible hosts. While vaccinia has a very wide host range, other characteristic members of the pox group (variola, mousepox) have a restricted host range.

Both myxoma[38] and fibroma[39] cause a generalized disease in the laboratory rabbit, which is characterized by a primary lesion at the site of inoculation of the virus and secondary localization in the skin about a week later[40]. This train of events resembles closely that encountered with mousepox[41], and vaccinia in rabbits[42].

(7) *Pathology, including formation of inclusion bodies*. The strains of myxoma and fibroma viruses isolated from naturally occurring cases induce at first proliferation in the cells which they attack, followed later by necrosis. A variant strain of fibroma virus (*IA*) causes inflammation and necrosis from the outset. While these properties have led many investigators in the field of oncology to study the myxoma and fibroma viruses, they cannot be considered as of much importance from the point of view of taxonomy. Vaccinia and fowlpox viruses also cause hypertrophy and hyperplasia of infected cells[43].

Both myxoma and fibroma viruses produce acidophilic intracytoplasmic inclusion bodies in the epithelial cells of infected skin lesions[44,45], and in the ectodermal cells of the chorionic membrane of the chicken embryo[46], and in this they resemble the viruses of the pox group.

(8) *Symptomatology*. There is little left to be said of symptomatology which has not been mentioned earlier. Virologists concerned with the animal viruses are doubtful whether it has much importance in classification of these viruses.

## Summary

The points of resemblance of myxoma virus and accepted members of the pox group of viruses are so numerous, and the detailed morphological similarities of the elementary bodies so great, that the conclusion is inescapable that myxoma virus (and fibroma virus) should be included within the pox group. Of all the characters examined, myxoma and fibroma virus differ from viruses like fowlpox and vaccinia only in their sensitivity to ethyl ether. It would appear more logical to doubt the absolute importance of this property than to base the exclusion of myxoma virus from the pox group upon it.

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## LETTERS TO THE EDITORS

*The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications*

### A Fast and Efficient Neutron Detector

MEASUREMENTS of the variation of neutron cross-section with neutron energy have been made at Harwell using an electron linear accelerator pulsed neutron source, and a time of flight spectrometer technique[1]. In these measurements a boron trifluoride proportional gas counter was used, and in order to obtain an adequate efficiency of detection it was necessary to use a rather large gas volume. This counter limited the neutron energy resolution in two ways: at low neutron energies (10 eV.) the counter length of 50 cm. was the main indeterminacy in the neutron flight distance, and at high neutron energies (keV.) there was the additional and larger indeterminacy in the ion collection time in the counter.

Various alternative detection methods have been tried with the object of combining a more rapid response with increased neutron capture, and it now seems necessary to adopt some form of scintillation detector containing boron[2,3]. In the present investigation, the most promising substance tried was borazole[4], $B_3N_3H_6$. Solutions of borazole in *para*-xylene, with *para*-terphenyl added to a concentration of 5 gm. per lit., have the following useful properties: (1) processes of exciton transfer in xylene are not quenched by the borazole; (2) scintillation pulses obtained by irradiation with polonium alpha-particles are proportional in intensity to the molar concentration of xylene; (3) scintillation response time is less than $10^{-8}$ sec. Thus, for example, an equimolecular solution of borazole in xylene is a detector with a boron density increased by a factor of 400, and a response time shortened by a factor of 100, when compared with the boron trifluoride counter.

I am indebted to Mr. W. L. Borrows, of the Admiralty Research Laboratory, Teddington, for the preparation of the borazole. I also wish to thank Dr. K. W. Bagnell for information about borazole and guidance on boron chemistry, and to acknowledge the help and encouragement given by Dr. E. Bretscher and Mr. G. N. Harding.

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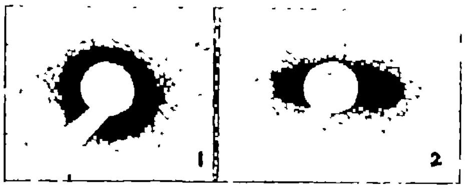
### Low-angle X-Ray Diffraction of Bone

THE study of diffuse scattering of X-rays at low angles has been used for evaluating the size of crystallites and of particles[1]. We have applied this technique to bone tissue in order to study the arrangement of hydroxylapatite crystallites in this structure.

Earlier wide-angle investigations have shown that the *c*-axis of the hydroxylapatite unit cell is parallel to the fibre axis of the collagen[2]. This arrangement can also be demonstrated in *in vitro* experiments[3].

Longitudinal- and cross-sections of compact bone from several animals were prepared by grinding. The sections were about 0·1 mm. thick. Both wide-angle and low-angle diffraction patterns were registered simultaneously on films placed at different distances from the sample. Nickel-filtered copper radiation was used. In Fig. 1 is shown the low-angle diffraction pattern from a cross-section of bone, and in Fig. 2 the pattern from a longitudinal section (longitudinal axis of bone is vertical). The wide-angle and low-angle diffraction patterns from cross-sections showed no appreciable orientation, but in the case of longitudinal sections the low-angle scatter showed marked equatorial orientation, and the 002 reflexion in the wide-angle pattern showed meridional intensifications. In bone, therefore, the hydroxylapatite crystallites are elongated with their long axes parallel to the collagen fibres.



Estimations of the short dimension of the crystallite (the width) gave an approximate diameter of 60–80 A. When estimating the long dimension of the crystallites, the small-angle meridional diffraction of the collagen interferes. Several orders of a fundamental spacing of about 660 A. were obtained from the intact bone tissue. The long dimension is estimated to be about three times the width.

Full details of this work will be published elsewhere.

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### Shadow Microscopy for Measurement of Height

THIS note describes a simple optical microscope shadow technique which permits measurement to be made of the heights of small objects such as particles, spores, steps on surfaces, etc., and also reveals qualitative surface topographical features in a striking manner. This is an optical analogy to the familiar metallic shadow-casting method which is used with electron microscopes. I have used it with powers up to that of a 4-mm. objective.

When an object on a specially prepared slide on a microscope stage is illuminated by a parallel light pencil at incidence near to grazing, then a reasonably sharp long shadow is cast on to the slide. Provided the object is appreciably larger than the wave-length of the light used, then the ratio of shadow-length to object-height is the tangent of the angle of incidence. For grazing angles of 5° and 3° the respective lengths

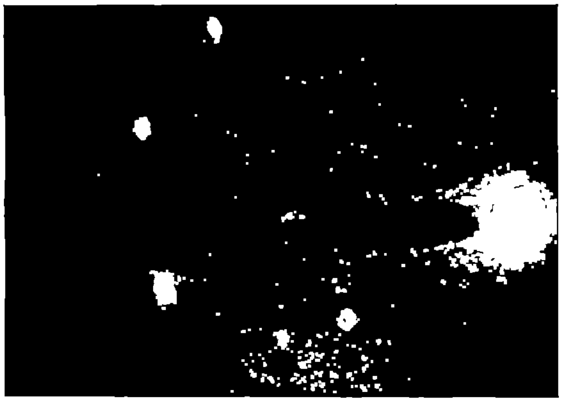

Fig. 1. Lycopodium and *Trichoderma viride* spores: microscope, × 240; shadow, × 12; total, × 2,900. (Reduced in reproduction to about a half)

of shadows are some 11 and 19 times the object height. Thus with a microscope magnification × 500, the magnification of height in a shadow at incidence slightly less than 3° has the astonishing value of × 10,000. Such magnifications are not always necessary, but are available if needed.

A bright parallel beam of some 1 mm. diameter is projected on to the object by a lens stopped down with an iris. The angle of incidence, and thus the shadow-length magnification, is adjustable by raising or lowering the illuminating lens. The angle of incidence need not be measured, as the introduction into the field of view of approximately spherical particles of measurable diameter secures calibration for any particular illumination set up, irrespective of the power of the microscope objective used. Thus any convenient spherical particles can be used for establishing the shadow magnification, for then the visually observed diameter is equal to the height. Alternatively, the ratio of length to width of shadow gives the magnification ratio.

Lycopodium powder is quite suitable for this purpose as the particles are reasonably spherical and easily measured.

An essential basic feature of this technique lies in the correct preparation of the surface receiving the shadow. This will usually be either (*a*) a slide to receive small objects such as particles, filaments, grains, crystals, biological objects, etc., (*b*) the surface of, say, a crystal, metal or some other extended object with topographical features on it. The surface receiving the shadow must be a reasonably flat fine-grain scattering surface. For example, if lycopodium be scattered on to a glass slide, shadow-casting illumination will produce no shadow at all. The system behaves like dark-ground illumination pushed to the limit and one sees the brightly illuminated particles, without any shadow, for no light scatters up to the microscope from the polished glass surface. A number of suitable surfaces have been developed, but by far the best is to deposit on a slide a layer of silver and then expose this to aqua regia vapour, which converts it into a cloudy white matt fine-grain deposit, capable of producing shadows of high definition when particles are placed on it. The fine grain is the important point. To examine the topographical features of, say, a crystal, this is first coated with silver and then exposed to the aqua regia vapour, thus creating the matt surface *in situ*. The dark shadows for particles will often be bordered by brighter diffraction edges. By photographing on to a reasonably contrasty plate a sharp clean finish to the shadow obtains and both shadow-length and -width can readily be measured.

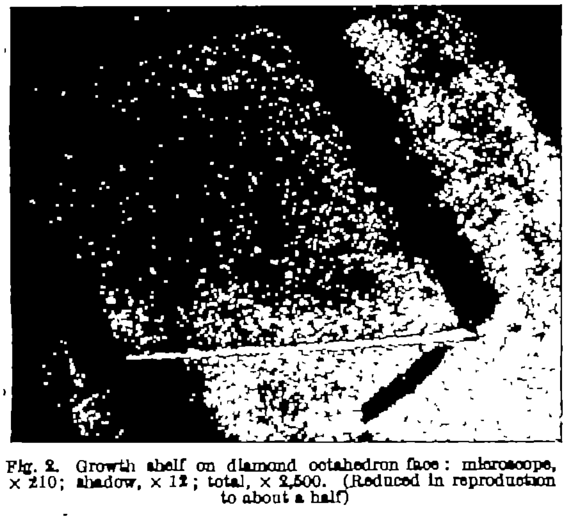

Fig. 2. Growth shelf on diamond octahedron face: microscope, × 210; shadow, × 12; total, × 2,500. (Reduced in reproduction to about a half)

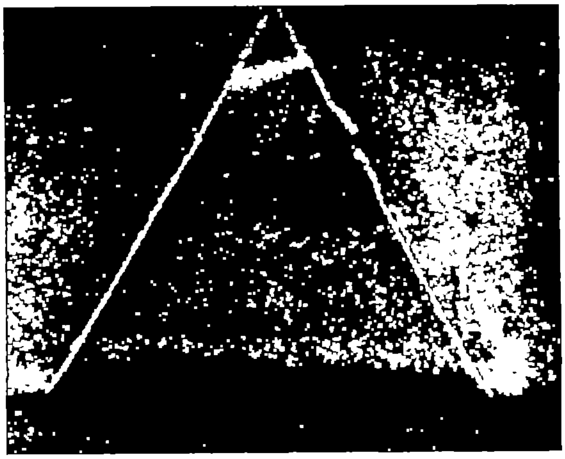

Fig. 3. Hollow growth trigon on diamond octahedron face: microscope, × 210; shadow, × 12; total, × 2,500. (Reduced in reproduction to about a half)

Typical applications are shown in the accompanying figures. Fig. 1 shows spores of *Trichoderma viride* and a lycopodium particle using × 240 magnification in the microscope. The magnification in shadow is × 12, which makes the total effective magnification of height about 2,900 in the shadow. Fig. 2 shows at × 210 and shadow magnification at × 12 growth shelves on a diamond octahedral face. A further example in which total shadow magnification is also × 2,500 is shown in Fig. 3, which is a hollow trigon depth about 3 μ. When such an object rotates, the shadow of a ledge sweeps round, vanishing when the ledge is parallel to the direction of the incident light pencil. On further rotation the front of the ledge then becomes a brightly illuminated wall and there is still no shadow.

It is clear that this shadow technique has wide applications. An experimental study is being made now of the lower limit of height which will reveal a detectable shadow. It is to be expected that diffraction will confuse the situation considerably for very small particles and this is under examination.

This is largely a technique for studying features above the general level, that is, particles, hillocks, shelves, elevations, etc., rather than one for looking into hollows, unless in fact the hollow has a much larger flat bottom extension than its height. In some cases contrast is decidedly improved by plane polarizing the illuminating beam, largely through cutting out scatter from the object.

It should be noted that the shadows of single particles may at times be forked or show a multiple structure, revealing thus unsuspected peaks or valleys on the surfaces of the particles. The patterns given by transparent crystallites require to be interpreted with reference to the possible transmitted light which can appear within the centre of the shadow.

Quite apart from the height-measuring capabilities of this system, the grazing illumination on the fine-grain matt surface turns out to be a new vivid technique for revealing topographical features by creating new contrasts. It is, of course, a modified form of controlled and heightened dark-ground illumination. One sees far more by this technique than by direct microscopy.

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## Polarized Ultra-Violet Absorption of Anthracene

Theoretical calculations of $\pi$-electron states in aromatic molecules give values for three important properties of spectral transitions. These are the wave-length, intensity and polarization of the band systems which correspond to jumps between the calculated states.

Finding the polarization of observed band systems to check the calculations is more difficult than finding the wave-length and intensity, and has not often been attempted in aromatic hydrocarbons except in the weakest band systems, for which quite thick crystals give measurable optical densities[1,2]. However, by working with the thinnest sublimation flakes that could be transferred without shattering to a silica plate, we have now measured the polarizations of some stronger systems in the near ultra-violet spectrum of anthracene.

The thinnest of these crystals show retardations under the polarizing microscope of less than 100 $\mu\mu$ and are pale gold, or occasionally blue, by reflected light. Their thickness is of the order of $0{\cdot}1\,\mu$. Specimens examined by X-rays invariably show that the developed face is a (001) plane, and this contains the $a$- and $b$-crystal axes which are mutually perpendicular. The positions of the $b$-axis were found either by means of X-rays or microscopy, and the crystal mounted on a rotating stage with its face perpendicular to the optic axis of a Hilger Littrow quartz spectrograph. Light passed through the crystal into a quartz Wollaston prism and on to the slit, the two beams of plane-polarized light being about 4 mm. apart. The optical densities for the two directions of polarization were measured by sector photometry against equally long exposures of the light source without the crystal. The ratio of these optical densities for electric vector directions parallel to the $a$- and $b$ crystal axes was compared with that calculated from the known inclinations of molecular axes within the crystal.

The spectral range accessible to the quartz spectrograph includes three regions of absorption, each corresponding to a distinct band system of anthracene. In the systems at 3800 A. and 2700 A., absorption is greater for the electric vector parallel to the $b$-crystal axis; in the system at 2300 A. absorption is less for the $b$- and greater for the $a$-direction. These results cannot at once be put in terms of molecular axes, since three molecular axial directions cannot be characterized from two crystal directions. However, much evidence suggests the inactivity in transitions in the near ultra-violet of one of the molecular axes, namely, that normal to the plane of the rings; and if this inactivity be accepted, it follows from our results that the band system at 2700 A. is polarized along the shorter in-plane axis, that the system at 3800 A. has at least a strong component along this axis, and that the system at 2300 A. is polarized along the longer in-plane axis.

There is clear evidence in the 3800 A. band system of the displacement of the absorption maxima in $a$-polarization from those in $b$-polarization, so that the whole band system appears to be displaced as well as changed in intensity, as the polarization direction of the incident light changes in the $ab$ face. The split maxima have separations in the range 50–100 cm.$^{-1}$. This may be the phenomenon, a theory of which was first given by Davydov[3], in which intermolecular forces split the molecular energy-levels into pairs of crystal states with different polarization properties.

These preliminary results will later be incorporated in a more complete report. We wish to acknowledge valuable discussions with Prof. C. K. Ingold. We have also received important help from Dr. H. G. Poole, who designed the optical arrangements, and from Mr. Philip Knight, who made several X-ray examinations of anthracene crystals and so made possible their correct orientation in the light beam.

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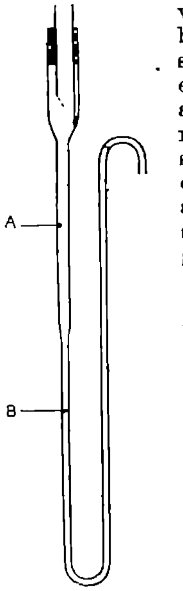
## Estimation of the 9 : 10-Dihydroxystearic Acids and their Acyl Derivatives

The occurrence of esters of 9 : 10-dihydroxystearic acid (melting point, 132°) among the autoxidation products of oleic and elaidic acids has been established by Ellis[1], who utilized the sparing solubility of the dihydroxy acid for its isolation and estimation. In the presence of a high proportion of oily products, however, a quantitative separation of the acid is sometimes difficult, and the presence of silica following prolonged alkaline hydrolysis may also be a source of error.

The method of estimation to be described takes advantage of the fact that, under suitable conditions, periodic acid oxidizes the 9 : 10-dihydroxystearic acids almost quantitatively to nonaldehyde and azelaic semialdehyde[2], of which the former may readily be isolated by distillation in steam and its



volume measured. The reaction is best carried out in feebly alkaline solution, avoiding an unnecessary excess of periodate. Thus, an amount of material containing not more than 1 gm. of dihydroxystearic acid is dissolved in 100 ml. of seminormal sodium hydroxide and brought to $p$H 8 with dilute sulphuric acid. After adding 0·2 gm. (0·75 gm. if the amount of dihydroxy-acid is thought to exceed 0·25 gm.) of potassium periodate, the solution is distilled at a moderate rate through a simple water-cooled condenser into a trap (see diagram), in which the non-aldehyde collects as a nearly insoluble oil on the surface of water in the tube *A* (bore 3·5 mm.; length 7·5 cm.), while the aqueous part of the distillate siphons over into a measuring cylinder[1,2]. When no further aldehyde distils over and some 20 ml. of water has been collected, the trap is detached and the oil run into the capillary *B* (bore c. 1·75 mm.), where its depth is accurately measured after standing for 10 min. or more. The capillary may be calibrated by oxidizing pure dihydroxystearic acid (melting point, 132°) under the same conditions; or, if the bore of the capillary is known, the mass of non-aldehyde (*d*, 0·827) can be calculated, an allowance of 0·001 gm. being made for its solubility in 20 ml. of aqueous distillate. The yields of nonaldehyde (Table 1) range from 82 to 95 per cent of the theoretical and, except for very small amounts, are reproducible to within ± 2·5 per cent; but it is important that the still and trap should be cleaned with chromic-sulphuric acid and well washed prior to each estimation. The isomeric dihydroxy-acid (melting point 95°) gives almost identical results.

Table 1

(*a*) Using 0·20 gm. of potassium periodate

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Dihydroxystearic acid (mgm.) | 25 | 50 | 75 | 100 | 125 | 150 | 175 | 200 | 225 | 250 |
| Nonaldehyde (mgm.) | 10 | 18·5 | 28·5 | 39 | 49 | 59 | 70·5 | 84·5 | 96·5 | 108 |

(*b*) Using 0·75 gm. of periodate

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Dihydroxystearic acid (mgm.) | 100 | 200 | 300 | 400 | 500 | 600 | 700 | 800 | 900 | 1,000 |
| Nonaldehyde (mgm.) | 37·5 | 80 | 120 | 163 | 207 | 252 | 295 | 340 | 385 | 422 |

For the estimation of acyl esters of dihydroxystearic acid, 0·75–1·0 gm. of the material is saponified by refluxing or, where volatile hydrolysis products are formed[1,4], slowly distilling with 100 ml. of seminormal aqueous sodium hydroxide for 2 hr. The cooled solution is diluted if necessary to about 100 ml., brought to $p$H 8 and distilled with periodate as described. When estimating esters in autoxidized oleic or elaidic acid, certain corrections may be necessary. First, elaidic acid oxide, which is normally present[4], is saponified to dihydroxystearate under these conditions to a variable extent. The amounts of nonaldehyde arising from this source are given in Table 2. Secondly, 10-hydroxy-9-ketostearic acid similarly gives a good yield of nonaldehyde on oxidation with periodate[5]; but except during the advanced stages of autoxidation neither this nor free dihydroxystearic acid appears to occur in significant amount in these products, as may be shown by distilling the unsaponified material at $p$H 8 without and with periodate.

Table 2

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Elaidic acid oxide (mgm.) | 25 | 50 | 100 | 150 | 200 | 250 | 300 | 400 | 500 |
| Nonaldehyde (mgm.) | 8 | 9·4 | 11 | 12·1 | 13 | 14 | 14·7 | 16·1 | 17·3 |

A few typical results are summarized in Table 3.

Table 3

| | Dihydroxystearic acid (per cent) | | |
|---|---|---|---|
| | Present, or theoretical value | Found | |
| | | Periodate method | Isolation method |
| Mixture of dihydroxystearic acid (m.p. 132°), and elaidic acid | 20·0 | 19·9 | 19·7 |
| Mixture of dihydroxystearic and oleic acids | 20·0 | 19·4 | 16·2 |
| Mixture of dihydroxystearic and nonanoic acids | 66·7 | 67·8 | — |
| Autoxidized elaidic acid (corrected value) | — | 7·0 | 5·5 |
| Oily fraction of the above, insoluble in *n*-hexane | — | 12·4 | 6·7 |
| Impure mono-azelaate of dihydroxystearic acid, after saponification | 65·0 | 62·2 | 62·4 |
| 9 : 10-Hydroxyacetoxystearic acid (m.p. 81°) after saponification | 88·3 | 85·5 | — |

The scope of the periodate reaction is well known[6] and the method should be applicable to other suitable 1 : 2-glycols or ketols.

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## Hardening of Kaolin on Rehydration

An investigation of the durability of fired clay minerals revealed an unexpected hardening of kaolin on rehydration. Samples from Gordon, Victoria, fired at 500°–950° C., followed by rehydration in saturated steam at 200° C. for periods up to 96 hr., showed compressive strengths for small cylinders of 5,000–14,000 lb./sq. in., compared with strengths of 1,000–2,000 lb./sq. in. before rehydration. The compressive strength of the kaolin fired at 1,250° C. was 4,000 lb./sq. in.

X-ray analysis of the rehydrated kaolin indicates that the increase in strength may be related to a higher crystal symmetry, since the powder pattern has fewer lines, with *k* reflexions absent or reduced in intensity. Electron micrographs of the original material before and after firing show well-formed hexagonal flakes, whereas the rehydrated kaolin is composed of clusters of much smaller and more irregular particles similar in appearance to those of the 'third form' of kaolin discussed by Bramao *et al.*[1]. This kaolin, however, differs from the rehydrated material in having a disordered structure.

Differential thermal curves show a large endothermic peak at 130°–150° C., followed by a continuous endothermic reaction up to the main endothermic peak at 550° C., some 70° C. lower than the corresponding peak in the original kaolin. The final exothermic peak is unaffected. Activation energy for the main dehydration process calculated from the differential thermal curves is about 40 kcal. for the rehydrated kaolin, compared with 55 kcal. for the original material. The slope ratio of the main endothermic peak is 4–1 for the rehydrated material, a figure which has been thought characteristic of halloysite[1]. The slope ratio for the untreated kaolin is 1·25–1.

Preliminary tests on other materials indicate that the hardening effect occurs in relatively well-crystallized kaolins.

Possible industrial applications of the phenomenon are being investigated.

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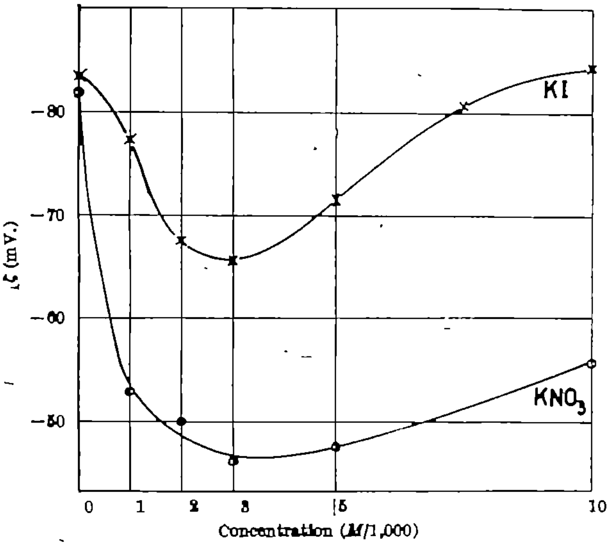
## Centrifugation Potentials in Sols of Silver Iodide

If a sol is centrifuged, an electrostatic potential difference is set up between two points in the sol at different distances from the axis of rotation (centrifugation potential)[1]. These potentials are connected with the $\zeta$-potential of the colloidal particles by the formula:

$$V_{\mathrm{C.P.}} = \frac{m'n}{\sigma}\,\frac{D\zeta}{6\pi\eta}\,\frac{\omega^2}{2}\,(R_2^2 - R_1^2). \qquad (1)$$

Here $m'n$ is the apparent mass of dispersed substance per cm.$^3$, $\sigma$ the electrical conductivity, $\eta$ the viscosity, $D$ the dielectric constant of the sol, $\omega$ the angular speed of rotation, and $R_2$, $R_1$, the distances from the axis of the two points between which the centrifugation potential is measured. Conversely, from the value of $V_{\mathrm{C.P.}}$, $\zeta$ can be calculated; therefore the measurement of centrifugation potentials is of considerable interest.



Values of $\zeta$ in sols of silver iodide after the addition of potassium nitrate and of potassium iodide

Extensive measurements of these potentials in sols of arsenic trisulphide have been made by G. Jacobs[2]. One of his results, and certainly the most unexpected, was the shape of the $\zeta - c$ curves for the addition of indifferent electrolyte (potassium nitrate). Between 0 and 3 millimol./l., $\zeta$ decreases from − 100 to − 73 mV. and then rises slowly again.

We decided to repeat these measurements, in order to see whether Jacobs's result was a general one, for sols of silver iodide. To obtain the necessary quantities a continuous electrodialyser was constructed[3]. We prepared a concentrated sol, containing 50 gm./l. of silver iodide; the coarsest particles were eliminated by pre-centrifugation, resulting in a sol of about 20 gm./l. with which the measurements were made.

The results are shown in the accompanying graph; the reproducibility of the points was about 3 per cent. There is again a strong decrease of $\zeta$, followed by a slow increase, for the addition of indifferent electrolyte; for the addition of potential-determining electrolyte, there is also a decrease of $\zeta$, followed by a much more marked increase. This last feature is in agreement with expectation, and gives us confidence in the experimental procedure; the first result is quite unexpected, and, so far as we are aware, cannot be explained by the current theories of the double layer. In fact, these theories always lead to a monotonic change of $\zeta$ with concentration.

We are proposing to make simultaneous measurements of $\zeta$ and $\varepsilon$ (the total potential) in order to obtain more insight into this problem.

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## Curves of Succinoxidase Inhibition by Surface-active Agents

Inhibition of the succinoxidase system by a variety of surface-active agents has been noted by Hockenhull[1]. The inhibition of this enzyme system by certain water-soluble androgens has recently been demonstrated[2]. The effect of these androgens suggested a surface phenomenon[3].

Two detergents were therefore studied in this laboratory to compare curves of inhibition with those found for the androgens. Sodium deoxycholate was chosen because it is both an ionic detergent and a soluble steroid salt. Polyoxyethylene sorbitan monolaurate ('Tween 20') was the neutral detergent used. The manometric technique employed was that described in Umbreit's text-book[4]. The accompanying curves (Figs. 1 and 2) show the influence of detergent concentration on the succinoxidase system of rat liver.

The sigmoid shape of these curves is similar to that of curves obtained when sodium androsterone sulphate is the inhibiting agent. If we consider per cent inhibition analogous to uptake of inhibitor by the enzyme system, we may compare the curves obtained here with adsorption curves in other system For example, Coolidge[5] found this type of curve the adsorption of water vapour by charcoal ur conditions of increasing vapour pressure. Evid derived from the work with androgens indicate

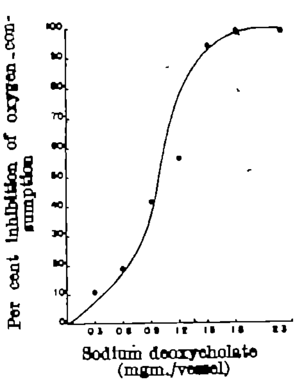

Fig. 1

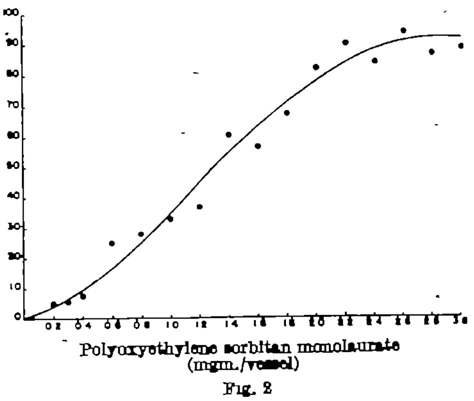

Fig. 2

Fig. 1. Effect of concentration of sodium deoxycholate on the succinic dehydrogenase system

Fig. 2. Effect of concentration of polyoxyethylene sorbitan monolaurate ('Tween 20') on the succinic dehydrogenase system

succinic dehydrogenase is the target of the inhibitor[5]. It is suggested that the mechanism of inhibition of the isolated succinoxidase system by surface-active agents is due to their adsorption by succinic dehydrogenase.

I am indebted to Prof. W. C. Cutting for helpful suggestions.

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## The Trinitratouranyl Complex Ion

SALTS having the general formula $M[UO_2.(NO_3)_3]$ (where $M$ is $NH_4$, K, Rb, Cs) have been referred to in recent literature[1]. The tetramethylammonium salt has been prepared by reaction of the appropriate nitrates in pure nitric acid medium[2], and the identity of a trinitratouranyl ion has been established in solutions of uranyl and tetra-*n*-butylammonium nitrates in acetone or methyl isobutyl ketone[3].

Comparison of the ease of formation of the trinitrato- with that of the tetranitrato-complex is of importance in the chemistry of uranyl compounds, particularly in view of the unusual co-ordination number apparently involved in the former compound. It is therefore interesting that salts of the trinitrato-complex are formed directly from uranium metal by reaction in liquid dinitrogen tetroxide, under experimental conditions which do not favour the formation of any one particular complex. Reaction between the pure metal and liquid dinitrogen tetroxide is very slow; but when diethylammonium nitrate is dissolved in the tetroxide, reaction becomes rapid, with evolution of nitric oxide. On standing, the liquid deposits transparent yellow-green crystals which contain no combined dinitrogen tetroxide; analysis of this product is in accord with the formula $(Et_2NH_2)[UO_2.(NO_3)_3]$. When a dilute solution of this compound is electrolysed, the ion containing uranium migrates to the anode, confirming that the uranyl group is present in an anionic complex. Using diethylammonium nitrate solutions, this is the only salt which crystallizes. A similar reaction occurs with solutions of mono- or tri-ethylammonium nitrate in liquid dinitrogen tetroxide; with the monoethyl compound the crystalline product varies in composition with concentration of the solution, and is probably a mixture of the salt $M[UO_2.(NO_3)_3]$ with a little of the tetranitratouranyl salt $M_2[UO_2.(NO_3)_4]$. However, the ready formation of the trinitratouranyl complex under these conditions illustrates its high stability in media of low dielectric constant. The complex undergoes ionic dissociation in water.

The rates of the above reactions show large positive temperature coefficients. Again, the rate of reaction between uranium metal and the liquid tetroxide alone is increased by the addition to the tetroxide of other compounds (for example, diethylnitrosamine) able to increase the dielectric constant of the medium. For these reasons (as with metallic zinc[4]) we consider that the initial (rate-determining) reaction involves $[NO^+]$ $[NO_3^-]$ ion-pairs, so that:

$$U + n\mathrm{NO}^+ = U^{n+} + n\mathrm{NO}$$

On kinetic grounds, $n$ is likely to be a small number. Reaction of the ion with the tetroxide then gives rise to progressive oxidation:

$$U^{n+} \xrightarrow{N_2O_4} UO^{2+} \xrightarrow{N_2O_4} UO_2^{2+}$$

Only the hexavalent uranium salt crystallizes, although the mother liquor contains some uranium in a lower valency state.

Many reactions in liquid dinitrogen tetroxide may be correlated on the basis of a solvent system[5] which involves the ionization:

$$N_2O_4 \rightleftharpoons NO^+ + NO_3^-$$

The salts described above illustrate clearly the amphoteric nature of uranium in this solvent system. The $NO_3^-$ ion is equivalent to the $OH^-$ ion in the aqueous system, and there is a striking similarity between the commonest type of uranate produced in 'basic' solutions of the two media.

| | $H_2O$ system | | $N_2O_4$ system |
|---|---|---|---|
| (*A*) | $M_2U_2O_7.3H_2O$ | | |
| (*B*) | $M_2[(UO_2)_2.(OH)_6]$ | (*D*) | $M_2[(UO_2)_2.(NO_3)_6]$ |
| (*C*) | $M[UO_2.(OH)_3]$ | (*E*) | $M[UO_2.(NO_3)_3]$ |

Treatment of a uranyl compound in aqueous solution with alkali results in the precipitation of the diuranate (*A*). If three molecules of water are regarded as constitutional, the compound may be formulated as (*B*) or (*C*). The analogous compound produced from liquid dinitrogen tetroxide is (*E*), or its dimeric form (*D*). Structures (*B*) and (*D*) are attractive, in that they enable the compounds to be formulated as binuclear complexes of 6-co-ordinate uranium, although crystal structure determinations on the compound $Rb[UO_2.(NO_3)_3]$ indicate that in this salt the uranyl complex is mononuclear[6].

We wish to thank the Director, Atomic Energy Research Establishment, Harwell, for making available a supply of pure uranium metal.

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## Reversible Dissociation of Insulin

In the past few years the dissociation of insulin in acid and neutral solution has been extensively studied. Although most of this work has pointed towards a minimum molecular weight of 12,000 from osmotic pressures[1], sedimentation[2,3] and light scattering[4] measurements, we raised the possibility of a value of 6,000 as the lower limit, from the extrapolation of sedimentation and diffusion data[5]. This value has been confirmed by surface monolayer studies[6] and by Craig and Harfenist's method[7]. Further, chemical analysis does not preclude it[8].

It has already been postulated that insulin molecules dissociate when the electric charge is increased by fixation of protons, this producing a repulsion between positively charged submolecules. It would be expected that a similar phenomenon would occur in alkaline media when submolecules carry a sufficiently high negative charge.

In the present investigation we have determined sedimentation and diffusion constants in moderately alkaline solutions of insulin, respectively by a 'Spinco' analytical ultracentrifuge and by the Lamm's scale method. (The insulin used was five times recrystallized beef insulin obtained through the courtesy of the Lilly Research Laboratories, Indianapolis.)

Fig. 1 shows the effect of $p$H on the sedimentation constant of insulin (corrected to 20° and water) at a constant concentration of 0·25 per cent protein and ionic strength 0·1. The dissociation becomes effective around $p$H 8 and reaches its maximum by $p$H 10. Titration curves indicate that at this $p$H insulin carries about 10 negative charges (calculated on the basis of 12,000 molecular weight). This is identical with the positive charge of insulin at $p$H 3 where maximum-dissociation takes place also[5]. This behaviour provides good evidence that the dissociation is mainly determined by electrostatic repulsions.

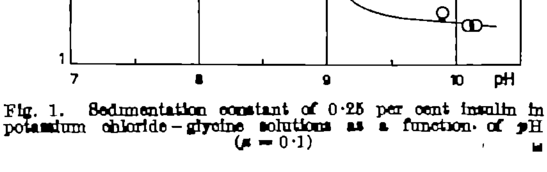

Fig. 1. Sedimentation constant of 0·25 per cent insulin in potassium chloride – glycine solutions as a function of $p$H ($\mu$ = 0·1)

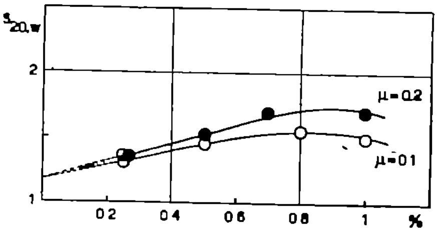

Fig. 2. Sedimentation constant of insulin in potassium chloride-glycine solutions at $p$H 10·1 as a function of protein concentration

Fig. 2 shows the effect of protein concentration on the sedimentation constant of insulin at $p$H 10·1 and ionic strength 0·1 and 0·2 (buffer potassium chloride – glycine). As at[5] $p$H 2·7, the sedimentation constant rises when the concentration decreases from 1 to 0·7 per cent, in accordance with the ordinary charge effect, but goes down below this point because the dissociation becomes the overwhelming factor. At both buffer concentrations the values tend to become identical and point towards a minimum around 1·2. Similar conclusions can be drawn from diffusion data (Table 1).

Table 1. Diffusion Constants of Insulin at $p$H 10·1 (Corrected to 20° and Water)

| | Potassium chloride – glycine 0·1 $N$ | Potassium chloride – glycine 0·2 $N$ |
|---|---|---|
| 0·15 per cent | 15·7 | 14·1 |
| 0·30 ,, | 15·0 | 12·5 |
| 0·45 ,, | — | 11·3 |

The extrapolation of sedimentation and diffusion constants at zero protein concentration gives an approximate value for the insulin submolecule. It is much lower than 12,000. A combination of $s$ = 1·2, $D$ = 16 and a partial specific volume of 0·72 [8] would give a molecular weight around 6,000.

The stability of insulin in these moderately alkaline solutions under the experimental conditions given is well established by Waugh's experiments on the biological activity of insulin after alkali treatment[9]. On the other hand, it can be completely and easily recrystallized after standing two days at $p$H 10 at room temperature. It also regains its normal sedimentation constant when brought back to $p$H 7.

Although in acid solution the sedimentation constant varies with the sample of insulin considered and with its age, results are much more constant at $p$H 10 (Table 2).

Table 2. Sedimentation Constants of 0·25 per cent Insulin at Ionic Strength 0·1

| | $p$H 2·7 | $p$H 10·1 |
|---|---|---|
| Lot *T*-2344 | 1·3 to 1·6 | 1·3 |
| Lot 483.098 | 1·8 | 1·3 |
| Lot 200-1*B*-11 | 1·5 | 1·3 |

Similarly, in neutral or alkaline media, the dissociation is not influenced by the nature of the anions present; 0·1 $N$ phosphates, chlorides or thiocyanates give identical values for $s_{20}$ at $p$H 10·1. In acid solutions the dissociation is much influenced by the nature of the anions[5]. We related it to the binding capacity of insulin for such ions; this binding capacity does not exist in alkaline solutions.

It has been pointed out[5] that the lowering of the dielectric constant of the medium will increase the tendency of insulin to dissociate. Experiments in solutions of 20 per cent dioxane in water and 0·2 $N$ potassium chloride show that the sedimentation constant of insulin both at $p$H 3·6 and 8 is markedly depressed. At $p$H 3·6 a molecular weight of 13,700 has been deduced from sedimentation-diffusion in 20 per cent dioxane – 0·2 $N$ potassium chloride; in aqueous solution it is more than 30,000. Moreover, the use of still higher concentrations of dioxane greatly increases the solubility of insulin in the isoelectric region. In 40 per cent dioxane – 0·5 $N$ potassium chloride, 1 per cent insulin can be kept in solution throughout the entire $p$H scale.

A detailed account of this work will be published elsewhere. We gratefully acknowledge a research grant from Eli Lilly and Co., Indianapolis.

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## Apparent Degradation of Wool by Diazomethane Solutions

THE action of diazomethane on proteins has been studied by a number of workers, who report that both O- and N-methylation occur. There is apparently no fission of the peptide chains, although it is stated[1] that the action of diazomethane on insulin causes a decrease in the cystine content. On the other hand, Kirst[2] claims that the cystine bridges in wool are unaffected by the reagent, and Herzig and Landsteiner[3] state that wool is rather more resistant to diazomethane than are other proteins. In most of this earlier work, it was specifically stated that dry proteins and dry ethereal solutions of diazomethane were used. Recently, Kuhn and Ruelius[4] have shown that diazomethane acts on aqueous solutions of peptides with formation of the corresponding betaines, while serum albumin and ovalbumin in water are slowly converted to insoluble products. We have now found that wool can be extensively degraded by ethereal diazomethane solutions, the product being almost completely soluble in water. The diazomethane, prepared from nitrosomethylurea, is added to the wool over a period of several days, together with small quantities of water. The soluble product contains no sulphur, and diffuses through 'Cellophane', while the appearance of the wool during the reaction closely resembles that of wool treated with strong alkali.

Diazomethane is known to contain methylamine as an impurity[5], and our solutions were approximately 0·01 $N$ with respect to this compound. However, this weak base alone is without visible attack on wool even at high concentration. Although there is apparently very little action between diazomethane and aliphatic amines in water-free solution (cf. ref. 6), we have found that, when water is present, methylamine, but not higher aliphatic amines, is slowly methylated, producing first trimethylamine and then tetramethylammonium hydroxide, as proved by potentiometric titration and isolation of the corresponding crystalline iodides. The quaternary ammonium hydroxide is a very strong base, and the amount produced from the methylamine impurity in the diazomethane solutions, when absorbed from the ether solution by the small amount of water on the wool, is more than enough to account for the extensive digestion observed. In fact, wool is attacked even by solutions in which the diazomethane has been previously destroyed by the addition of small amounts of water. Samples of diazomethane prepared from $p$-toluenesulphonmethylamide[7] or from hydrazine and chloroform[8] also contain basic compounds and show a similar degradation of wool. The removal of the methylamine impurity proved difficult, but partial success was achieved by repeated treatment with either methyl iodide or $p$-toluenesulphonyl chloride followed by distillation. These base-free solutions show no degradative attack on wet wool.

The above results indicate that some caution might be necessary when diazomethane is used in protein studies, for example, in Chibnall's method for the determination of C-terminal residues[9]. Further, it would appear likely that some of the results observed by Head[10] during a study of the action of diazomethane on cotton and various modified cotton celluloses could be attributed to the presence in the reagent of tetramethylammonium hydroxide.

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## Nitrogen Metabolism of Apple Trees

IN most plants nitrate is the form in which nitrogen is absorbed from the soil and translocated upwards from the roots. Accumulation of nitrate in upper parts of the plant may follow, nitrate reduction and formation of organic nitrogen compounds occurring in many organs. Thomas[1] showed that the nitrogen uptake of apple trees was atypical in that nitrates could normally be detected in only the finest roots, and suggested that nitrate reduction and formation of amino-acids occurred in these organs. Absence of nitrates from apple leaves has since been confirmed by many workers; but under certain conditions they have been detected[2].

During work on stock-scion nutrient interrelations in the apple, the nitrogen supply from stock to scion has been investigated. This was done by examining the level and forms of nitrogen present in tracheal sap, extracted by a simplification of the method of Bennett *et al.*[3], from one-year old shoots of mature apple trees.

The total nitrogen content of this sap, as determined by a micro-Kjeldahl method, showed considerable seasonal variation. Over the winter months the sap contained approximately 10 μgm. of nitrogen per ml. There was an increase to 20 μgm. about three weeks before blossoming, followed by a rise to a peak of 150 μgm. at flowering (about October 1). This level was maintained for about three weeks, and

FRACTIONATION OF TOTAL NITROGEN OF TRACHEAL SAP OF APPLE TREES
Results expressed as μgm. nitrogen per ml. of sap

| Date | Variety | Stock | Ammonia nitrogen | Glutamine amide nitrogen | Asparagine amide nitrogen | Amino-nitrogen | Total of ammonia, amide and amino-nitrogen | Total nitrogen as determined by micro-Kjeldahl |
|---|---|---|---|---|---|---|---|---|
| 23/10/51 | Gravenstein | Northern Spy | 1 | 11 | 21 | 88 | 121 | 121 |
| 1/11/51 | Delicious | Malling XII | 4 | 22 | 30 | 105 | 161 | 158 |
| 1/11/51 | Delicious | Malling XVI | 6 | 16 | 32 | 103 | 157 | 155 |
| 1/11/51 | Gravenstein | Northern Spy | 2 | 8 | 23 | 71 | 104 | 98 |
| 11/12/51 | Delicious | Malling XII | 1 | 10 | 7 | 36 | 54 | 54 |
| 11/12/51 | Delicious | Malling XVI | 1 | 4 | 20 | 56 | 81 | 77 |
| 11/12/51 | Gravenstein | Northern Spy | 1 | 2 | 12 | 12 | 27 | 20 |
| 24/ 3/52 | Granny Smith | Malling XVI | 0 | 1 | 2 | 13 | 16 | 17 |
| 24/ 3/52 | Granny Smith | Northern Spy | 0 | 2 | 2 | 13 | 17 | 16 |
| 24/ 3/52 | Granny Smith | Malling XII | 0 | 1 | 2 | 13 | 16 | 19 |

from time of petal fall there was a gradual decline until, at the end of January, the level was down to 20 μgm. and by the end of March it was back to 10 μgm.

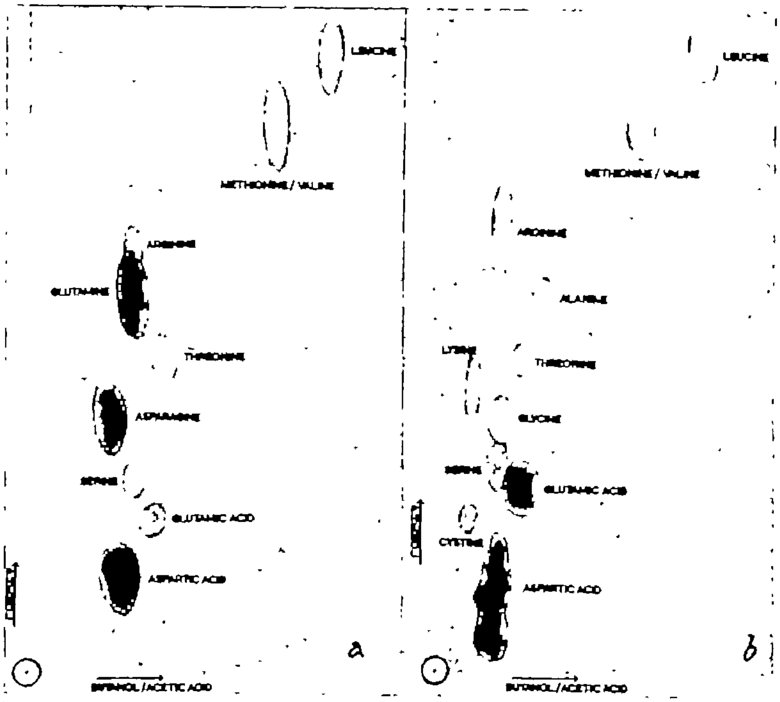
Fractionation of this nitrogen has been possible. Using phenol disulphonic acid, no nitrate could be detected. Ammonia, glutamine amide and asparagine amide were determined by vacuum distillation methods[4]. Amino-nitrogen was determined in the Van Slyke manometric apparatus, the usual correction for glutamine amide nitrogen being made. Results obtained from sap extracted at different times during the season are given in the accompanying table. It is apparent that ammonia + amide + amino-nitrogen can account for all the nitrogen present.

The individual nitrogenous compounds have been examined by paper chromatography. Tracheal sap, concentrated *in vacuo* at room temperatures, was run in phenol and butanol/acetic acid. Amino compounds were revealed by spraying with ninhydrin (0·1 per cent in *iso*propanol). The principal compounds present were always glutamine, asparagine, aspartic acid and, to a lesser extent, glutamic acid. Judged by spot intensity, these four compounds would account for up to 90 per cent of all nitrogen present. Also present in lesser amounts were serine, threonine, arginine, methionine, valine and leucine. Sometimes present in traces were alanine, tyrosine and γ-amino butyric acid. On acid hydrolysis of sap, the serine and alanine spots increased in intensity, while glycine and faint spots corresponding to lysine, cystine and sometimes cysteic acid appeared, indicating the probable presence of a peptide.

Recent work[5] has confirmed, at least with some plants, the older view that solutes absorbed by the roots pass up through the xylem vessels. The present work has shown that in the apple tree this sap contains nitrogen throughout the year, and, at times, is comparatively rich in this element. It would seem that a significant part, if not all, of the nitrogen absorbed by the root system does pass to the scion in the xylem sap.

The view that complete reduction of nitrate to amino-acids occurs in the roots is substantiated. Apart from a small amount of ammonia nitrogen, the nitrogen of amino-acids and amides accounts for all the nitrogen in the tracheal sap.

The predominance of the two dibasic amino-acids might be expected as they, together with their amides, are considered to be some of the first products formed in the synthesis of organic nitrogenous compounds. Their importance as translocatory compounds has been shown here. The presence of glutamine is of particular interest as it has not been detected[6] free in apple fruits.



Paper chromatograms showing amino-acids of tracheal sap of Granny Smith apple tree on Northern Spy stock: (*a*) sap concentrated *in vacuo* at room temperatures; (*b*) sap hydrolysed in 6*N* hydrochloric acid for 3 hr.

It is hoped to publish these results in more detail elsewhere.

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## Effect of Leaf Roll Virus Infection on the Soluble Nitrogen Composition of Potato Tubers

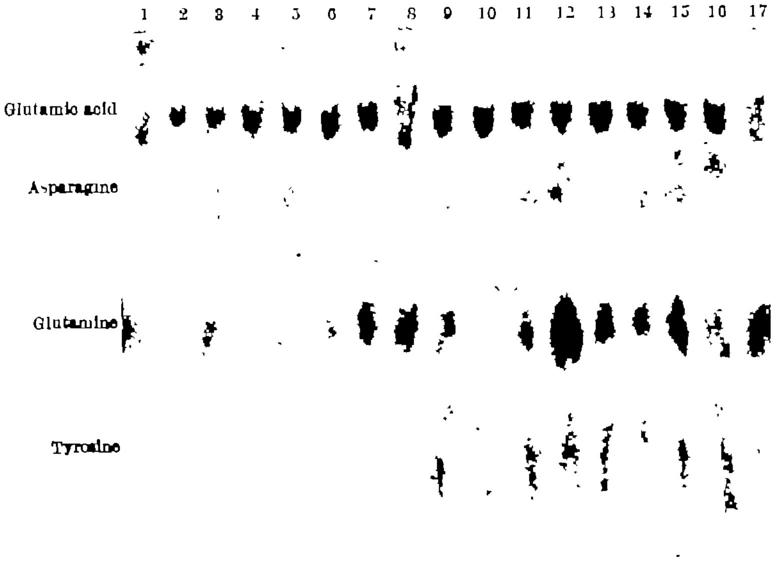
In an attempt to verify and extend the findings of Andreae and Thompson[1] to a range of potato varieties, an apparent relationship between glutamic acid, glutamine, and virus infection has been noted. The diseased tissue used was primary infected material which had been obtained from grafts.

Microscopic examination of the tissue did not reveal the presence of necrotic lesions, which, because of the gross physiological changes involved in their formation, might conceivably be expected to produce, as secondary effects, similar biochemical differences to those found. Alcoholic extracts were prepared according to Dent, Stepka and Steward[2], taking the same weight of healthy and diseased tuber tissue (20 gm.) for each extraction. A preliminary survey of seven varieties was made by applying equal volumes of the extracts to a one-dimensional paper chromatogram (see photograph) run in phenol : water, 75 : 25 w/v. A standard set of amino-acids containing aspartic and glutamic acids, glutamine and tyrosine was run in the first, eighth and seventeenth positions. One of these compounds, glutamine, contained impurities which confuse the picture in the aspartic – glutamic acid region. In four of the seven varieties the diseased tissue appears to contain higher concentrations of glutamic acid, glutamine and asparagine. Two-dimensional chromatograms, run with *n*-butanol : acetic acid as the second solvent, showed that the amounts of alanine present were insufficient to account for the large differences appearing in the glutamine region of the single-dimensional chromatogram, but that other amino-acids, for example, serine, accounted for the apparent differences in asparagine content.

Analyses of five further varieties by two-dimensional chromatography have shown that the differences in glutamic acid and glutamine are the most consistent. Diseased tissue had two to three times the glutamine concentration of healthy tissue, while glutamic acid differences were much smaller although covering the same varietal range. Tyrosine and tryptophane, however, showed no consistent differences over the varietal range tested. A very noteworthy biochemical difference occurs in Arran Pilot tubers, in which the total amino-nitrogen in diseased tissue appears to be reduced to approximately one-third of that present in healthy tissue.

In view of the importance recently assigned to glutamic acid and the γ-glutamyl group of glutamine by Hanes, Hird and Isherwood[3], in respect of transpeptidation reactions, these observations may have significance beyond the fact that they show promise of providing the basis for a simple and rapid diagnostic test for leaf-roll virus in potato tubers.

A fuller account of this work will be published elsewhere. I acknowledge gratefully the co-operation of Mr. C. M. Driver, who provided the material, and Miss C. M. Smart, who performed the grafts and microscopic examination of the material.



Chromatogram of soluble nitrogen fraction of healthy and diseased potato tubers. (1), (8) and (17) are standard amino-acids. The following pairs are for each variety, healthy and diseased, respectively (2, 3) Arran Banner; (4, 5) Arran Chief; (6, 7) Arran Consul; (9, 10) Arran Pilot; (11, 12) Chippewa (13, 14) Craig's Defiance, (15, 16) Dunbar Standard

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## Bacterial Degradation of Choline

During work on the production of trimethylamine by organisms isolated from the flora of the whale, it was found that some types were able to produce this substance from choline[1]. Similar observations on organisms from other sources had been made previously, the products of the degradation of choline characterized as trimethylamine and ethylene glycol, and the enzyme responsible named 'choline deaminase'[2]. No kinetic information was available, nor had the specificity of the enzyme been determined, though it had been reported that certain Enterobacteriaceæ produce trimethylamine from acetylcholine but not from betaine[3], so investigation of these questions seemed likely to prove fruitful.

The organism used was a strain of *Aerobacter aerogenes*, recently isolated from whale tissue, chosen in preference to the other choline-splitting species, which were either anaerobes or slowly growing aerobes. Its enzyme system proves to be specific for choline and acetylcholine. Ethyltrimethylammonium hydroxide and tetramethylammonium hydroxide may be attacked very slightly; but with the small quantities involved it is difficult to tell whether the trimethylamine has increased or not. It is without action on *iso*-choline, betaine, phosphorylcholine or dimethylaminoethanol.

It has been reported that trimethylamine production from choline is inhibited by glucose, and suggested that this is because the ethylene glycol simultaneously produced is no longer needed as a source of energy[3]. We have confirmed the inhibition by glucose but have found that ethylene glycol does not prevent choline breakdown. Kinetic experiments have proved to be impossibly difficult, but some observations have been made which seem worth recording. Choline is attacked by *A. aerogenes* only in the logarithmic phase of growth. When active division ceases, so also does production of trimethylamine; washed suspensions are completely inactive. The enzyme system involved is not adaptive.

We have been unable to proceed further because of difficulties in the chemical estimation. Choline cannot be estimated by the reineckate method in the presence of trimethylamine which is also precipitated, and ethylene glycol is probably metabolized. Trimethylamine can be estimated by titration with perchloric acid in a non-aqueous system or by a colour reaction with *cis*-aconitic anhydride. Both methods require the extraction of the base into an organic solvent, and we have found that direct extraction with toluene is incomplete at the higher concentrations (60–70 mgm. per cent), and that in the lower ranges (0–20 mgm. per cent) it is impossible to aspirate the trimethylamine completely into glacial acetic acid. A method of trimethylamine estimation by gas–liquid partition chromatography has been devised, but it is unsuitable for serial estimations in kinetic experiments[4].

This work was carried out as part of the programme of the Food Investigation Board of the Department of Scientific and Industrial Research.

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## 'Parsnip Canker'

Green and Hewlett[1], in a summary of their investigations on 'parsnip canker', stressed the importance of the disease and showed that the term 'canker' had been loosely applied to several infections which they therefore specified and classified. They concluded that only the commonest form, and the one without a known causative agent, should be so named, and they suggested that critical indoor rather than field experiments would be needed to reveal the agent. We have found from such experiments carried out over several seasons that cultures of *Streptomyces scabies* (Thaxter) Waksman and Henrici cause cankering and other stages of parsnip scabbing.

The possible link between 'canker' and the scab pathogen was indicated by cankering of parsnips and scabbing of carrots growing adjacently in a field, and led to a test of the infectivity of a culture of *S. scabies* to parsnips. The resultant cankering suggested tests of further cultures of the pathogen, which confirmed the first infection and showed that one culture, Millard and Burr's[2] strain 17, formed a common range of lesions on potatoes, beet, mangolds and radishes as well as on carrots and parsnips. Frequently one kind of lesion predominated, so that the raised scab characterized the infections on beet, mangolds, French breakfast radishes and carrots, while the surface-to-sunken sort prevailed on the potato, white icicle radish and on mature parsnips; but on parsnip seedlings the scabs were raised at first. Throughout these infections, except where union had blotted out their origins, it was clear that lesions arose in lenticels and, in all plants except the potato, the centring of lenticels in side-root rows permitted the involvement of root initials. Microtome sections confirmed this possibility, especially in carrot scabs, and they also showed, in both carrot and parsnip lesions, the series of cell changes noted by Jones[3] in potato scabs. The similarity in structure of the pitted scab of the tuber and that of parsnip cankers was close even in details, but the cankers usually formed only one protective cork barrier.

The presence of the pathogens in lesions was confirmed by re-isolating them several times and in different seasons and, in one season, a number of isolates so obtained from carrot and parsnip lesions cankered parsnips in a later season. In addition, the cultural and morphological features of the isolates agreed with those of the infecting cultures. Since the cultures used were of varied and widespread origin, being derived from potato or beet scabs formed in England, Wales and the United States, and the culture most commonly used, Millard's strain, is a well-known potato pathogen capable of scabbing several kinds of crop, these pathogens could, no doubt, cause in Nature the commonest sort of 'parsnip canker' noted by Green and Hewlett.

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## The Term 'Soil'

When a term of wide use is shared between different scientific disciplines, some confusion may result from its use in publications of common interest unless there is complete agreement regarding its meaning. Such a term is the word 'soil', the rapid development of the scientific study of unconsolidated mineral aggregates by engineers having given rise to much pointed criticism of their use of this very common word.

To the agricultural scientist, the meaning of the word is clear. He uses it to describe that thin upper layer of the earth's crust, a few feet only in thickness, which is responsible for all vegetable growth. The engineer uses it in exactly the same way, since he, too, is concerned with soils at the surface, especially in road and airport work. But he extends its use to include all similar unconsolidated material overlying, to whatever depth, solid rock. Through a possibly unfortunate translation of the German expression *Erdbaumechanik*, he has coined the name 'soil mechanics' to describe his new-found scientific interest in the material for so long disdainfully regarded as mere 'earth' or often as just 'mud'.

It is this name which seems to disturb so many ricultural soil scientists and which now appears be arousing the ire of geologists. But in my very ited geological reading, many references have been ted showing that geologists themselves have for ng used the word 'soil' in exactly the same way engineers—and no modern geological writer yet ppears to have suggested a satisfactory alternative neric name for the unconsolidated part of the rth's crust. Three typical references may be cited, ritish, Canadian and American. In his famous Memoir to the Map of the Strata of England" (1815), Villiam Smith said: "The chances were thought uch against my ever completing it as a map, of the reater part of our island, large enough to show the neral course and width of each stratum of the soil nd minerals, with a section of their proportions, ip and direction . . . ". John William Dawson, in is "Acadian Geology" (Edinburgh, 1855, p. 23), tates that: "The western part of Nova Scotia resents some fine examples of marine alluvial soils". Villiam Henry Brewer, writing on "The Deposition f Clay in Salt Water" (*Amer. J. Sci.*, 29, 1; 1885), ays: "I have carried on a long series of experiments n the sedimentation of clays, and the finer portions f soils and the pulverized rocks . . . ".

Geologists, therefore, would be following a well-stablished tradition if they accept the use of the vord 'soil' as a general description of unconsolidated naterial. By their use of the term 'soil profile', gricultural soil scientists show clearly that they hemselves do not confine the use of the word to hat thin layer with high organic content which they ometimes suggest is the 'proper' use of the word. f 'soil' is to be used to describe the 'C-horizon', ow can the pedologist logically object to the use of he same word in the same way by the engineer, ut used to describe the same material at depths in which the soil scientist has no interest?

Would it not therefore be generally useful to have common understanding as to this well-accepted nd well-established general use of the word 'soil'? he engineer can make his contribution by refraining rom using the expression 'soil profile' to describe the ecord of his sub-surface exploration (as is often done t present). The three disciplines chiefly concerned—ivil engineering, geology and pedology—have so nuch to gain by an interchange of information on oil studies that there would seem to be nothing to ose and much to gain, for the benefit of science in eneral, by the adoption of the very modest suggestion erein advanced.

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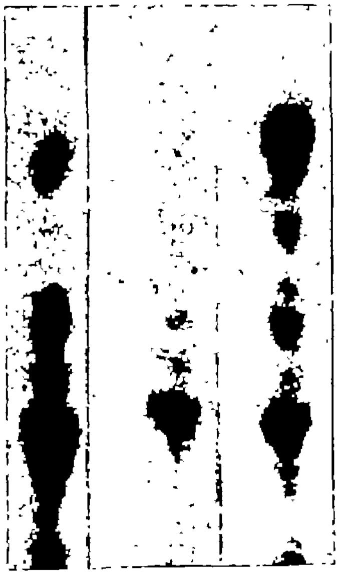
## Identification of Recessive Gene Heterozygotes by means of Paper-Partition Chromatography

PAPER-PARTITION chromatography of tissues of genetically known strains of *Drosophila melanogaster* as well as those of certain plants has shown that each strain gives a constant and distinctive pattern. The chromatographic patterns of heterozygotes carrying recessive genes can be easily distinguished from those of either parental homozygous strain, even though the phenotype of the heterozygote is indistinguishable from that of the homozygous dominant. This is the case for: (*a*) the fluorescent patterns observed under ultra-violet light in the chromatograms of adult *Drosophila melanogaster* heterozygous for the following mutants: bent, eyeless[2], short-vein, spineless-aristapedia, vestigial; (*b*) the ultra-violet-fluorescent and the ninhydrin-positive patterns of root-tip smears of heterozygotes for the mutant male-sterile[3] in tomato[1]; (*c*) the ultra-violet-fluorescent and the ninhydrin-positive patterns of root-tip smears and leaf extracts of heterozygotes for the yellow-green mutant of musk melon[4] (see also chromatogram).



Ninhydrin-positive materials in the chromatograms of smeared root tips of musk melon (genotypes: homozygous wild type; homozygous yellow-green; heterozygous yellow-green). Solvent: 4 *n*-butanol : 5 water : 1 glacial acetic acid

In all cases one-dimensional descending chromatograms were obtained on Whatman No. 1 filter paper, using the following solvents: (*a*) two parts of *n*-propanol and one part of 1 per cent ammonia; (*b*) four parts of *n*-butanol and 1 part of glacial acetic acid, made up with five parts of water. The chemical nature of the substances revealed in the patterns has not been investigated.

The remarkable constancy of the results obtained, the fact that the biochemical patterns of every tissue tested seem to fall under the control of the genotype (with a high degree of independence of feeding and other environmental conditions), and the high degree of chemical specificity evidently imparted by the genotype to the organism suggest that this technique will prove to be of value for the physiological study of gene action and for an analysis of the biochemical basis of individuality. A fuller report will be published elsewhere.

I wish to thank Dr. Charles M. Rick, of the Department of Truck Crops, University of California, Davis, California, and Dr. Thomas W. Whitaker, of the U.S.D.A. Bureau of Plant Industry, Soils and Agricultural Engineering, La Jolla, California, for the plant materials used, and members of the Department of Zoology, University of California, Berkeley, California, for help and facilities provided. The work was carried out while visiting professor at the last-

named institution, in part with a grant from the Rockefeller Foundation.

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## Genetic Analysis of Intact Incomplete Asci of Yeast

GENETIC analysis in yeast is usually based on tetrad analysis, that is, on microdissection and culture of the four haploid ascospores from normal four-spore asci. Incomplete asci, that is, containing only one, two or three ascospores, constitute, however, a high proportion of all asci in many crosses. We have investigated whether or not these incomplete asci could be conveniently utilized, without dissection, for genetic analysis; we find that, within limits, Mendelian analysis of one-, two- and to some extent three-spore asci is sufficiently informative to be convenient.

The strains used in the present crosses were nutritional mutants derived by ultra-violet irradiation from strains *B15* and *C24–135* of *Saccharomyces cerevisiae* kindly supplied by Prof. B. Ephrussi. They were heterothallic, practically never producing asci in cultures derived from single ascospores. The crosses reported here were always carried out by placing two haploid cells of opposite mating type next to one another in a hanging drop, observing the formation of the zygote and isolating the diploid derived from it.

One-, two- or three-spore asci formed by these diploid strains were isolated individually and germinated intact on a nutrient agar medium. The cells from the colonies so obtained were analysed for ploidy and genotype. The genetic markers used, besides mating type, were either or both of the following monogenic differences in nutritional requirements: *AD/ad*, independence of, versus requirement for, adenine; *TRYP/tryp*, independence of, versus requirement for, tryptophane.

*One-spore asci.* Forty one-spore asci were isolated from a diploid α *ad* // a *AD*. Twenty-two germinated, all producing haploid strains, and eighteen of these were of *a* mating type. Thus, about 80 per cent of the α mating type ascospores did not produce colonies. It is not yet known whether the low viability of these ascospores is due to the mating type allele itself or to some closely linked locus. The normal formation of diploid colonies from two- and three-spore asci (see below) shows that this low viability does not manifest itself in the heterozygote or in the haploid ascospore if the latter fuses immediately with one of opposite mating type. Of the twenty-two haploid strains obtained, thirteen were *AD* and nine *ad*; that is, the two alleles segregated in ratios not significantly different from 1 : 1; there is thus no evidence of close linkage between this locus and the mating type locus. The results with one-spore asci show that the single spore represents one of the four products of meiosis.

*Two-spore asci.* Intact two-spore asci gave origin on germination either to colonies made up only of diploid cells all of one kind, or to colonies made up only of haploid cells which could be all of one type or of two types. Diploid colonies arise when the two spores are of opposite mating type; haploid colonie when the two spores are of the same mating type

Table 1. COLONIES ORIGINATING FROM INDIVIDUAL TWO-SPORE ASC

(*A*) Two spores of complementary mating types: colonies contain ing only diploid cells.

Cross α *ad* // a *AD*

| | Phenotypes *AD* | *ad* | Tota |
|---|---|---|---|
| No. of colonies: | | | |
| Obtained | 66 | 11 | 77 |
| Expected (5 : 1 ratio) | 64·2 | 12·8 | |

Cross: α *TRYP* // a *tryp*

| | *TRYP* | *tryp* | Tota |
|---|---|---|---|
| No. of colonies: | | | |
| Obtained | 36 | 6 | 42 |
| Expected (5 : 1 ratio) | 35 | 7 | |

Cross: a *ad TRYP* // α *AD tryp*

| | *AD TRYP* | *AD tryp* | *ad TRYP* | *ad tryp* | Tota |
|---|---|---|---|---|---|
| No. of colonies: | | | | | |
| Obtained | 30 | 3 | 3 | 1 | 37 |
| Expected (25 : 5 : 5 : 1 ratio) | 25·7 | 5·1 | 5·1 | 1 | |

$\chi^2 = 2·5 \quad p = 0·45.$

(*B*) Two spores of same mating type: colonies containing onl haploid cells (only a mating type analysed).

Cross α *ad* // a *AD*

| | Phenotypes in sample of cells: all *AD* | *AD* and *ad* | all *ad* | Tota |
|---|---|---|---|---|
| No. of colonies: | | | | |
| Obtained | 5 | 10 | 4 | 19 |
| Expected (1 : 4 : 1 ratio) | 3·2 | 12·7 | 3·2 | |

$\chi^2 = 1·8 \quad p = 0·40.$

Expected ratios are based on the assumption of free recombinatio between all the markers used and between them and their centromere

Table 1 shows the classification of the colonie obtained from two-spore asci in three crosses in whic only gene *AD/ad*, only gene *TRYP/tryp* or both respectively, were segregating, besides mating type The results show that the two ascospores of two-spor asci represent two out of the four haploid product of meiosis, and provide no evidence of linkage between the three loci involved in the crosses.

*Three-spore asci.* Individual colonies from intac three-spore asci are expected to contain two kind of cells: diploid, resulting from fusion of two ascospores of complementary mating type, and haploid resulting from the odd ascospore. In fact, about hal the colonies obtained from three-spore asci were foun to contain only diploid cells, presumably because i the other half the odd spore, which should have given origin to haploid cells, was of α mating type and faile to germinate (see Table 2). The diploid cells from each ascus have been invariably found to be of on type, confirming that usually two ascospores of complementary mating type fuse on germination without first dividing. Whether this conclusion is of general validity or is the consequence of the poor viability of the α mating type cells in the present crosses remains to be seen. The results show that the three

Table 2. COLONIES ARISING FROM INDIVIDUAL THREE-SPORE ASCI
CROSS α *ad* // a *AD*

| Phenotypes of Haploid cells | Diploid cells | No. of colonies |
|---|---|---|
| a *AD* | *AD* | 5 |
| | *ad* | 0 |
| a *ad* | *AD* | 4 |
| | *ad* | 0 |
| α *AD* | *AD* | 0 |
| | *ad* | 0 |
| α *ad* | *AD* | 0 |
| | *ad* | 0 |
| Not present | *AD* | 3 |
| | *ad* | 2 |
| | Total | 16 |

| | | Phenotypes *AD* | *ad* | Total |
|---|---|---|---|---|
| Diploids: | Obtained | 14 | 2 | 16 |
| | Expected (5 : 1 ratio) | 13·3 | 2·7 | |
| Haploids: | Obtained | 5 | 4 | 9 |
| | Expected (1 : 1 ratio) | 4·5 | 4·5 | |

pores of three-spore asci represent three out of the four products of meiosis.

The present work indicates that Mendelian analysis, as distinct from tetrad analysis, is possible in yeast, and in certain cases it is labour saving.

E. A. Bevan*

Department of Genetics,
University of Glasgow. Oct. 16.

* Present address: Department of Zoology, Dartmouth College, Hanover, N.H., U.S.A.

## Absorption of Water by the Egg of the Garden Chafer, *Phyllopertha horticola* L.

Many insect eggs absorb water from the environment[1]. Absorption usually occurs over a limited period during the early stages of development. The mechanism of the control of absorption is being studied in the egg of the garden chafer.

In Nature, the female chafer lays her eggs in June; about the middle of July the larvæ hatch and begin to feed on the grass roots. For 3¼ months the grubs feed and grow, moulting twice. The full-grown third instar larva goes into hibernation about the end of October, resting in a small cavity 3–5 in. deep in the soil. Pupation occurs towards the end of April and the beetle emerges from the pupal skin at the end of May. After staying in the hibernation cavity for a few more days, to complete development, the adult emerges from the soil to mate. The female returns to the soil to lay her eggs.

When laid, the egg is usually a white prolate spheroid, weight 1 mgm., length 1·5 mm. and diameter 1 mm. approximately. On the third day after laying, at 20° C. and 100 per cent relative humidity, the egg begins to absorb water and by the eighth day reaches a weight of 3 mgm., measuring about 2 mm. × 1·5 mm. The weight then remains at that level until the larva hatches on the twentieth day.

The absorption period, from the third to the eighth day, is accompanied by changes in the rate of loss of water of the egg when desiccated. On the first day after laying, the egg loses water (in 0 per cent relative humidity) at the rate of 1 mgm./sq.cm./hr. On the second day the rate of water loss increases, rising to a maximum, on the fifth day, of about 20 mgm./sq.cm./hr. Thereafter the rate falls and by the tenth day has dropped to 0·7 mgm./sq.cm./hr. It is well known that insect-covering membranes show asymmetry in that water passes across them more rapidly in one direction than the other[2]. Thus the rate at which the egg loses water tells us little about the rate at which water is able to pass in through the egg shell. However, changes in rate of loss of water will reflect changes in permeability to inward flow of water.

Changes have also been observed in the thickness of the egg shell. The shell of the new-laid egg is about 8 µ thick. By the end of the absorption period the shell is nearly 15 µ thick. This increase may perhaps be a swelling of the shell material itself, but seems more likely to be due to the addition of material by the embryo.

These observations suggest a possible mechanism by which the uptake of water is regulated: the egg is laid down having a relatively waterproof layer in the shell. This is broken down by the developing embryo; the egg can then absorb water apparently passively due to its high osmotic pressure. When the egg has swollen to its full size, the shell is re-waterproofed by the embryo and absorption stops.

Roger Laughlin

Agriculture Department, King's College,
Newcastle upon Tyne. Aug. 28.

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[1] Buxton, P. A., *Biol. Rev.*, 7, 275 (1932). Matthee, J. J., Union of S. Africa, Sci. Bull., No. 316 (1951).

[2] Hurst, H., *Discuss. Farad. Soc.*, No. 3, 193 (1948).

## Nocturnal Mating in *Tæniorhynchus* (*Mansonioides*) *uniformis* (Theobald)

Mating in *Tæniorhynchus* (*Mansonioides*) *uniformis* (Theobald) was observed taking place on the night of December 7, 1951, between 18.30 hr. and 22.30 hr., while all-night trapping of mosquitoes was in progress at a cattle-shed in a village on the outskirts of Colombo. On this night it was quite dark by 18.15 hr., but for the light of the moon which was two days after the first quarter. Mating activity took place in three stages. In the first and third stages, which lasted from 18.30 hr. until 19.30 hr. and during 20.30 hr.–22.30 hr. respectively, mating was in active progress. In between these two periods of considerable activity there occurred a lull from 19.30 hr. until 20.30 hr., during which far fewer pairs of mosquitoes were observed copulating, and relatively few males were found coming into the trap. But at no time during this period of four hours was mating not in progress, and 292 females and 195 males were caught; these numbers represented only a small proportion of *T. uniformis* in the trap, for owing to great activity among the mosquitoes, catching was seriously interfered with. No mating occurred after 22.30 hr.

Three types of mating behaviour were observed occurring simultaneously. In the first, males were copulating with blood-fed females which were resting on the trap-net. In the second, males and females were seen flying *in copulo*, the females being in the lead, while in the third type males were seen to copulate with females in flight.

Although observations have been carried out at this site on more than a hundred occasions, no swarming of males of *T. uniformis* has ever been encountered, while mating only occurred on this particular night. These observations on *T. uniformis* appear to be the first record of nocturnal mating of a mosquito in Nature. It took place over a period of four hours and in the absence of any swarming by the males.

A more complete account will be published elsewhere.

S. H. Jayewickreme

Medical Research Institute,
Colombo 8. Sept. 17.

## Absence of the Sickle Cell Trait in the Bushmen of South-West Africa

During the course of a general survey of the black races of southern Africa for the sickle cell trait—the results of which will be published elsewhere—an opportunity arose of examining blood specimens from 118 Bushmen. Fifty-eight specimens were obtained from Barakwenga or River Bushmen living in the western section of the Caprive Zipfel in the north-east of South-West Africa. The remainder were from south of the Okavango River near the western border of Bechuanaland.

Whole blood specimens were collected in sterile 'Venules' or sterile corked specimen tubes and sent to Johannesburg by air for examination, where they arrived about a week after collection. Sixty samples collected in specimen tubes arrived showing a moderate degree of hæmolysis, whereas the specimens collected in the 'Venules' arrived in excellent condition. The bloods were tested for the sickle cell trait using the sodium hydrosulphite method of Williams and Mackey[1] or the sodium meta-bisulphite method of Daland and Castle[2]. Fifteen specimens were tested by both these methods and by the sealed coverslip method read after 24 hr. Fifty-eight specimens were examined in parallel with specimens of known sickle cells in order to assess the efficiency of the reducing agent used. These controls invariably showed marked sickling within 30 min. The specimens of Bushmen bloods were examined 30, 60 and 90 min. after adding the reducing agent. All of 118 specimens examined were found to be negative.

The age- and sex-distribution of fifty-eight specimens is shown in the table. The youngest individual tested was a male aged five years— the oldest was a male aged fifty-six. The remaining sixty specimens were random samples obtained from the population of the area. At the same time, 119 specimens of blood from members of the Mpukushu tribe living in the Western Caprive Zipfel were also examined with similar negative results.

| Age in years | Males | Females | Total |
|---|---|---|---|
| 0–5 | 1 | 1 | 2 |
| 6–10 | 8 | 5 | 13 |
| 11–15 | 2 | 5 | 7 |
| 16–20 | 4 | 2 | 6 |
| 21–25 | 2 | 5 | 7 |
| 26–30 | 3 | 8 | 11 |
| 31–35 | – | 5 | 5 |
| 36–40 | 3 | 1 | 4 |
| 41–45 | 1 | 1 | 2 |
| 46–50 | – | – | – |
| 51–55 | – | – | – |
| 56–60 | 1 | – | 1 |
| Total | 25 | 33 | 58 |

The ethnological importance of the absence of the sickle cell trait in the Bushman, contrasting with the high incidence of the trait in the black races of Central, East and West Africa, and especially in the Pygmies of Central Africa[3], will be discussed elsewhere.

I wish to thank Dr. Kuschke, regional health officer of the Okavango area, who collected these specimens.

S. B. Griffiths

South African Institute for Medical Research,
Johannesburg.
Aug. 12.

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[1] Williams, A. W., and Mackey, J. P., *J. Clin. Path.*, **2**, 141 (1949).

[2] Daland, G. A., and Castle, W. B., *J. Lab. and Clin. Med.*, **33**, 1082 (1948).

[3] van den Berghe, L., and Janssen, P., *Ann. Soc. Belge de Méd. Trop.*, **30**, 1553 (1950).

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## Tainting of Tobacco by a Dichloropropene–Dichloropropane Soil Fumigant

I wish to refer to the letter under the above title from Dr. C. J. Shepherd in *Nature* of December 20, p. 1073. The work mentioned was carried out while Dr. Shepherd was employed by the Tobacco Pest Control Research Scheme here and was submitted to the Executive Committee, of which I was chairman. After very full consideration it was decided that tl results of this particular investigation should not l published, as it was of a preliminary nature ar carried out on a commercial crop on a farm. l other words, no control was possible and it is eve conceivable that the tainting resulted from incorre use of the fumigant. The Tobacco Pest Contr Research Scheme has ceased operations and its ac ivities have been handed over to the Tobacco Researc Board, which has well-designed experiments in pr gress to check this using both dichloropropene dichloropropane and ethylene dibromide.

I appreciate that Dr. Shepherd's communicatio is in the nature of a preliminary notification of wor in progress, and this could have been equally we achieved by omitting the first paragraph. I am cor cerned, however, lest a completely wrong impressio be given regarding the quality of Rhodesian tobacc The estimate of five per cent of the crop being affecte is a very wild guess, and the considered opinion c authorities here is that the little tainting noticed wa due either to failure to follow instructions for th use of the fumigant, or to the abnormal wet weathe experienced at time of planting.

R. McChlery
(Director of Research
and Specialist Services

Division of Agriculture and Lands,
P.O. Box 25 Causeway,
Southern Rhodesia.
Jan. 26.

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## A Riss-Würm Interglacial Deposit at Ipswich

During recent months, excavations for new sewage works near Ipswich have exposed lacustrine deposits, between the Upper Chalky Boulder Clay (Gipping) and contorted beds, which there is every reason to believe are referable to the Würm glaciation.

The deposits, consisting of silt, calcareous clay and peaty detrital mud, are cut into and are overlaid with mixed materials which elsewhere in the district can be demonstrated to be equivalent to a 'till' with derived masses of Gipping C.B.C. included. There is a very rich molluscan fauna with which are associated bones and teeth of field mice, voles, frogs or toads, fishes and the European freshwater tortoise (*Emys orbicularis* L.). Bison and *Elephas primigenius* are indicated by fragmentary remains; but the use of mechanical excavators results in breaking up the bones of the larger fauna, few of which are found. A split deer radius bearing cuts suggests nearby human occupation.

It is evident these deposits are contemporary with the well-known Stoke Tunnel Beds examined by the late Miss N. F. Layard, where mammoth and *Emys* were also discovered together with *Bos primigenius*, *Cervus elaphus*, *Equus caballus*, and lion, bear, wolf, fox, etc.

The molluscs and pollen grains are being studied. A number of coleopteran fragments are available for examination.

Harold E. P. Spencer

Museum Buildings,
High Street,
Ipswich.
March 9.

# FORTHCOMING EVENTS

## Saturday, March 28

ASSOCIATION OF CLINICAL BIOCHEMISTS (at the Postgraduate Medical School of London, Ducane Road, London, W.12), at 2.30 p.m. —Inaugural Meeting.

## Monday, March 30

INSTITUTION OF ELECTRICAL ENGINEERS (at Savoy Place, Victoria Embankment, London, W.C.2), at 5 30 p m.—Discussion on "Use and Abuse of Research" (to be opened by Dr. S. Whitehead).

SOCIETY OF ENGINEERS (at the Geological Society, Burlington House, Piccadilly, London, W.1), at 5.30 p m.—Dr. R. Week: "Structural Failure and What we Learn from It".

ROYAL GEOGRAPHICAL SOCIETY (at 1 Kensington Gore, London, S.W.7), at 8.15 p.m —Dr. E. Wyss-Dunant: "Swiss Everest Expedition, 1952" (Dickson Asia Lecture). (Admission by special ticket only.)

## Tuesday, March 31

SOCIETY OF INSTRUMENT TECHNOLOGY (joint meeting with the CONTROL SECTION, at Manson House, 26 Portland Place, London, W.1), at 6 30 p.m —Dr. G. L. d'Ombrain "The Presentation of Control Theory and the Training of Control Engineers".

ROYAL AERONAUTICAL SOCIETY (at 4 Hamilton Place, London, W.1), at 7 p m.—Mr. W. E. Gray: "Experimental Work on Boundary Layer Flow".

## Wednesday, April 1

SOCIETY OF PUBLIC ANALYSTS AND OTHER ANALYTICAL CHEMISTS (at the Chemical Society, Burlington House, Piccadilly, London, W.1), at 7 p.m.—Discussion on "The Determination of Small Amounts of Lead in Foods and Biological Materials".

# APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned.

ANALYST, Grade IVb (Int), for duties concerned mainly with analysis of agricultural products in advisory and experimental work—The Secretary, Edinburgh and East of Scotland College of Agriculture, 13 George Street, Edinburgh (April 4)

EDUCATIONAL PSYCHOLOGIST (with a degree in psychology)—The County Medical Officer, County Hall, Kingston-upon-Thames, Surrey (April 4).

ASSISTANT LECTURERS IN THE DEPARTMENTS OF BIOLOGY, CHEMISTRY, PHYSICS—The Warden and Secretary, Royal Free Hospital School of Medicine, Hunter Street, London, W.C.1 (April 10).

SOIL CHEMIST (with a degree in science, preferably honours, and an interest in chemistry relating to soils or in physical chemistry) at Auchincruive—The Secretary, West of Scotland Agricultural College, 6 Blythswood Square, Glasgow, C.2 (April 10).

ASSISTANT LECTURER IN ANIMAL PHYSIOLOGY—The Secretary and Registrar, The University, Southampton (April 11).

STEROID CHEMIST TO THE ENDOCRINE LABORATORY at the Chelsea Hospital for Women—The Secretary, Queen Charlotte's Hospital, 339 Goldhawk Road, London, W.6 (April 11).

ASSISTANT EXPERIMENTAL OFFICER for laboratory and field work in plant pathological research on diseases of the potato—The Secretary, Agricultural Research Council, 15 Regent Street, London, S.W.1 (April 15).

LECTURER IN INORGANIC CHEMISTRY (with experience and interest in research in some branch of inorganic chemistry)—The Registrar, King's College, Newcastle-upon-Tyne (April 15).

ENGINEER OR PHYSICIST IN THE MECHANICAL ENGINEERING DEPARTMENT, Royal Aircraft Establishment, Farnborough, to carry out analytical and experimental work on problems in connexion with cooling of high-speed aircraft—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting A 67/53A (April 16).

INSPECTOR (Salmon and Freshwater Fisheries) IN THE MINISTRY OF AGRICULTURE AND FISHERIES (candidates must hold at least a second-class honours degree in natural science with zoology or biology as a principal subject, or in some other natural science and have specialized subsequently in zoology or biology)—The Civil Service Commission, Scientific Branch, Trinidad House, Old Burlington Street, London, W.1, quoting S.101/53 (April 16)

SENIOR GEOLOGISTS in the Atomic Energy Division of the Geological Survey—The Civil Service Commission, Scientific Branch, Trinidad House, Old Burlington Street, London, W.1, quoting S.169/53 (April 16).

ASSISTANT LECTURER IN THE DEPARTMENT OF PHYSICS—The Registrar, University College, Aberystwyth (April 18).

ASSISTANT ZOOLOGIST (with an honours degree in zoology and a knowledge of botany) for work in connexion with investigations on potato root eelworm—The Secretary, School of Agriculture, Cambridge (April 20).

LECTURERS OR ASSISTANT LECTURERS IN AGRICULTURE, AGRICULTURAL ENGINEERING and AGRICULTURAL CHEMISTRY, at the University College of Khartoum, Sudan—The Secretary, Inter-University Council for Higher Education in the Colonies, 1 Gordon Square, London, W.C.1 (April 20).

ASSISTANT FUEL ENGINEER (with a good B Sc., mechanical engineering or fuel technology, or equivalent qualification) in the Experimental Mobile Testing Unit of Production Department—The National Coal Board, Establishments (Personnel), Hobart House, Grosvenor Place, London, S.W.1, quoting TT/609 (April 22).

ASSISTANT LECTURER OR LECTURER IN THE DEPARTMENT OF GEOGRAPHY—The Registrar, University College of North Staffordshire, Keele, Staffs. (April 22).

CHAIR OF MORBID ANATOMY at Charing Cross Hospital Medical School—The Academic Registrar, University of London, Senate House, London, W.C.1 (April 23).

ASSISTANT LECTURER IN APPLIED MATHEMATICS—The Registrar, University College, Hull (April 24)

READERSHIP IN AGRICULTURAL ECONOMICS at Wye College—The Academic Registrar, University of London, Senate House, London, W.C.1 (April 24)

SCIENTIST, Grade II (with a good honours degree, or equivalent, and at least three years postgraduate research experience in telecommunications, automatic control or electromagnetic theory) at the Central Research Establishment II, Worton Road, Isleworth—The National Coal Board, Establishments (Personnel), Hobart House, Grosvenor Place, London, S.W.1, quoting TT/608 (April 25).

ASSISTANT LECTURER IN GEOLOGY (with special qualifications in petrology)—The Registrar, The University, Manchester 13 (April 27).

ASSISTANT LECTURER OR LECTURER IN PHYSICS—The Registrar, The University, Leeds 2 (April 27).

ASSISTANT (Scientific) for histological and general biological work—The Director, The Laboratory, Citadel Hill, Plymouth (April 30)

LECTURER IN MECHANICAL ENGINEERING (special experience in heat engines and/or fluid mechanics an advantage) at the University of Sydney—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (April 30).

ASSISTANT LECTURER OR LECTURER IN CHEMISTRY (with special interest in inorganic or analytical chemistry), an ASSISTANT LECTURER IN CHEMISTRY (with special interest in physical chemistry), and an ASSISTANT LECTURER IN CHEMISTRY (with special interest in organic chemistry)—The Registrar, The University, Sheffield (May 1)

ASSISTANT LECTURER IN CHEMISTRY—The Registrar, The University, Manchester 13 (May 6).

LECTURER OR ASSISTANT LECTURER IN PHYSICAL OR ORGANIC CHEMISTRY—The Secretary and Registrar, The University, Southampton (May 9).

RESEARCH OFFICERS (Chemical Engineers, with B.Sc. honours or B.Sc. (Eng.) degree in chemical engineering or equivalent qualification) for process development work in the National Chemical Research Laboratory, Pretoria—The Secretary-Treasurer, South African Council for Scientific and Industrial Research, P.O. Box 395, Pretoria, South Africa (May 11).

LECTURER IN BOTANY at the University of Melbourne—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C 1 (May 15)

LECTURER IN THEORETICAL PHYSICS—The Registrar, The University, Liverpool (May 15).

SENIOR and JUNIOR FELLOWSHIPS—The Director, Atomic Energy Research Establishment, Harwell, Didcot, Berks (May 18).

LECTURER (with a university degree in mining and a first-class colliery manager's certificate) IN MINING—The Registrar, The University, Leeds 2 (May 29).

RESEARCH ASSISTANTS for work (*a*) on the physical and chemical aspects of selective flotation (candidates should hold a good honours degree in physics or physical chemistry), and (*b*) on mining research problems, either in the Department's laboratories or, where necessary, in the mines (candidates should hold a good honours degree in mining or in civil or mechanical engineering)—The Registrar, The University, Leeds 2 (May 29)

ASSISTANT (with an honours degree in electrical engineering, and some research experience desirable) IN THE DEPARTMENT OF ENGINEERING—The Secretary, The University, Edinburgh (June 1).

FOULERTON RESEARCH FELLOWSHIP IN MEDICAL SCIENCE—The Assistant Secretary, Royal Society, Burlington House, Piccadilly, London, W.1 (June 1).

BOTANIST OR PLANT PHYSIOLOGIST (with honours degree) to assist in the investigation of the uptake of nuclear fission products by marine algae—The Secretary, Institute of Seaweed Research, Inveresk, Midlothian.

DESIGN ENGINEERS to undertake duties of project engineers, including the design and layout of special plant and equipment—The Ministry of Supply, Division of Atomic Energy (Production), Risley, Warrington, Lancs, quoting 440.

ELECTRICAL ENGINEERING ADVISER in Ceylon under the Colombo Plan, to advise on the planning, construction and operation of hydro-electric and thermal power stations—The Ministry of Labour and National Service, Almack House, 26 King Street, London, S.W.1, quoting A 12/CE.300/52.

EXECUTIVE ENGINEER, Public Works, Electricity and Land Survey Department, Zanzibar—The Director of Recruitment, Colonial Office, Great Smith Street, London, S.W.1, quoting CDE 112/10/01.

EXPERIMENTAL OFFICER IN THE RADIO RESEARCH ORGANIZATION, Teddington, for abstracting scientific and technical articles on radio research and development—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting D.x68/52A

GRADUATE IN CHEMISTRY OR PHYSICS to undertake abstracting of technical literature, preparation of literature surveys and other technical intelligence work—The Secretary, Research Association of British Rubber Manufacturers, 105 Lansdowne Road, Croydon.

LECTURER OR ASSISTANT LECTURER IN THE DEPARTMENT OF CIVIL ENGINEERING—The Secretary and Registrar, The University, Southampton

MECHANICAL ENGINEER IN THE PUBLIC WORKS DEPARTMENT, Malaya—The Director of Recruitment, Colonial Office, Great Smith Street, London, S.W.1, quoting CDE.112/60/08

ROBERT CORMACK FELLOWSHIPS IN ASTRONOMY—The General Secretary, Royal Society of Edinburgh, 22 George Street, Edinburgh 2.

SCIENTIFIC OFFICER (non-medical) IN THE DEPARTMENT OF HAEMATOLOGY—The Superintendent, Royal Hospital, West Street, Sheffield 1.

SENIOR and JUNIOR positions in the DEPARTMENTS OF ANATOMY, PHARMACOLOGY and PHYSIOLOGY, HEBREW UNIVERSITY—Prof. Samson-Wright, Middlesex Hospital Medical School, London, W 1.

STATISTICIAN IN THE DEPARTMENT OF AGRICULTURE, Kenya, to advise on the design of field and other experiments conducted by the Department, including sampling investigations and surveys, and to assist in the statistical analysis of results—The Director of Recruitment (Colonial Service), Colonial Office, Sanctuary Buildings Great Smith Street, London, S.W.1, quoting CDE.63/7/03.

# REPORTS and other PUBLICATIONS

*(not included in the monthly Books Supplement)*

## Great Britain and Ireland

Report from the Select Committee on Nationalised Industries, together with the Proceedings of the Committee, Minutes of Evidence and Appendices. Pp. xxvi+140. (London: H.M. Stationery Office, 1952.) 6s. 6d. net. [1612

Volta River Aluminium Scheme. (Cmd. 8702.) Pp. ii+22. (London: H.M. Stationery Office, 1952.) 9d. net. [1612

National Parks and Access to the Countryside Act, 1949. Third Report of the National Parks Commission for the Year ending 30th September 1952. Pp. iv+30. (London: H.M. Stationery Office, 1952.) 2s. 6d. net. [1612

Air Ministry: Meteorological Office. Meteorological Reports No. 11: Duststorms of the Anglo-Egyptian Sudan. By M. H. Freeman. (M.O. 535f.) Pp. ii+22+4 plates. (London: H.M. Stationery Office, 1952.) 1s. 6d. net. [1612

Planning Maps. Explanatory Texts, No. 5: Vegetation—the Grasslands of England and Wales. Pp. ii+10. (Chessington: Ordnance Survey Office, 1952.) 9d. net. [1612

Ministry of Food. Domestic Food Consumption and Expenditure, 1950, with a Supplement on Food Expenditure by Urban Working-Class Households, 1940–1949: Annual Report of the National Food Survey Committee. Pp. 182. (London: H.M. Stationery Office, 1952.) 4s. 6d. net. [1612

Northampton Polytechnic. Report of the Governing Body for the Year 1951–52. Pp. 14. (London: Northampton Polytechnic, 1952.) [1812

Department of Scientific and Industrial Research. Report of the Road Research Board with the Report of the Director of Road Research for the Year 1951. Pp. iv+86+8 plates. (London: H.M. Stationery Office, 1952.) 3s. 6d. net. [1812

Ministry of Fuel and Power: Safety in Mines Research Establishment. Research Report No. 49: Dispersion of Dust Deposits by Blasts of Air, Part 2. By J. G. Dawes. Pp. 44. (Sheffield: Safety in Mines Research Establishment, 1952.) 2s. 9d. [1812

Philosophical Transactions of the Royal Society of London. Series A: Mathematical and Physical Sciences. No. 896, Vol. 245: The Disturbance due to a Line Source in a Semi-Finite Elastic Medium with a Single Surface Layer. By Margery Newlands. Pp. 213–308. 22s. No. 897, Vol. 245: A Negative Experiment relating to Magnetism and the Earth's Rotation. By P. M. S. Blackett. Pp. 309–370. 14s. (London: Cambridge University Press, 1952.) [11

Philosophical Transactions of the Royal Society of London. Series B: Biological Sciences. No. 642, Vol. 237: The Morphology of *Stauropteris burntislandica* P. Bertrand and its Megasporangium *Bensonites fusiformis* R. Scott. By K. R. Surange. Pp. 73–91. (London: Cambridge University Press, 1952.) 9s. 6d. [11

Scottish Marine Biological Association. Annual Report, 1951–52. Pp. 40. (Millport: Marine Station, 1952.) [11

Bulletin of the British Museum (Natural History). Zoology, Vol. 1, No. 10: Mammals collected by Mr. Shaw Mayer in New Guinea, 1932–1949. By Eleanor M. O. Laurie. Pp. 269–318. (London: British Museum (Natural History), 1952.) 15s. [11

Ministry of Works. Post-War Building Studies No. 29: Fire Grading of Buildings. Part 2: Fire Fighting Equipment; Part 3: Personal Safety; Part 4: Chimneys and Flues. By a Joint Committee of the Building Research Board of the Department of Scientific and Industrial Research and of the Fire Offices' Committee. Pp. 131. (London: H.M. Stationery Office, 1952.) 4s. 6d. net. [11

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# EXPANSION OF TECHNOLOGICAL AND TECHNICAL EDUCATION

MR. BOYD-CARPENTER'S written answer to questions in the House of Commons on January 29 regarding Government plans for the establishment of a technological university made it clear that the Government has no intention of establishing an entirely new institution of that type. Instead, it has decided to build on an existing foundation, and the decision to expand the Imperial College of Science and Technology in London to twice its present size has the advantage not merely of being less costly, but also of minimizing the difficulties and delays in assembling teaching staff of the high calibre essential. There is the further merit that the Imperial College already possesses a firm basis of prestige to which it will now be expected to add.

While the statement claims that this decision is in pursuance of the policy already announced by the Government and that the Government proposes also to make resources available for further developments in other parts of Great Britain, this claim must be firmly challenged. The Chancellor of the Exchequer has, it is true, already asked the University Grants Committee to advise him where such further resources might be most usefully deployed, but that the choice of the Imperial College comes seven months after Mr. Butler's announcement last June is suggestive of absence of a policy rather than pursuance of one. There is no indication as to what guidance has in the meantime been given to such claimants, for example, as the Royal Technical College, Glasgow, or the Manchester College of Technology, where considerable schemes of expansion are contemplated or in progress, nor is there any indication that the Government appreciates the importance of relating technological and technical education.

Perhaps the clearest proof that the Government has a policy for higher technological education would be an unequivocable announcement that the responsibility for it had been placed fairly and squarely on some one body, as the Advisory Council for Scientific Policy has already recommended. Apparently the Government proposes to use the University Grants Committee for that purpose; by according that body the *de jure* recognition in place of the merely *de facto* recognition it already enjoys, the Government could well establish the *bona fides* of its policy, and at the same time the position of the technical colleges at Glasgow and Manchester, both of which are already included in the returns from the University Grants Committee, might be resolved.

But the question what other institutions of higher technological education should be expanded is no more a matter for piecemeal decision than the choice just announced. The expansion of technological education in Great Britain must obviously be determined by the extent of the national resources, financial and material, as well as the man-power situation. It should equally be determined by a wide and clear view of national needs; and present concern arises in part from the impression gained from a good deal of scattered evidence that neither the present Government nor its predecessor has had any such view.

The Government appears to accept the prevalent view that while Britain is pre-eminent in fundamental research she is lacking in its industrial application, and proposals to expand technological education are the immediate consequence. Any real policy to this end must, however, be concerned equally with the expansion of technical education, and with the effective use to be made of the new graduates in technology which the expansion of technological institutions would provide. There is as yet little evidence of an increased demand from British industry for their services as technologists, nor could their services as such be fully utilized without an appropriate expansion in the numbers of technicians, which are required in far greater numbers.

For this reason alone, a sound policy for the expansion of technological education can be framed only in line with one for the expansion of technical education. In the upgrading of technical colleges to provide them with the resources and the conditions of academic freedom that are essential for such work, the danger is not simply of spreading available resources too thinly. The effect on the resources for technical education must also be considered, quite apart from the question, on which differing views are held, as to whether technological and technical education can be given efficiently in the same institution.

Nor can it be assumed that the expansion of technological education is all that is required to provide Britain with the technologists she requires. As Dr. D. W. Hill pointed out in a recent article, a better distribution of the existing scientific personnel may provide a partial solution. Stress has been laid by the Advisory Council for Scientific Policy, as well as by Dr. R. L. Meier in an article, "Research as a Social Process", in the *British Journal of Sociology* (1951), on the lesser esteem which technological work enjoys in Great Britain. Attention to this factor, both in the schools and elsewhere, is undoubtedly required, whether or not it is necessary to make the financial rewards offered for technological work more attractive.

The point to which Dr. Hill directs more particular attention is the lesser use made of the technologist in high managerial positions in Great Britain compared with the United States. There it is customary for the executive heads of large industrial concerns to be technologists, particularly engineers. Dr. Hill notes that every president of the great Du Pont de Nemours concern since the First World War has been either a chemist or an engineer. Men so trained naturally attach high importance to the technological standards of their staff, and part of the problem of increasing the supply of technologists for Great Britain may well be to discover why the demand for them here is not more insistent.

There is a further reason why this requires consideration in elaborating a policy for technological education. Evidence has been provided in some of the productivity team reports of the Anglo-American Council on Productivity that leaders in British industry are not sufficiently receptive to technological advances. A large proportion of British industry consists of smaller firms which may not employ anyone competent to assess the significance for industrial development of new scientific or technological advance.

No matter what care is taken in the existing technological institutions of Great Britain and in their expansion to see that students are given the wide training that fits them to occupy ultimately high administrative positions, that of itself will not meet the difficulty of the smaller firm. A change of outlook on the part of industry generally is also likely to be required. How far government action could foster a change in the climate of opinion or encourage the wider spirit of adventure in industry for which Sir Henry Tizard pleaded in his Messel Memorial Lecture is a matter of opinion; but it is at least a factor of which the Government must take careful account in formulating a policy for technological education. Such a policy cannot bear its full fruits unless the Government does all in its power to remove hindrances or obstacles to enterprise, and to encourage the adventurous acceptance of the challenge of the times and the exploitation of new techniques and products and the discarding of outmoded methods and obsolete plant.

This aspect was not dealt with by Lord Halsbury when he reviewed the controversy over higher technological education in addressing the Institution of Chemical Engineers in Manchester on January 23. He agreed that the expansion of technological education meant limitation of resources available for other types of education and for other purposes, but he favoured a steady expansion of the technological faculties of our universities to an extent when the supply of technologists slightly exceeded supply. The surplus, he thought, would be absorbed in administrative positions; but it may be recalled that Prof. R. Peers, at a recent conference at Nottingham on industry and the universities, took a similar view regarding the absorption of arts graduates as administrators in industry.

There can be little doubt that the expansion of the universities, and especially the steady increase in the proportion of students receiving assistance in some way or other from public funds, has markedly affected the quality of direct recruitment from the schools to industry. Industry will perforce come to rely increasingly on entry from the universities to fill its managerial and more responsible positions; but it scarcely seems sound so to plan the expansion of higher technological education as to provide technologists in excess of a reasonable assessment of the demand for technologists as such. It is as implicit in much current discussion of university education as in the discussions on the content of technological education that training in institutions of that type should provide, not simply professional skill and knowledge, but first of all the capacity for clear and independent thought, the ability to tackle a problem, initiative and a sense of perspective and values, as well as the readiness to accept responsibilities. These are the qualities which will determine the graduate's capacity to fulfil positions of responsibility in middle life and later, and they can be imparted as much on the arts side as on that of science and technology, provided the arts courses are attuned to the general problem of living in the technological society of to-day.

For that reason Lord Halsbury's suggestion appears to be unsound, and the expansion of technological education should be planned rather in accordance with factual requirements, so far as they can be ascertained. It does not appear that the Government has attempted any recent assessment of the real needs: that contained in Sir Ewart Smith's address at the British Association meeting in Birmingham in 1950 certainly should be taken further to provide a basis for policy. Some such quantitative estimate might provide one means of minimizing further controversy over the institutions to be selected for development, the scale of expansion and the types of technology to be included.

A very reasonable summary of the present situation and measure of agreement was given by Colonel B. H. Leeson in an address to the Institution of Electrical Engineers last October. He visualized the expansion of higher technological education as concentrated on a regional basis in a few selected larger colleges provided with first-class accommodation and staff, and stimulated by adequate opportunities and resources for research. The selected institutions would enjoy academic freedom under self-governing representative administration, and would not come under local education authorities. They would have facilities for postgraduate work, but would be expected to earn their prestige.

The small body which should be set up by the Government to select and to guide the colleges when chosen, in consultation with professional bodies, learned societies and industry, could well be a committee of the University Grants Committee; but until some such step has been taken the Government cannot claim to have a policy for technological education. It is emphatically not a matter primarily for the Minister of Education, though that Ministry will be required to renounce its authority over the selected colleges, and must also be concerned with the adjustments in the technical education that are involved. The technicians required, as Col. Leeson pointed out, outnumber the technologists by at least five to one, and whether or not the training of technicians and technologists can usefully and efficiently proceed side by side, at least in the selected institutions, the provision of facilities for training technicians will remain the responsibility of the Ministry of Education. Equally, the expansion of those facilities must match that of technological education. Parsimony or unwise retrenchment here could go far to thwart the expansion of technological education.

That due weight must be given to the content of technological education in planning its expansion, and especially to the exact technologies which are to be included, is indicated by the nature of the claims which have been advanced for the institution of new faculties such as pharmaceutical engineering science. Discussions at the conferences on industry and the universities, arranged by the Federation of British Industries, indicate that little support for such extravagances is likely to be forthcoming from the industrial side. That they should be advanced at all is a further reason for urging the early establishment of some agreed authority with the clear responsibility for encouraging the development of higher technological education.

Such a step in itself will not remove all difficulties in the way of co-ordination. While, for example, the Royal Technical College, Glasgow, has an independent board of governors and the local authority exercises no control, to develop further higher technological education there under the University Grants Committee would involve a transfer of responsibility from the Scottish Education Department. The position of another claimant, the College of Technology, Manchester, is more complicated. This includes the faculty of technology of the University of Manchester, and the College has received Government grants for more than forty years in the same way as other universities and university colleges. Nevertheless, the College is still subject to local authority control, though this need not perhaps be the main obstacle to its development as one of the few regional centres for the expansion of higher technological education. That obstacle is to be found rather in the limitations on its expansion placed by its equally important work in training technicians. The present plans for the expansion of the Manchester College of Technology contemplate the decentralization to subordinate centres of the more elementary work. This may give sufficient room for the development of the advanced work, and at the same time provision for part-time students from industry should minimize any drawbacks the partial divorce of technical from technological education might entail.

Quite apart, however, from the question whether it is wise to attempt to carry out technical and technological education side by side in the same institution, even when physical considerations such as siting do not impose limitations on expansion, the separation of technical and technological education should be determined on practical rather than on theoretical grounds, but in accordance with policy rather than by piecemeal decisions. Even on technical education the Minister of Education has given no signs as yet of having a policy, though formulation of policy is the first step towards the wise and efficient use of national resources. Such a policy must take account, not only of the balance between the numbers of technicians and technologists required by industry, of the probable demand for the services of both, of the resources and distribution of existing institutions, and the claims which expansion must make on available national resources, it must also take account of the well-attested gap which exists in Great Britain between pure and applied scientists and of the general impact of technology on society, and the stresses and needs which are liable to develop in consequence. Ultimately, it is concerned with the rate of technological change and its general effects; and at a time when a prime reason for urging the expansion of technological education is to promote the economic development of Great Britain, it is the more important that heed should be given, in planning both our policy of technical education and its content, to the effects on society.

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# KINEMATIC RELATIVITY AND THE CREATOR

Modern Cosmology and the Christian Idea of God
Being the Edward Cadbury Lectures in the University of Birmingham for 1950. By E. A. Milne. Pp. vii+160. (Oxford: Clarendon Press; London: Oxford University Press, 1952.) 21*s.* net.

THE late Prof. E. A. Milne had been asked to give a series of ten lectures on the Edward Cadbury Foundation at the University of Birmingham in the autumn and winter of 1950–51. The manuscript of these lectures was completed only a few days before his sudden death in September 1950, and the lectures are now published in book form, having been edited by his former pupil, Dr. G. J. Whitrow.

The original intention of the founder of the lectures was that they should be concerned with the relations, past, present and future, of Christianity to civilization and culture. Milne was invited to choose the relationship between cosmology and Christianity to-day. He states that he chose chiefly to discuss his own brand of cosmology because he had no faith in other theories of cosmology. The lectures, therefore, consist in the main of an exposition of kinematic relativity, which, being intended for a general audience, is practically free from mathematics. They provide the only exposition of this theory by Milne himself that can be described as non-technical. In the main, they cover the same ground as his book "Kinematic Relativity", but go beyond that work in giving an account of his last paper on a possible relation between gravitation and magnetism and a revision of his dynamical theory of light.

Kinematic relativity is a deductive theory which, starting from the cosmological principle in its narrow sense and from the basic facts of the dimensionality of space and time, and of the propagation of light, seeks to derive as much information as possible about the universe. The theory has been developed to cover not only cosmology but also a great part of theoretical physics. It employs two different time-scales: the so-called $t$-scale in which the relative motions of the observers are non-zero but unaccelerated, and the $\tau$-scale in which the observers appear to be at rest. The zero of the $t$-scale, which is the instant at which the universe was created, corresponds to negative infinity on the $\tau$-scale. The ordinary dynamical and physical laws employ $\tau$-time, but the $t$-scale is regarded as the fundamental one. Though any statement involving one scale can be transformed into a statement involving the other, statements in $\tau$-measure of anything but local phenomena are strange and unfamiliar. The $\tau$-scale is an ephemeral one, only appropriate to epochs near the present epoch of the observer using it.

Milne considers that the universe started as a transcendental point singularity at $t = 0$. At that instant, the linear dimensions of all atoms, stars and galaxies of every type of configuration must have been zero. Thereupon expansion began, the motions being radially outwards; at any subsequent time the distance travelled by any given particle is proportional to its velocity. Kinematic relativity leads to a unique model universe; Milne argues that this uniqueness implies an absence of rational alternatives in creation and that this is a genuine argument for both the rationality and the oneness of God. He considers that the possibility of constructing a rational system of time-keeping by congruent clocks implies that the universe has been deliberately created.

Kinematic relativity requires the constant of gravitation and Planck's constant to increase proportionally to the age of the universe reckoned from the natural zero of time ($t = 0$). The inverse-square law of gravitation can be put into an invariant form only by those observers in uniform relative motion for whom identical world pictures present themselves. On this subject of gravitation Milne asserts that "The law of gravitation cannot have been created by God by an arbitrary fiat; it is a consequence of the disposition of matter and motion in the Universe, in our $t$-description. God is a geometer in the more extended sense of a mathematician who extends the geometry of static figures of points, lines, and planes to idealised particles in motion".

According to Milne's theory the number of galaxies is infinite, although the space occupied by them is finite. Thus as we get farther and farther from any one galaxy we cannot avoid getting near other galaxies. As the universe expands, it creates the space it needs. But there is no last galaxy; we can never reach the edge. The apparent density of the universe is everywhere finite, but it becomes arbitrarily large at an arbitrarily small distance inside the expanding frontier. The most swiftly receding galaxies will appear, owing to the slowing-down of their clocks, to have been created a very short time ago. Milne will have nothing to do with the concept of continuous creation on the ground that it offers no explanation of how the frames of motion, in which the hydrogen atoms appear sporadically, are created. Nor does he accept the theory of the heat-death of the universe, which was advocated by Eddington and Jeans. He does not regard it as an inevitable consequence of the second law of thermodynamics, when applied to the universe as a whole. It is not possible to make valid propositions about the entropy of all the bodies in the universe because the universe has no final state. "Near its inaccessible frontier, the world will appear ever young, though each individual member will be growing old. There is no need of any appeal to any principle of rejuvenescence. For the universe as a whole has no age and no size, only an age and a size when a particular observer is singled out, at a particular stage of his experience".

Milne considers the evolution of spiral nebulæ. He asserts that the kinematic theory of gravitation goes far towards explaining the spiral form of many of the galaxies; the spiral arms are a consequence of the secular increase of the constant of gravitation. He concludes that the whole course of the evolution of a galaxy is one of interchange of its members with other galaxies. There is an outward drift in the neighbourhood of each nucleus, and the particles are continuously accelerated until they momentarily reach the velocity of light; deceleration then sets in, and each particle eventually comes to rest near a distant nucleus, becoming part of its galactic cloud of gas and dust particles. The galaxies are thus continually losing particles to distant galaxies but at the same time gaining particles from other distant galaxies. These particles when moving with speeds close to that of light are considered by Milne to constitute what we know as 'cosmic rays'.

Milne's discussion leads him to the following conclusions. "Laws of motion are not special creations but are indissolubly connected with the creation of the material content of the universe in the only manner in which such creation could have taken place, namely, by the recognition by the Creator of the impossibility of choosing special velocity frames when there is nothing to distinguish one frame from another, and of the impossibility of effecting the act of creation otherwise than at a point-singularity owing to the impossibility of choosing, unambiguously, simultaneous events separated from one another. Creation, the act, became a more and more difficult process the more we study it, until we see how God the Creator put aside the difficulties by the device of the creation of an infinite universe at a point as an initial point-singularity. . . . For the creation by God of an extended universe would require an impossibility, the impossibility of the fixation of simultaneity in the void—impossibility, that is, to a rational God. The paradox follows that the Deity himself, though in principle all-powerful, is yet limited by his very rationality. With God all things are not possible. This equally rules out the idea of continuous creation of matter everywhere in space, for there would have to be a pre-created space in which the creation of matter could take place; and there would exist a constant, namely the rate of creation of such matter, which could not be rationally accounted for."

Many readers of this exposition of kinematic relativity will not regard these conclusions as justified. But all will find much that is stimulating and thought-provoking in this exposition by its creator of a theory which has provided a searching examination of the concepts of time and space and which has great achievements to its credit. H. SPENCER JONES

## BOTANICAL TAXONOMY

### Taxonomy of Vascular Plants

By Prof. George H. M. Lawrence. Pp. xiii+823. (New York: The Macmillan Company; London: Macmillan and Co., Ltd., 1951.) 60s. net.

THERE has been a great need for an up-to-date and comprehensive handbook on the classification of vascular plants, and botanists all over the world are grateful to Prof. George Lawrence for undertaking to fill the gap. This he has done with notable judgment and skill, and with, inevitably, the expenditure of much time and labour that could no doubt be ill-spared from his research and other activities. As a result, he has produced a volume that will, for many years, be the daily companion of all concerned with the taxonomy of flowering plants and ferns.

The book is divided into two parts. The first, consisting of fourteen chapters (330 pages), deals with what may be broadly described as the principles and practice of systematic botany, while the second part (400 pages) is concerned with individual families, arranged in the sequence of Engler and Diels. There are two appendixes comprising a suggested syllabus for an elementary course in taxonomy, and an illustrated glossary of terms. An excellent single index completes the volume. Prof. Lawrence has chosen to scatter his very valuable bibliographies throughout the book after the relevant sections, and one thus misses the ease of finding a particular reference afforded by a single alphabetical bibliography, coupled with lists of abbreviated references after each chapter; but the saving of space no doubt dictated his choice, and, as it is, the bibliographies, especially those after each family in Part 2, will be one of the most welcome features of the book.

In Part 1 Prof. Lawrence gives excellent accounts of the history of botanical classification, leading to a survey of current systems, and has chapters on geographical distribution, nomenclature, identification, literature, field work and herbarium techniques, and on the writing of monographs, revisions and Floras. But it is probably to the sections on the more controversial aspects of taxonomy that many readers will turn first, for there are very few easily accessible recent summaries on the relationship between classification and phylogeny (Chapter 5), and on biosystematics and experimental taxonomy (Chapter 8). Prof. Lawrence's two chapters are undoubtedly the clearest and most up-to-date treatments so far produced, and show an awareness of many of the subtle difficulties that are so often ignored. In his discussions in phylogeny and taxonomy, however, and on biosystematics, one misses a clear statement of the basic aims of classification in general, and of biological classification in particular, without which the present troubled state of these subjects can scarcely be resolved. The idea that there can ultimately be one comprehensive classification of living things based on all their characters is a very attractive one to the human mind; but the belief that this concept is chimaerical is slowly gaining ground, and a number of biologists are gradually realizing that, in common with all other types of object, animals and plants must be classified in different ways for different purposes. Against the background of this view, morphological, phylogenetic and 'biosystematic' classifications will be seen as systems existing in their own right, for their own particular purposes, rather than as stages towards the final goal of an all-embracing taxonomy of living things. It is to be hoped that, in future editions, Prof. Lawrence will carry his analysis one stage deeper and discuss more fully this borderland region between philosophy and biology.

In the second part of the book a clear and thorough account is given of all the important families of flowering plants and ferns, and, in addition, many other families are mentioned, under their orders, without description. The choice of the sequence of Engler and Diels, because "it is the only available system that has been devised to account in detail for the flora of the world", is a convenient and sensible one. Perhaps the most valuable feature under each order and family is the summary of the phyletic treatment given to it by various authors in the past—information not easily available elsewhere. The text figures illustrating each family add greatly to the usefulness of the descriptions.

Prof. Lawrence has produced one of the most important books for many years in the field of systematic botany, and it is to be hoped that, despite its inevitably high price, it will be widely bought and used by students. J. S. L. GILMOUR

# X-RAY CRYSTALLOGRAPHY IN TECHNOLOGY

### X-Ray Crystallographic Technology

By André Guinier. English translation by T. L. Tippell; edited by Prof. Kathleen Lonsdale. Pp. xiii+330+16 plates. (London: Hilger and Watts, Ltd., 1952.) 56*s*. net.

THIS book was originally published in 1945 and was a good survey of X-ray crystallography as it was at that time. Since then, many developments have occurred which the author has not dealt with; however, the methods have not altered much, and the book forms a good introduction for the university student and research worker.

There are five parts and twelve chapters. The first three chapters are devoted to a study of the general properties of X-rays, the means of producing X-rays, and the theory of crystallography and X-ray diffraction. Chapters 4–6 are devoted to powder photographs, single-crystal photographs and the special applications of strictly monochromatic radiation. Chapters 7–9 deal with the determination of texture, chemical identification by measurement of cell dimensions, the study of phase diagrams and of elastic strains by accurate measurements of cell dimensions and, lastly, the study of order – disorder states in metals. The closing chapters, 10–12, deal with crystal imperfections, the diffraction of X-rays by amorphous substances, and the determination of the size of submicroscopic particles by low-angle scattering. The first appendix contains fundamental theory of X-ray diffraction too difficult to incorporate in the body of the text, and the succeeding appendixes give material such as tables of data about elements and the relation between θ-angles and the spacing for various wave-lengths which can also be found in the standard reference works. A number of plates are provided to illustrate various types of photographs referred to in the preceding chapters.

The book can be recommended as an introduction to the subject, although it is doubtful whether it will satisfy the needs of the technician, to whom the author specifically addresses the book. The omissions of subject-matter which might be expected in a modern book are no doubt partly due to the original time of its production, just after the Second World War, when there was much isolation of the scientific workers in France from those in Britain and other countries. It is almost certain that X-ray crystallographers need to know much more about high-temperature powder cameras, about moving-film cameras of various types, and more about spectrometers and Geiger counters than is here included. The actual description of instruments is, with only one or two exceptions, confined to the principles on which they are constructed. The technician usually requires to know the merits and demerits of various types, and even how to modify a given type to suit his particular purpose. The treatment given here is too brief and too academic really to serve the technician, though it will be useful to students in general.

There is one innovation which seems unfortunate to me—namely, the introduction of the term 'crystal base' to signify the nature and arrangement of the contents of a unit cell of the crystal. In the German literature '*basis*' is firmly established as the correct word; but in English writing 'basis' has only occasionally been used and usually the word 'structure' serves. A possible objection to the use of the word 'structure' is that it also signifies the nature and arrangement of the atoms in the whole crystal, though this ambiguity is not usually a serious difficulty. There are, however, weighty objections to the use of the word 'base'. It has the ordinary meaning of 'lower surface', and if the term 'base' is introduced, as in this book, it will be necessary, for example, to make a confusing statement such as "the base of sodium chloride contains four sodium and four chlorine atoms". Further, the plane (001) is invariably referred to as the 'basal plane', and hence the 'base' in morphology means this plane. If the term 'crystal structure' is not adequate, perhaps 'unit-structure', 'cell-structure' or 'cell-assembly' might be used.

The production of the text, tables and photographs is excellent, and there appear to be few misprints.

W. A. WOOSTER

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# PSYCHOPATHOLOGY OF GENIUS

### The Infirmities of Genius

By Dr. W. R. Bett. (Medical Viewpoint Series.) Pp. 182+6 plates. (London: Christopher Johnson (Publishers), Ltd., 1952.) 18*s*. net.

IN this book, parts of which have already appeared in *Clinical Excerpts*, Dr. W. R. Bett sets out to describe briefly the lives of fifteen men of genius and to relate their mental activity to the various afflictions which beset them. Beginning with Carlyle, whose neurasthenia he attributes to dyspepsia, he proceeds to discuss, among others, Shelley, Whitman, Swinburne, Baudelaire, Burns, Byron, Pope and Lafcadio Hearn. In every case he shows that there can be little doubt that the maladies from which his subjects suffered influenced their literary output and their relation to the society in which they lived. This is what would be expected, and Dr. Bett's treatment of his cases is too slight to enable the reader to consider the much more difficult problem of the precise relation that genius itself bears to the medical history of each individual.

There is no doubt that the literary output of such persons as Byron, Pope or Baudelaire was highly coloured by their infirmities; but these misfortunes were merely those which affect many others and which are clearly not related to genius itself. What is more probable is that the man of genius is likely to suffer from psychosomatic complaints which arise from the very fact of his genius setting him somewhat apart from his fellows; and, indeed, the examples chosen by Dr. Bett would seem to some to suggest this, although the cruder physical deformities naturally played their part in moulding the general attitude of those suffering from them.

What has to be distinguished is genius itself (whatever this may be) and the results of that genius as seen in literary and artistic production. How far such production proceeds purely from the conscious mind or is related to subliminal processes engendered by alcohol or drugs, as seems to have been the case with De Quincey and Coleridge, we do not know. It seems clear from Dr. Bett's intriguing study that, in the cases he cites, genius, although at times hampered and restrained, was able to surmount infirmity and add much without which the world would be considerably the poorer.

E. J. DINGWALL

## A Manual on the Weeds of the Major Crops of Ceylon

Prepared by a Committee consisting of Dr. J. C. Haigh and representatives of the Tea, Rubber and Coconut Research Institutes. (Department of Agriculture, Ceylon: Peradeniya Manual No. 7.) Pp. iii+50+vi+50 plates. (Colombo: Ceylon Government Press, 1951.) 5 rupees.

THIS work is perhaps better described as an annotated atlas rather than a manual, since its chief feature is the set of coloured plates of fifty of the commonest weeds of Ceylon, which admirably portray their habits and also exhibit some details of the reproductive organs. The accompanying text is comparatively brief and provides botanical and native names with short notes on habit, habitats, flowering time and flower colour, modes of propagation, a few descriptive details and mention of uses and means of control. The whole atlas is contained in a loose-leaf cover so that, as the promised supplements appear, the plates can be rearranged in alphabetical order.

It is interesting to note, in this half-century of common weeds, how few would appear to be regarded as definite pests, and many appear to provide useful vegetation-cover for the soil. One notes that the eradication of two species of *Oxalis* is described as impracticable. The perennial grass, *Imperata cylindrica*, evidently plays the part of a tropical couch grass, while the recently introduced annual grass, *Cenchrus echinatus*, has spread to an extent that is causing concern. A dwarf vegetatively propagated variety of the mugwort, *Artemisia vulgaris*, appears to be a greater nuisance than the taller type, which is propagated mainly by seed.

One can look forward to the supplements that are to appear in due course, and the whole should make a valuable addition to the bibliography of the weed flora of Ceylon. E. J. SALISBURY

## The Subject Index to Periodicals, 1951

Issued by the Library Association. Pp. xi+313. (London: Library Association, 1952.) £5 5s. 0d.

THIS index maintains the high standard of production characterizing the earlier volumes and, although now limited to publications in English which are issued in the British Commonwealth, provides the general reader with a key to the contents of many periodicals which are not indexed elsewhere. United States and Canadian periodicals are excluded only because they are adequately covered by the indexes of the H. W. Wilson Co. Highly specialized periodicals in the fields of science and technology are also omitted, because they are mostly indexed or abstracted by the societies and institutions concerned; but the scientific worker and technologist will nevertheless find this index a very useful key to general discussions, in the responsible monthly reviews as well as in scientific and technical periodicals, of such questions as technological education, industrial research, broadcasting, science and society, and the like. The 'proceedings' and 'transactions' of many local societies concerned with archæology, natural history, etc., are covered. The compilation is done on the plan of the 'dictionary catalogue', all entries being arranged under black-letter headings in a single alphabetical order. While cross-references are freely used to link up related subjects and direct attention to unusual, out-of-the-way topics which would otherwise be overlooked, one weakness has been noticed in the referencing from the general to the particular: the referencing under particular countries has made it rather difficult to determine the extent to which this index covers the more general current discussion of Colonial development and welfare or economic assistance of backward areas, whether under United States Point Four Aid or otherwise.

## Sound Recording and Reproduction

By J. W. Godfrey and S. W. Amos. (BBC Engineering Training Manuals.) (Published for *Wireless World.*) Pp. 271+10 plates. (London: Iliffe and Sons, Ltd., 1952.) 30*s.* net.

ALTHOUGH this book has been written primarily as an instruction manual for the use of the engineering staff of the British Broadcasting Corporation, it cannot fail to be of interest to all who are engaged in the techniques of sound recording and reproduction. The equipment described is, quite naturally, mainly that used by the B.B.C., but the principles dealt with concern not only engineers but also those students who are interested chiefly in the academic side of this subject of ever-growing importance.

The first chapter deals with the general principles involved in recording and reproduction, and thereafter the book follows a logical order, dealing comprehensively, though of course not exhaustively, with disk recording, magnetic recording and reproduction and, finally, recording on film. For those requiring data for reference purposes, there are a number of useful appendixes, and to help those who need still further information, a list of references is given.

Throughout the book the text is assisted by many excellent photographs, diagrams and graphs, and altogether the book makes very good reading. As the B.B.C. is now one of the largest users of recorded material in the world and has developed equipment of a very high standard, it does seem that such a book as this is really necessary, and it should receive a hearty welcome, especially by the staff in training.

## An English Course

For Royal Society of Arts and Technical Students. By Stanley Day and S. H. Wiltshire. Pp. 164. (London: Macdonald and Co. (Publishers), Ltd., 1952.) 7*s.* 6*d.* net.

THIS is an excellent little book. It covers more ground than does Sir Ernest Gower's "Plain Words", it is more systematic and it does not fall into the pits about which it warns others. It is succinct but not scrappy, logically developed with interesting and adequate exercises, and delicately spiced with a gentle humour. The book would do a good work in fields besides those of English courses for Royal Society of Arts and technical students for which it is primarily intended. It would solve many of the problems of expression which are met by science workers who have to convey their meanings by using the English language.

Many science students who need a little French and German would derive much benefit by taking this course in their mother tongue as an aid to their studies in other languages. A simple, direct English style which avoids ambiguity and circumlocution is the key to good science-writing, and this is the aim of the authors. An appendix gives a very useful list of books, including drama, novels, and poetry for the extended reading of the student. There is a good section on précis-writing. W. L. SUMNER

# PRODUCTION AND USES OF RADIOISOTOPES*

By Dr. HENRY SELIGMAN
Atomic Energy Research Establishment, Harwell

BEFORE the War one could make materials artificially radioactive by bombardment in big machines like cyclotrons, or by using relatively weak neutron sources. In the cyclotron, one can generally only use one target at a time and the irradiation is therefore costly. The weak neutron sources induce only weak activities. Therefore only a few research workers profited from the radioisotopes which one could produce in these ways.

The situation changed suddenly with the discovery of fission of uranium in 1939. This discovery showed that chain reactions were possible in which more neutrons are created than used. Accelerated by war research, the first chain-reacting atomic pile was working on December 2, 1942, in Chicago. Since 1947 we have had a pile working in Great Britain, and since early 1949 we have had a bigger reactor, BEPO, in full operation.

Such a conventional atomic reactor consists of fissionable material, like uranium metal, and a moderator like, for example, graphite or heavy water. The British piles use graphite as moderator. With the construction of such piles most formidable sources of neutrons were made available, which can be used for the bombardment of nuclei in order to make them radioactive. The great advantage is that in such a reactor a large quantity of material can be made radioactive at the same time. Since 1949, radioactive isotopes, of great specific activity, have been readily available in Great Britain.

New radioisotopes were quickly discovered and the chart of radioactive isotopes started to expand. To-day, there are more than six hundred radioactive isotopes, of which, however, only some hundred can be made conveniently in an atomic pile. For most elements there is at least one usable radioactive isotope. The only notable exceptions are the two elements nitrogen and oxygen for which no convenient radioactive isotope exists.

The process of irradiation is extremely simple. The material to be irradiated is put in a container and then inserted into the pile. After a certain time it is retracted, and either chemically processed or sent direct to the user.

There are a few points which are of importance. The neutron flux varies in the pile from place to place, and has to be carefully measured if one wants to get the right activity for each sample. The second important factor is that one has to observe the self-shielding of highly absorbing materials like gold or cobalt. The specific activity is a function of nuclear data, such as half-life, excitation cross-section for neutrons as well as irradiation time and neutron flux. The neutron flux in the isotope production pile at Harwell is greater than $10^{12}$ neutrons/cm.$^2$/sec.; but even this very high flux is, in some cases, not enough to produce a high specific activity for the purposes for which the isotopes are wanted in industry, research or medicine, and in some cases special preparations have to be made in order to eliminate the non-radioactive isotopes. This is usually done by a chemical process, when the isotope produced is chemically different from the other atoms. One such process is the $n,\gamma$-reaction followed by a $\beta$-decay, of which the production of iodine-131 from irradiated tellurium is a good example. A number of neutron–proton reactions occur easily in the pile, and the production of carbon-14 from nitrogen-14 and phosphorus-32 from sulphur-32 are the most important of these applied reactions. Tritium is extracted from irradiated lithium after an $n, \alpha$-reaction. Fission products can be separated either on ion-exchange columns or by co-precipitation methods. Szilard–Chalmers reactions are used, especially in the preparation of carrier-free radioiron, for which potassium ferrocyanide is irradiated. In all these cases extensive radiochemical preparations have to be made and sometimes the extraction procedures involve only between $10^{-9}$ and $10^{-12}$ gm. of material. Quite a number of syntheses, mainly of organic compounds, have been made by the Radiochemical Centre at Amersham, which is an out-station of Harwell.

Radioisotopes are useful for three reasons. The first is the very great sensitivity in detecting the smallest amounts of active material. If we compare the sensitivity with orthodox methods, for example, spectroscopy, we find that in many cases, if not all, it is much better. The limits of detection in spectroscopy are usually between $10^{-7}$ and $10^{-8}$ gm. Some of the carrier-free radioisotopes can be detected up to $10^{-14}$ gm.; but even if the material is not carrier-free, a sensitivity of $10^{-10}$ and $10^{-12}$ gm. is quite usual, and shows that isotopes are superior to orthodox methods of analysis by anything between a thousand and a thousand million times. Therefore, rightly, the application of these new tools to science has been compared with the discovery of the microscope. Another similarity with the microscope lies in the fact that it is possible to locate these small traces without damaging the material, whereas with chemical methods, when testing trace amounts, the material is either destroyed or dislocated. It is this possibility of locating the trace elements which is so important in research and industry. The third big class of applications is the use of the beta- and gamma-radiations emitted from radioisotopes. They are used for ionizing air in order to make it conductive for electricity, for penetrating materials for the purpose of making radiographs or for destroying tissue or blood corpuscles.

Industry has made use of the sensitivity of the method in tracing underground currents of water. For this purpose one can use tritiated water; although the beta-radiation from tritium is rather weak, with modern methods of detection very small traces of this material can be measured. The advantage of using tritiated water is that there is no danger of ion adsorption on soil that would occur with most other ions. In the oil industry, it is frequently necessary to mark the interphase between two oils pumped through the same pipe-line. Indeed, it is becoming a routine method of detection to add a radioactive isotope to indicate when a different oil is coming through a pipe-line at a distant location.

Leaks in water mains and pressurized cables have been detected successfully by adding small amounts of radioactive materials to either the water or the gas in the pressurized cables. In France, a method has been developed for using methyl bromide in which the bromine is radioactive. This is injected into the gas of the pressurized cables ; if it leaks out into the ground, the methyl bromide remains in the soil and can therefore be easily detected hours later by monitoring on the surface with simple detection instruments. All these applications of radioisotopes enable us to carry out operations which would be very difficult to do by any other method.

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* Substance of a Friday Evening Discourse at the Royal Institution on February 6.

We are frequently called upon to make ventilation experiments in factories or assembly rooms. Here we use radioactive vapours or gases. Ethylenedibromide has been used successfully, but will eventually be replaced by noble gases like krypton-85 or xenon-133, when they become available in the near future. Great care has to be taken that these gases are not adsorbed on walls or machines, and therefore noble gases are more suitable than radioactive vapours.

Isotopes can also be used in problems of mixing. The problem may be to find when the mixing process is complete between small amounts of material like vitamins and large amounts of other foodstuffs. By adding a small amount of harmless short-lived radioisotope, the mixing can be controlled and checked when the material is transferred to the conveyor belt.

A thickness gauge has been developed which works by attenuation of radiation by the material. Another system of measuring the thickness of the coating of materials makes use of the reflexion of beta-rays. The reflexion depends on the atomic number and the thickness of the reflecting material, and can be used to measure the thickness of one material on another, where the two materials have different atomic numbers.

The discharge of electrostatic electricity produced during a manufacturing process which entails rolling insulating material like plastic, rubber, paper, etc., is often a great problem to industry. Dust particles are, for example, attracted to the fabrics in weaving nylon or rayon when they are left in the looms overnight. In some cases one can neutralize the static charges by ionizing the air with a radioactive source giving beta-radiation such as thallium-204.

The ionization from radioisotopes can also be used to help in starting gas discharges. A gas discharge can only start if a free electron is present. The presence of beta-emitting isotopes makes the starting operations more reliable and is being used to promote ignition at spark gaps and to make cold cathode ray tubes work more smoothly.

In process control, radioisotopes have been used successfully in the operation of ion-exchange columns. Thus, radioactive sodium ions are kept back by a resin and the radiosodium can afterwards be dissolved out under controlled conditions. This method is used in the separation of zirconium and hafnium by adding a small amount of radiozirconium and radiohafnium, which are retained in the column. One can find out when the column is saturated by measuring the activity at the bottom of the column ; the washing-out agent for one material is then added, and when this one is totally dissolved, which again is checked by activity measurements, the second washing-out agent is added. It is a remarkably easy way of ensuring a constant accurate analytical control.

An important use of radioactive sources is for gamma-radiography. Isotopes have a number of advantages over X-ray equipment. They are less cumbersome. A 2- or 4-mm. cylinder can be used for insertion into a small pipe, for example, or for taking radiographs under water. By this means welds, for example, in the shipbuilding industry can be tested. Radiographs can be made in the field, as no electrical supplies are necessary, and lastly, these gamma-sources need no maintenance. The main disadvantage is that the exposure-times necessary at present are relatively long ; but this disadvantage will become less and less serious as sources of higher specific activities become available. Three isotopes are available for gamma-radiography, depending on the purpose needed. Cobalt-60 emits on average 1·2-MeV. gamma-rays, which can be used for making radiographs of 2–6 in. of steel ; iridium-192 emits gamma-rays of 0·6 MeV. and can be used for investigating thicknesses of steel $\frac{1}{4}$–2 in. ; and thallium-170 with 80-KeV. gamma-radiation can be used for radiography of light alloys. Industry in all countries is already making extensive use of these sources.

Much use has been made of isotopes in metallurgy for measurements of self-diffusion, especially by following the movements of molecules under heat treatment. The measurement of wear of metals becomes easy by making one part of the metal radioactive. Thus, the wear of piston rings in an engine can be determined by making them radioactive and measuring the activity on the cylinder walls and in the lubricating oil.

In physical chemistry, labelled catalysts have been used to demonstrate their part in chemical reactions, and small vapour pressures of different materials have also been measured. The passage of water through membranes or 'Cellophane' has been accurately determined by using tritiated water.

Activation analysis is being used, especially in cases where the normal methods of chemistry fail. A special advantage is the localization of trace amounts. In France, use was recently made of activation analysis in establishing evidence in a murder case. A man had been poisoned with arsenic ; but difficulty arose in finding out when arsenic was first administered to him. Arsenic accumulates very quickly in the hair after administration, and, having a high activation cross-section, becomes very radioactive by pile irradiation, whereas the normal components of hair are scarcely affected. Therefore, by irradiating a hair of the poisoned victim in the French pile and making an autoradiograph of the hair afterwards, the time could be established when the arsenic was administered, since the rate of growth of hair is known. Industry is making use of activation analysis in, for example, the determination of impurities of arsenic in germanium for the electrical industry, where one can determine 0·01 parts per million. Traces of copper have been accurately measured in the manufacture of rubber, where copper has a very adverse effect.

The uptake of phosphorus in plants has been determined by using radioactive phosphorus. Such experiments were made in order to find the best fertilizing conditions, and, in fact, it is the only method of distinguishing between the phosphorus taken by plants out of the ground and that given as fertilizer. It is claimed that this investigation has made possible considerable savings by demonstrating the optimum fertilizing conditions.

In zoology, radioisotopes have been used as tracers to follow animals underground.

Great progress has been made in biochemistry. Quite a number of metabolism studies have been made which would be difficult, if not impossible, without the help of isotopes. The protein and plasma protein metabolism have been investigated, using carbon-14 amino-acids. Penicillin has been made active and its reaction has been followed in animals.

The future will see an expansion of the use of radioactive materials as bigger sources are used for irradiation purposes. At the moment work is in hand in examining chemical synthesis or changes happening under very strong radiations. At the same time, some progress has been made in trying to sterilize foods and penicillin by radiation. The dosages necessary for this are very big indeed. They are of the order of a hundred thousand or millions of roentgens, and in Great Britain it will be another year or two before facilities are available for this kind of research.

The Atomic Energy Research Establishment at Harwell and the Radiochemical Centre at Amersham are sending out more than nine thousand shipments of radioactive materials a year to some thirty-seven countries, including the United States, most South American countries, Africa, India, Australia and New Zealand. The majority are used in medical research, diagnosis and therapy.

In medical diagnosis very small amounts of activity are required and have been used successfully for blood circulation tests. Work is in hand in tracing tumours of the brain by tracer methods. In therapy, the greatest use is that made of radioiodine in the treatment of thyroid toxicosis. Some cases of thyroid cancer can be treated successfully with radioiodine. Cancer of the bladder can be treated with an active bromine solution in a rubber balloon. Colloidal gold is used as a palliative treatment of malignant pleural and peritoneal effusions. Radiosodium is used in plastic surgery. Radiophosphorus is used in polycythæmia vera. Big telecurie sources are used for general irradiation, and special beta-sources which only penetrate a few millimetres of skin are used in the treatment of some surface cancers. These are usually applied as radiophosphorus built into a plastic. The plastic is irradiated in the pile and, after irradiation, the radiotherapist cuts out the right shape of the plastic which he needs and applies it to the malignant tissue, leaving it a calculated time in order to give the exact radiation dosage.

In the early post-war days, people were apt to speak of isotopes as 'by-products' of atomic piles. This picture has changed now. Radioisotopes have helped industry in solving many problems, they have widened the field of research in many sciences and have helped the medical man to treat disease and, in some cases, to save life. They have become an important part of the atomic energy development, and I am convinced that we are only at the beginning of the development of 'isotopics'.

# THE NATURE CONSERVANCY

SOME aspects of the work of the Nature Conservancy were the subject of discussion at a meeting of the Linnean Society on February 19. In his opening remarks, Captain C. Diver said that conservation and research, the Conservancy's two main functions, are necessarily very closely linked. He and Dr. Conway dealt with two ways by which scientifically valuable places might be safeguarded for study; Mr. Skellam and Dr. Ovington, who are each in charge of one of the half-dozen main research programmes now being carried out by the Conservancy, then outlined one or two of the problems on which they have been working.

The most effective means of conserving any special place is to acquire it or otherwise arrange for it to be managed as a Nature reserve. This is not always easy because of land requirements for forestry, agriculture, service training, and development of one kind or another. To exemplify these conflicting demands, twelve cases were mentioned where places of the highest scientific value have been lost or threatened; these included the requirement of Bilston Glen for dumping colliery spoil and the Arne heaths in Dorset for ball-clay working.

The Conservancy has, however, already declared nine reserves (two in Scotland and seven in England) totalling about 22,000 acres; and negotiations are proceeding satisfactorily in respect of at least seventeen more. Informal agreements have also been made with the owners of several other properties; and help is being given with the management of a few sites already held as reserves by other bodies. Two local authorities are using their new powers to establish local reserves.

The Conservancy has also acquired two properties —one in the Lake District and one in Dorset—which are being equipped as research stations; and field research facilities are being provided at Moor House Reserve (Westmorland) and at Beinn Eighe Reserve (Wester Ross).

Dr. V. M. Conway said that the making of Nature reserves can safeguard only a small fraction of the wild country that must be kept in something like its present state if reasonable stocks of the native flora and fauna are to be preserved. Power to conserve other interesting places rests largely with local authorities; but under Section 23 of the National Parks and Access to the Countryside Act, 1949, the Conservancy has the duty of notifying planning authorities about the areas which are of special scientific interest by reason of their flora and fauna, or geological or physiographical features. Local planning authorities are required to consult the Conservancy before giving planning permission for developments likely to affect areas so notified. The Conservancy can then put the scientific case for conservation, and can approach owners and other interested parties. One of the weaknesses of this arrangement is that changes in sylvicultural or agricultural methods do not constitute 'development' and might, therefore, occur without the Conservancy's knowledge, often to the detriment of the valuable characteristics of the area.

The choice of areas for notification under Section 23 rests primarily on the recommendations of the local committees of the Nature Reserves Investigation Committee which was at work during the War. These recommendations have been checked and revised since the Conservancy came into being in 1949—work which has been made possible only by a large amount of voluntary help. Notifications must be made with minimum delay because so many good places are being lost all the time, and planning authorities need information as quickly as possible. For this reason there are many gaps and inequalities in the existing lists; but by careful collection of information over the next four or five years it is hoped that these may be largely removed in time for the first revision of county development plans.

Passing from administration to research, Mr. J. G. Skellam said that the statistical analysis of observational data enters into all aspects of the Conservancy's scientific work. In order to illustrate the mathematical approach, he selected just one topic, that of quadrat sampling. This subject is of considerable importance to the Conservancy because of the need to assess floristic and faunistic changes which may be taking place in the same locality with the passage of time and to measure the differences which exist from place to place; and in both cases to do so with known accuracy.

Mathematics can be applied to biological problems in two ways. In the first place, mathematical functions can be used for describing numerical results in a concise way. But such descriptions are often arbitrary and only acquire meaning when they can be related to the underlying causes. It is instructive in this connexion to construct simple models or idealized versions of the biological situation as suggested by observation and experiment and to deduce their consequences. In this way we not only discover functions which are suitable for description of numerical data, but we also construct standards which play the part of a basis for comparison against which the real complexities may be critically demonstrated.

Dr. J. D. Ovington then briefly described some of the woodland research carried out by the Conservancy over the past three years in co-operation with the Forestry Commission. Investigations are progressing at several widely different localities in Great Britain. Each locality contains a number of woodland plots of different tree species established on what were originally fairly uniform sites. The principal characteristics of the various woodlands and their dynamic relationships are being considered with particular reference to the climate, soil and ground flora. Tree canopies intercept precipitation and in so doing diminish and redistribute the rainfall reaching the soil. The irregular distribution of the precipitation pattern in woodlands can in part be attributed to the raindrops coalescing on the canopy and falling as large drops. Once established, the trees influence soil formation, and, after twenty years of afforestation, marked differences, particularly in the accumulation of surface organic material, soil *p*H and nutrient content, develop under different tree stands. The weight of the ground flora present in a woodland may be related to the age and closeness of the trees and to the type of woodland that has been established. The associated woodland floras differ considerably in their floristic composition and give some indication of the extent to which site conditions have been modified by the various woodland plantations.

Discussing Dr. Ovington's paper, Dr. J. Ramsbottom directed attention to the importance and specificity of the fungal flora in different types of woodland—facts which are frequently overlooked. Dr. Ovington confirmed that the species of fungi present in the plots he has worked on show differences like those described by Dr. Ramsbottom, and he thinks it is of primary importance to understand the part played by these species in the nutrient cycles. Replying to Mr. W. T. Stearn, he explained the technique used for measuring the size and dispersal of raindrops.

Speaking of the Midlands, Dr. A. Tindell Hopwood said some useful work might be done on the covering of slag-heaps with vegetation. Dr. Conway replied that one of the research students supported by the Conservancy is already working on this problem and that the Conservancy might take a direct interest in it when it has made sufficient headway with its primary task of conserving unspoilt areas of land. Prof. C. T. Ingold expressed the hope that the Conservancy will not get too departmentalized and will keep in close touch with local natural history societies and possibly issue a journal. Captain Diver said that he expected regular reports will now be issued. Mr. Stearn pointed out that many places are not in a static condition but are changing all the time, and asked what will be done about this. Captain Diver replied that when places are considered for reservation it is essential to know whether one wants to maintain them in a particular phase, for example, downland turf, or to study the natural sequence of change as in a prograding coast; and reserve management policy has to be directed to achieve the required result.

# ELECTRICAL DEVICES FOR CONTROLLING THE MOVEMENTS OF ANADROMOUS FISH

INCREASING attention has been paid, over the past few years, to the use of electric currents as aids for catching fish in freshwaters, and it is evident that the use of electrical methods promises to become an important technique both for the fisheries biologist who wants to carry out census work and the owner who wants to reduce or eliminate populations of unwanted fish from his waters.

A recent communication[1] by a member of the staff of the North of Scotland Hydro-Electric Board has described other uses of electric currents in fisheries. Hydro-electric works are bound to have important effects on the movements of migratory fish, since they frequently interpose barriers to migration or create other unnatural hazards in the course of their operation. Over much of the area covered by the North of Scotland Hydro-Electric Board, salmon are the most important migratory fish, and it has been found necessary to try to discover ways in which the potentially deleterious effects of hydro-electric developments could be minimized. When constructing impounding dams, the Hydro-Electric Board is legally bound to provide fish ladders so that migrating fish can pass upstream or downstream; but the construction of hydro-electric power stations creates other problems. Downstream migrants may be drawn into the tunnels or aqueducts which lead to the turbines, and the volume and turbulence of the water discharged in the tailrace from the stations may deflect migrants from their course and so interfere with their passage upstream. In the communication mentioned, an account was given of devices which are being used for trying to solve both these problems, following experimental work in the Board's laboratory at Dundee.

At Morar, an electric screen has been erected to deter salmon and sea trout from entering the tailrace of the power station. This screen consists of a row of aluminium electrodes, each about 14 ft. in length, which extends to three inches from the bottom of the channel, together with two electrodes, about 16 ft. apart, placed 7 ft. downstream from the main screen. A pulsating electric supply is applied across the electrodes. Salmon are seen to react when about 5–6 ft. from the outer electrodes since, at this distance, they turn and swim upstream past the end of the

Experimental screens at the Power Station, Pitlochry (Perthshire)

tailrace. Reactions are seen in sea trout when they are about 2–4 ft. (depending on their size) from the inner row of electrodes. Experimental work with this screen was first carried out in 1950, was repeated in 1951 and again repeated, with improved electrical equipment, during the spring of 1952. During the last period, constant observation was maintained on the movements of fish. No fish were seen to penetrate far into the tailrace, and all the fish seemed to behave normally after leaving the electrified zone; no signs of distress were seen and there was no inclination to remain inactive.

The success of this screen at Morar has led to the installation of similar screens at other sites. The accompanying photograph shows a screen which has recently been set up on the tailrace from the power station at Pitlochry, which is situated at the lower end of Loch Faskally.

Experiments on the use of electric screens to divert descending salmon smolts have been carried out, over the past three years, at Dunalastair Dam on the River Tummel in Perthshire. Here the screen consists of two parallel rows of aluminium tubes strung diagonally across the lower end of Dunalastair Reservoir immediately above the dam. The downstream row is made up of 272 tubes one foot apart, and the upstream row, which lies 6 ft. from the downstream row, consists of 34 groups of tubes spaced at 8-ft. intervals. As at Morar, a pulsed current is applied across the screen. The purpose of this screen is to divert the downstream-migrating smolts from the entrance to the aqueduct, which conveys water from the reservoir to the power station at Tummel Bridge, into the fish pass. Though this device has not been so successful as the tailrace screen at Morar, it has shown sufficient promise to warrant a continuation of this experiment.

As well as carrying out tests on the use of electric screens, the North of Scotland Hydro-Electric Board has also devised an automatic electrical counter which has been installed in the fish ladders at Clunie and Pitlochry Dams. Its operation depends upon the difference in resistance to electrical currents between a salmon or sea trout and the water in which it is swimming; the passage of a fish through the submerged pipe linking two chambers of the fish pass can thus influence an electrical bridge, and this disturbance can be made to work a counter. The apparatus can be adjusted so that only fish greater than a certain size are counted, and refinements make it possible to operate this equipment in waters of widely varying chemical content. The passage of salmon upstream and the passage of kelts downstream are recorded separately; but if a fish does not complete its journey through the pipe, its passage is not recorded. Branches of trees, logs of wood, empty tins and other debris passing down the fish pass do not affect the counter. This equipment was in operation at Pitlochry during 1952, and daily checks have shown the electrical counter to have an accuracy approaching 100 per cent.

The future development of all these devices will be followed with great interest by all who are concerned, professionally or privately, with the welfare of salmon fisheries. The importance of the electric fish screens needs no emphasis, and the counter, though it plays no part in controlling the movements of migratory fish, should produce records the value of which will increase as the years pass. It is to be hoped that the fullest possible records will also be kept of environmental conditions, since in these circumstances the records from the electric counter could prove valuable additions to what is known of the characteristics of the upstream migration of salmon.

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[1] Lethlean, N. G., "An Investigation into the Design and Performance of Electric Fish-screens and Electric Fish-counters", paper presented to the Royal Society of Edinburgh on February 2, 1953.

# OBITUARIES

## Prof. G. D. Hale Carpenter, M.B.E.

**Geoffrey Douglas Hale Carpenter**, professor emeritus of zoology (entomology) in the University of Oxford, died at the Radcliffe Infirmary on January 30 at the age of seventy. He came of a distinguished academic family and was a grandson of William Benjamin Carpenter, F.R.S., one of the most eminent physiologists of his time. His father was an assistant master at Eton, and his mother the daughter of another; but although born in the College itself his early education was received at the Dragon School and Bradfield. He then passed to St. Catherine's, Oxford, where he took his B.A. in 1904, obtaining second-class honours. Throughout this period he took a wide interest in natural history, and especially ornithology, conchology and entomology, so laying firm foundations for his future career. His first paper was an unpublished one on the mother-of-pearl moth (*Sylepta ruralis* Scop.) and its parasites which he read, while still an undergraduate, to the Ashmolean Natural History Society of Oxfordshire, one of the many societies of which he later became president, and which he always regarded with much affection. From Oxford he passed with a University Entrance Scholarship to St. George's Hospital, London, qualifying M.R.C.S., L.R.C.P., taking the degrees of B.M. and B.Ch. in 1908, and eventually holding the appointments of house-surgeon and house-physician.

Hale Carpenter's interest in entomology led him to specialize in insect-borne diseases, and in 1910 he entered the Colonial Medical Service. The following year found him in the Sesse Islands in the north-west part of Victoria Nyanza, where he had been sent to study the bionomics of the tsetse fly, *Glossina palpalis*, which had recently appeared in Uganda and within a few years had caused more than two hundred thousand deaths from sleeping sickness. The results of his researches were published in the Reports of the Sleeping Sickness Commission of the Royal Society (1912, 1913 and 1919) and were presented as a dissertation for his D.M. degree at Oxford.

In the First World War, Hale Carpenter served as a captain in the Uganda Medical Service, his duties taking him into many interesting parts of Africa that he would otherwise never have visited and providing him with rich material for his book "A Naturalist in East Africa" (1925) and for many scientific papers on insect bionomics, polymorphism and mimicry. For his war services he received the M.B.E. On demobilization he resumed his work on tsetse fly, becoming specialist officer for the control of sleeping sickness in Uganda. He retired from the Colonial Medical Service in 1930; but at the request of the Secretary of State for the Colonies undertook a special investigation into tsetse fly in Ngamiland during 1930–31.

While in Africa, Hale Carpenter kept up a voluminous correspondence about his observations on insects with Sir Edward Poulton, Hope professor at Oxford, and on returning to England he built a house on Cumnor Hill, just outside that city. For a year or two he visited the Hope Department of Entomology, Oxford University Museum, daily, studying the vast stores of African insects, many of which he had collected himself, and helping Sir Edward Poulton. When Sir Edward retired in 1933, Hale Carpenter succeeded him, occupying the chair for the next fifteen years, and so qualifying for the title of emeritus professor on his retirement in 1948. During this period he continued his studies on mimicry and geographical distribution, and paid special attention to the vexed question of the attacks of birds on butterflies and its significance for evolutionary theory. At the same time he was deeply concerned about the future of his Department, and not only did all he could to enhance its value, but also appealed to the University for a new building and an increased staff.

During the Second World War, Hale Carpenter lectured on camouflage and tropical medicine to troops in training near Oxford, prepared special booklets for the African campaigns and served as head warden of the air-raid precaution service for Cumnor.

He frequently attended and spoke at scientific meetings in London, was president of the Royal Entomological Society during 1945–46, vice-president of the Linnean Society during 1935–36 and was an ardent supporter of the British Association.

His writings included "A Naturalist on Lake Victoria" (1920) and "Mimicry" (1933). His study of the genus *Euplœa*, a genus of butterflies found on many Pacific Islands, was completed shortly before his death and is to appear in the *Transactions of the Zoological Society of London*.

Hale Carpenter was a tall, distinguished-looking man with white hair, easy of address and with a keen sense of humour. His chief recreation was gardening, the varied soils at his home at Cumnor Hill enabling him to grow a wide variety of plants. He was an ardent churchman, secretary of the Parochial Church Council, and chairman of the Cumnor branch of the Oxford Preservation Trust. His holidays were often spent in Cornwall, where he would walk, watch birds and collect insects.

He married in 1919 Amy Frances Thomas-Peter, of Treviles, Cornwall, who survives him.

B. M. Hobby

## Prof. N. A. V. Piercy

In the passing of Prof. N. A. V. Piercy, on February 1, the profession of aeronautical engineering has lost one of its ablest teachers and a pioneer in the teaching of aeronautics.

Norman Augustus Victor Piercy was born in London on August 10, 1891, and after being educated at Hampton Grammar School he was apprenticed to Yarrow and Company, Scotstoun (1908–13). He obtained an honours degree (London) in engineering at East London College (now Queen Mary College) in 1913 and immediately became engaged at Shoreham on the Cedric Lee aeroplane, known as the 'Doughnut', which had a circular ring for its wing plan-form. The period until 1919 found him engaged at East London College in researches on this novel wing, as well as special investigations for the Admiralty. During this time he designed his own 4-ft. wind tunnel, which was built of steel plating obtained from a destroyer. This tunnel is still in use.

In 1919 he was appointed head of the Department of Aeronautics at East London College and started the first university course with aeronautics as a recognized subject. In 1920 he obtained his D.Sc., for his work in connexion with the flow behind aerofoils. His subsequent researches in aerodynamics included flow in pipes, heat flow from moving bodies and aerofoil theory from which the 'Piercy aerfoil' was developed.

As a teacher Piercy inspired his students, and in consequence he soon gathered a small team of research workers around him. In 1934 he was appointed reader in aeronautics in the University of London, and in 1949 his work was officially recognized when the title of University professor of aeronautical engineering at Queen Mary College was conferred upon him.

During the Second World War Piercy was in charge of the Aeronautical Department in the University of Cambridge, in addition to his work at Queen Mary College.

Piercy was the author of "Aerodynamics", which was published in 1937 and revised in 1947, "Elementary Aerodynamics", published in 1944, as well as various papers read before learned societies. At the time of his death he was engaged in a third edition of "Aerodynamics", incorporating more recent advances in supersonic flow. He was a man of amazing energy and served on many committees dealing with the teaching of aeronautics, as well as being a member of the Council of the Royal Aeronautical Society during 1935–39. His other interests included music—he was an able pianist—golf and the collecting of antiques.

H. F. Winny

### Dr. Y. A. Bilibin

Yury Alexandrovich Bilibin was born on May 19, 1901, in Rostov in Yaroslav province, and he died on May 4, 1952, in Moscow. After active participation in the civil war of 1917–21, he graduated in 1926 at the Leningrad Mining Institute. His scientific work is intimately associated with the geological survey of Eastern Siberia, and he became an authority on the mode of occurrence and mode of origin of ores of gold, tin, copper and other metals. He constructed metallogenetic maps and lectured on metallogenetic provinces, and made considerable progress in the application of geochemistry to the problem of ore genesis. He also published important papers on the igneous rocks of the Aldan region in Eastern Siberia and was particularly interested in the origin of alkaline rocks. In 1943 he received his doctorate and was later elected a corresponding member of the Academy of Sciences. In 1948 he came to London to take part in the meeting of the International Geological Congress, and those who met him there will remember him as a shy but very friendly person who was an outstanding geochemist and geologist.

S. I. Tomkeieff

We regret to announce the following deaths:

Mr. Andrew Gray, technical general manager during 1928–32 of Marconi's Wireless Telegraph Co., Ltd., and an early assistant of Marconi, aged eighty.

Prof. J. W. McBain, F.R.S., emeritus professor of chemistry in Stanford University, California, and lately director of the National Chemical Laboratory, India, on March 12, aged seventy.

# NEWS and VIEWS

### Agriculture in the University of Sydney: Prof. W. L. Waterhouse

Prof. W. L. Waterhouse, research professor in the Faculty of Agriculture, University of Sydney, retired at the end of 1952. During his thirty-two years of service, he had occupied the positions of lecturer, reader and professor. Prof. Waterhouse lectured on plant pathology, genetics and plant breeding, and agricultural botany. The scientific discipline derived from these courses was ideal, and has stood many graduates in good stead no matter in what field of scientific endeavour they work; his teaching was inspired. His main researches were in the field of cereal diseases, in which he accepted the challenge of solving the wheat rust problem of Australia. He had many successes, the culmination of his work from a practical point of view resulting in the production of an outstanding variety known as Gabo, which was resistant to all the forms of stem rust existent in Australia up to 1948. But perhaps his greatest contribution was to give a complete understanding of the problem, a thorough knowledge of the rusts, techniques for breeding resistant varieties, and above all hope for the future. Prof. Waterhouse has been a good colleague and has played a considerable part in developing the Faculty of Agriculture in the University of Sydney. Although handicapped by wounds sustained in the First World War when he was awarded the Military Cross, he never spared himself in his teaching and research. Prof. Waterhouse's work has been recognized by many awards: he was given the Farrer Memorial Medal in 1937 and again in 1950; in 1943 he received the Clarke Memorial Medal of the Royal Society of New South Wales, and in 1948 the Australian Medal of Agricultural Science. Now his University has conferred on him the title of emeritus professor. Truly can it be said that here is a man who has devoted himself to science and to agriculture, so that the lot of the farmer and the community might be improved and the world made a better place in which to live.

### Geophysics at the Carnegie Institution of Washington: Dr. P. H. Abelson

Dr. Philip H. Abelson, chairman of the Biophysics Section of the Department of Terrestrial Magnetism in the Carnegie Institution of Washington, has been appointed director of the Geophysical Laboratory of the Institution with effect from September 1 next. Dr. Abelson's research career began under Prof. Ernest O. Lawrence at the University of California, Berkeley, where he made the initial identification of radioactive antimony, tellurium and iodine as products of uranium fission, gaining his Ph.D. in 1939. He then joined the Carnegie Institution as a staff member and took a prominent part in the design and construction of the cyclotron at its Department of Terrestrial Magnetism at Washington, D.C. During the Second World War he was a physicist at the Naval Research Laboratory, where he developed the liquid thermal diffusion method for enrichment of uranium-235, and under his general supervision a plant employing the method was designed and constructed at Oak Ridge for work in connexion with the atomic bomb. Dr. Abelson returned in 1946 to his old Department in the Carnegie Institution and organized a programme of biophysical work for using isotopes and radioactive nuclei in the study of the processes by which living cells select chemicals from their environment and organize them into new cells; as a result, a number of processes in the chemistry of amino-acids have been elucidated. At the same time he has continued his interest in geophysics and geochemistry, and in his new post he is going to a laboratory where during recent years much of the work has been focused on novel experimental techniques for studying the physics and chemistry of the solid state, such as the melting and solubility relations of silicates, especially in the presence of water, and the transport of minerals by solution in a gas phase.

### Dannie Heineman Prize of the Heineman Foundation

The first award of the Dannie Heineman Prize of the Heineman Foundation for Research, Educational, Charitable and Scientific Purposes, Inc., has been made to Prof. Otto Neugebauer, of Brown University, Rhode Island, for his book entitled "The Exact Sciences in Antiquity" (Princeton University Press, 1951, and Oxford University Press). The Prize, which is worth five thousand dollars, will be awarded every three years to the author of an outstanding book on mathematical or physical sciences which opens up important fields of research. Prof. Neugebauer, who is an Austrian by birth, is a mathematician who has turned his knowledge to the study of Egyptology and, in particular, to the deciphering of Babylonian and Sumerian cuneiform texts dealing with mathematical and astronomical subjects. The Heineman Foundation was established by Mr. and Mrs. Dannie N. Heineman, of Charlotte, North Carolina, in order to further educational, charitable, religious and scientific enterprises and projects, without reference to nationality, race, creed or colour. Further information can be obtained from the secretary of the Foundation at Suite 1700, 50 Broadway, New York 4, N.Y.

### Oil Palm Research in Nigeria

The Oil Palm Research Station, Benin, formerly a station of the Nigerian Agricultural Department, has recently been transformed into the West African Institute for Oil Palm Research. This Institute has been set up by statute to serve the British West African territories in all matters relating to research on the oil palm—a tropical crop of great contemporary value and importance. Annual reports on the work of the Institute are promised in due course, these continuing the records of the former Research Station. Meanwhile, quarterly progress reports are being made available to those who are interested in this crop; for the managing committee is anxious to make the work of the Institute as widely known as possible. Leaving aside the numerous matters of administrative detail, inseparable from the establishment of a new organization, the contemporary report (No. 3; October–December 1952) contains items of scientific and practical interest on problems of seed germination, the effect of leaf pruning, the effect of burning and non-burning techniques of land-clearing on subsequent yields—a matter of rather special interest to the tropical planter, the agronomist and the soil chemist—genetical and breeding investigations and progeny trials, and the investigation of various obscure diseases to which the oil palm is subject. Although at several points the work has been restricted and impeded by staffing difficulties, the Institute is now an active going concern. For this, much credit is due to the director, Mr. F. W. Toovey, for a notable administrative and scientific achievement in the face of difficulties that only workers with tropical experience are likely to appreciate to the full.

### Association of Clinical Biochemists

The Association of Clinical Biochemists was formed at a meeting held at the Postgraduate Medical School of London on March 28. Regional societies in the Midlands, Glasgow, the north-west and the south of England have been in existence for some time, and an interim committee of these groups was set up last year under the chairmanship of Prof. E. J. King. The activities of the new Association will be both scientific and professional and will comprise the field, now somewhat incompletely covered, between pathology, clinical medicine and biochemistry. The Association will hold regional and national meetings for reading papers and giving demonstrations, and expects to hold joint discussions with other organizations to deal with selected topics. It hopes to co-operate with other societies affiliated to the International Association of Clinical Biochemists in a scheme for the standardizing and periodical checking of analytical methods used in hospital laboratories. The following papers were read at the inaugural meeting: Mr. E. B. Love, on the laboratory control of anticoagulant therapy; Dr. I. D. P. Wootton, on the quartz spectrophotometer in clinical chemistry; Drs. H. Bickel, J. Gerrard and E. M. Hickmans, on the influence of phenylalanine intake on phenylpyruvic oligophrenia; and Dr. A. L. Latner, on quantitative paper-strip electrophoresis of serum proteins. The meeting accepted a set of rules submitted by the interim committee, which was instructed to nominate a president and to hold elections to a council not later than August 31. Until then the interim committee is to act as a temporary council; Dr. A. L. Tárnoky (Royal Berkshire Hospital, Reading) is secretary of the committee.

### Deep-sea Trawling

The results of the deep-sea trawling which was done by the Swedish Deep-Sea Expedition, 1947–48, are given in the "Reports" of the Expedition (2, Fasc. 1; 1951. Pp. 148+2 plates. Göteborg: Elanders Boktryckeri. 25 kr.). In an introductory paper, Dr. O. Nybelin, who was in charge of the zoological work, discusses the technical difficulties of trawling at depths greater than four thousand metres. For this work the expedition employed a thirty-foot otter trawl, of the type used by Scandinavian fishermen to catch the deep-water prawn, *Pandalus borealis*. In the operation of this trawl, considerable use was made of echo-sounding to avoid trawling over hard, rough bottoms, and also of calculations (by B. Kullenberg) on the shape and length of the cable during deep-sea trawling. Dr. Kullenberg's calculations are also published in the present volume. As a result of this preliminary attention to details of technique, the Swedish deep-sea trawl-hauls were relatively more successful than many of those taken on previous expeditions, and the remaining papers in the publication record the zoological catches, in particular the echinoderms, cœlenterates, bryozoans and polychætes. The starfish collections, described by Jensenius Madsen, strongly support the view that the real deep-sea fauna is essentially cosmopolitan. Thus, three species of starfish found by this expedition in the Atlantic had hitherto been known only from the Pacific or Indian Oceans.

### Mathematical Association: Meeting in Sheffield

The annual general meeting of the Mathematical Association will be held in the University of Sheffield during April 8–11. The business of the Association (election of officers and the Council, etc.) will be dealt with on the morning of April 9, and in the afternoon the president, Mr. K. S. Snell, of Harrow School, will give his address, his subject being "School Mathematics To-day and To-morrow". Other topics which will be considered at the meeting are the craft and science of metallurgy, infinity, the Mathematics Division of the National Physical Laboratory, the transition from the primary to the secondary school, the theory of games, and 'from examination question to industrial problem'. In addition to the usual exhibition of books, it is hoped to arrange an exhibition on teaching-aids in primary and secondary schools and another one on modern calculating machines. All arrangements for the meeting are in the hands of the local secretary, C. R. Barwell, 53 Duke's Drive, Newbold, Chesterfield, from whom further information can be obtained.

## Scientific Film Association

AT the annual general meeting of the Scientific Film Association, the following officers were elected for the year 1953–54: *President*, Sir Arthur Elton; *Vice-President*, W. J. C. Chapple; and *Honorary Treasurer*, K. Baron Hartley. As a result of recent changes in the articles of association, the council of management will in future consist of the officers, six elected members and seven members nominated by the Lord President of the Council to represent general scientific and public opinion. The elected members are B. Chibnall, Dr. R. C. MacKeith, J. Maddison, C. A. Ronan, C. H. Sylvester and R. A. Williams; the members nominated by the Lord President are Mrs. Jacquetta Hawkes, Dr. F. H. K. Green (Medical Research Council), Dr. Alexander King (Department of Scientific and Industrial Research), Sir Ian Orr-Ewing, J. Ryan, Sir William Slater (Agricultural Research Council) and Sir Robert Watson-Watt. The address of the Association is 164 Shaftesbury Avenue, London, W.C.2.

## Direct Reading Emission Spectroscopy

THE Industrial Spectroscopy Group of the Institute of Physics has formed a panel of members interested in direct-reading equipment for spectrochemical analysis. These devices combine spectrographs with electronic equipment in such a way that the intensities of characteristic spectral lines give a direct reading of the percentage of the elements present in the specimen. The object of the panel is to organize meetings which would serve the interests of users and potential users of this equipment. The first meeting arranged by the panel took place in the Institute's House on March 26 last, when Dr. A. C. Menzies introduced the subject. Mr. A. L. Pendrey and Mr. R. T. Staples gave accounts of their experiences in this type of work, and there followed a general discussion. Particulars relating to meetings on this subject can be obtained from the Secretary, Institute of Physics, 47 Belgrave Square, London, S.W.1.

## Handbook of Scientific Instruments and Apparatus

THE annual "Handbook of Scientific Instruments and Apparatus", giving details of the exhibits at the Physical Society's annual exhibition, is now a publication familiar to all men of science and manufacturers of scientific instruments. This year's exhibition, the thirty-seventh of the series, is to be held at the Imperial College of Science and Technology, South Kensington, London, during Monday, April 13–Friday, April 17, and will be opened on April 13 at 10.30 a.m. by Prof. R. Whiddington, president of the Physical Society. Three discourses are being given this year: (1) Dr. E. C. Bullard (director of the National Physical Laboratory) on "Seismic Study of the Ocean Basins"; (2) Dr. L. A. Jordan (director of the Paint Research Station) on "Particles, Pellicles; Pigments, Paints and Physics"; and (3) Prof. W. V. Mayneord (Department of Physics, Royal Cancer Hospital) on "Scintillation Counting and its Medical Applications". The prize distribution of the Craftsmanship and Draughtsmanship Competition will take place during the exhibition on April 13 at 5 p.m. The handbook, a volume essential to all workers interested in the progress and development of scientific instruments, gives instructive descriptions of the many instruments shown by about a hundred and fifty exhibitors, including government research establishments. This extremely useful volume, which is now available, is printed on glossy paper and is illustrated by numerous half-tone reproductions of scientific instruments. It should be in the hands of all physicists and scientific workers who use or design scientific instruments (pp. xii+262+A72. Physical Society, 1 Lowther Gardens, Prince Consort Road, London, S.W.7. 6*s*., or 7*s*. 3*d*. post paid).

## Announcements

SIR HENRY BERESFORD-PEIRSE, director of forestry for Scotland since 1947, has been appointed deputy director-general of the Forestry Commission. He will be succeeded in Scotland by Mr. A. H. H. Ross, at present conservator of forests for north-west England.

THE following have been appointed lecturers in the Queen's University of Belfast: S. McConaghy (agricultural chemistry), R. E. Parker and Dr. E. W. Simon (botany), and Dr. I. Leslie (biochemistry).

THE Commonwealth Fund (35 Portman Square, London, W.1) has awarded the following Home Civil Service Fellowships to British Civil servants for study in the United States during 1953–54: B. R. Feaver (Forestry Commission (Scotland)), G. Leitch (Ministry of Supply), L. S. Mills (Ministry of Civil Aviation) and P. E. Watts (Ministry of Fuel and Power).

THE Bone and Tooth Society will hold a symposium on "Vitamin C and Bone" on April 9 at the Institute of Orthopædics, 234 Great Portland Street, London, W.1. Dr. E. H. Allen will speak on "X-Ray Findings in Scurvy"; Dr. L. E. Glynn on "Vitamin C and Ground Substance"; Dr. G. H. Bourne on "Vitamin C and Ossification"; and lastly Dr. B. E. Clayton on "Cortisone and Vitamin C".

THE Ministry of Agriculture and Fisheries and the Department of Agriculture for Scotland propose to award, for the academic year beginning October 1, 1953, or earlier, a limited number of postgraduate scholarships in agricultural economics, husbandry, statistics, and agricultural and dairy engineering. The closing date for applications is May 1. Further particulars can be obtained from the Secretary, Ministry of Agriculture and Fisheries (Research Branch), 1–4 Cambridge Terrace, Regent's Park, London, N.W.1, or the Secretary, Department of Agriculture for Scotland, St. Andrew's House, Edinburgh 1.

A SCIENCE Meeting of the Physical Society will be held at the Imperial College of Science and Technology, London, S.W.7, during May 15–16, the subject of which will be "Recent Research in Electron Optics". The meeting is being arranged by Dr. O. Klemperer, of the Imperial College, and will be divided into seven sections as follows: electron lenses; correction of aberrations; electron guns; focusing in electron accelerators; electron optics in television tubes and valves; electron spectrometry; other subjects. Visitors wishing to attend this meeting should apply to the offices of the Physical Society, 1 Lowther Gardens, Prince Consort Road, London, S.W.7, for further particulars; the closing date for applications is May 7.

# SHEEP BIOLOGY LABORATORY, PROSPECT, NEW SOUTH WALES

By Prof. C. W. EMMENS

Department of Veterinary Physiology, University of Sydney, and Officer-in-charge of the Prospect Laboratory

THE Wool Use Promotion Act 1945 and the Wool Industry Fund Act of 1946, of the Commonwealth Government of Australia, made provision for additional funds to be devoted to the expansion of sheep and wool research. As a result of a survey made by the Commonwealth Scientific and Industrial Research Organization, it was clear that, although considerable progress had been made in the control of the diseases of sheep, relatively little had been achieved in the improvement of the productivity, including fertility, of the healthy animal.

It was therefore decided to found, within the Division of Animal Health and Production, a Sheep Biology Laboratory where problems of this sort would be tackled. A site of 116 acres was selected at Prospect, New South Wales, about twenty miles from Sydney, and acquired in September 1946. Plans were made to start work and to extend existing programmes without waiting for certain of the facilities at Prospect. Units eventually to move into the Sheep Biology Laboratories were strengthened, and new ones were set up in various other centres in Victoria and New South Wales. These have grown to such an extent that the staff destined for Prospect already amounts to some seventy or eighty persons.

The most important buildings, some of which are yet to be constructed, are as follows.

*Animal houses.* These are primarily intended to house sheep in single pens, or small multiple pens, and, so far, one has been constructed. Each is 282 ft. long by 40 ft. wide and accommodates about a hundred and fifty animals. At each end of these houses are offices, record rooms and various other servicing units.

*Fleece and shearing building.* This is 150 ft. by 40 ft. and is to be used for handling fleeces from shearing to storage, with air-conditioned laboratories attached for the study of fleece samples under standard conditions. It is ready for use.

*Climate control and examination building.* This will be a two-story building, 182 ft. long by 45 ft. wide, containing two climate-control rooms, each 13 ft. by 24 ft., and a larger preconditioning room of 24 ft. by 37 ft., small animal colonies, a clinical wing with operating theatre and associated rooms, and an X-ray unit as well as a photographic studio. In the climate-control rooms any prescribed climatic conditions will be maintained, and the rest of the building will have appropriate air conditioning.

*Prefabricated buildings.* These comprise two aluminium buildings, each 153 ft. by 40 ft., to be used as laboratories, stores, canteen, etc., while the main laboratory is under construction. They are nearly ready for occupation, and will house the first groups of workers mentioned above. When the Main Laboratory is ready, most of the workers will move into it; but some may remain in the prefabricated buildings.

*Main laboratory building.* This will be of two stories, approximately 215 ft. by 42 ft., with a single-story library wing. It will house the main group of laboratories, offices, library, records and storage rooms. Both this and the prefabricated buildings will be air-conditioned.

Other buildings, covering with those already specified an area of about five acres, are a large garage and workshop, a feed store, and various smaller sheds and houses for miscellaneous equipment. The main buildings will eventually be connected by covered ways giving sheltered access to almost any of the central group of facilities.

The following existing Research Sections will be housed in the Prospect Laboratories as soon as possible.

*Wool Biology.* This is a Section with an essentially long-range programme of work, directed in the first instance to the study of the skin and the fleece of sheep, but on a comparative basis. At present, the work of the Section falls under six main headings: the comparative development of the skin in sheep and other mammals, with special reference to the hair follicle group and its associated glands; the physiological mechanisms associated with skin, particularly with the growth of wool and the activity of the sebaceous and sweat glands; genetic effects on the growth and development of skin and their interactions with the above; the efficiency of fleece production in different breeds and strains; aspects of the physiology and anatomy of heat regulation in different breeds and strains; the relationship between fleece types and such environmental factors as nutrition, temperature and illumination.

*Fleece Analysis.* This is a Section responsible for the study and development of methods of measuring fleece characteristics, such as fibre length, fibre diameter, fleece density, and the variability associated with them. This Section already makes many thousands of examinations a year in association with the experimental programmes, mainly field studies, of other Sections or outside organizations, while simultaneously developing its own research programme. Physicists from this Section will also be responsible for the running of the climate-control rooms.

*Reproductive Physiology.* Two small groups of research officers and one or two isolated research workers form the nucleus of the Prospect team. At present they are working on the following lines: problems connected with the occurrence and distribution of matings in flocks under different conditions, and of subsequent pregnancies; the capacitation phenomenon in spermatozoa; problems connected with reproduction in the domestic fowl; and the preservation of semen under refrigeration. Most of these workers have also been concerned with investigations in the infertility of sheep on subterranean clover pastures, in collaboration with university research teams, a project which has resulted in the isolation of genistein, an œstrogenic *iso*-flavone, from the affected pasture.

*Ruminant Digestion and Physiology.* In this Section the sheep is taken as the main experimental subject; work is already in progress on the digestion of protein and on the metabolism of carbohydrate and fat. It is planned to expand these researches and to build up a team of investigators whose broad terms of reference will be physiological problems especially related to the ruminant.

*Field Studies.* The new laboratory will act as a centre, not only for laboratory research, but also for the organization of field trials, observations of stud and other practices, and for the collection of information from all possible sources. Officers of the present Wool Biology Section are now active in this field; in addition, they and others are collaborating in projects known as the 'strain trials', in which the performance of five different strains of merino sheep is being studied at three different localities in the eastern half of Australia. The trial will continue for many years. Such field studies as these are often best interpreted in the light of concurrent work on the smaller, closely controlled groups of animals for which the facilities of the Sheep Biology Laboratory were designed.

Following the lead of institutions like Rothamsted Experimental Station in Britain, the Sheep Biology Laboratory will develop a strong statistical section. Other aspects of its present structure that will be strengthened are the more biochemical and biophysical parts of the work. The exact degree to which it may participate in work of a more-or-less purely genetic nature will depend on its relationship with the newly formed Section of Animal Genetics of the Commonwealth Scientific and Industrial Research Organization, part of which may also be located at Prospect.

## BRITISH COMMONWEALTH GEOLOGICAL LIAISON OFFICE

During the recent nineteenth International Geological Congress at Algiers, the first meeting of the British Commonwealth Committee on Mineral Resources and Geology was held in the British Consulate Office, at which the following representatives of their respective Geological Surveys attended: Mr. C. J. Sullivan (Australia), Dr. J. W. Harrison (Canada), Dr. F. Dixey (the Colonies), Dr. B. C. Roy (India), Dr. N. M. Khan (Pakistan), Dr. A. M. MacGregor (Southern Rhodesia), Dr. L. T. Nel (South Africa), Dr. W. J. Pugh (United Kingdom) and Mr. R. W. Willett (British Commonwealth geological liaison officer).

The British Commonwealth Geological Liaison Office and the British Commonwealth Committee on Mineral Resources and Geology were set up on the recommendation of the 1948 Specialist Conference on Mineral Resources and Geology, the purpose and scope of the office being defined in the report of that Conference (Code No. 47–149. London: H.M.S.O., 1949). As a result, the Geological Liaison Office was established in May 1951 at the British Commonwealth Scientific Offices, Africa House, London, and at the same time the present British Commonwealth geological liaison officer, R. W. Willett, of the New Zealand Geological Survey, commenced duties.

The recommendations of the 1948 conference were as follows. (*a*) Permanent Commonwealth machinery should be set up to promote collaboration and interchange of information between government organizations concerned with the investigation of geology and mineral resources throughout the British Commonwealth. This machinery should take the form of a Committee, to be known as the Committee on Mineral Resources and Geology, with members representative of such organizations from each of the participating countries meeting at intervals of not more than three years in a Commonwealth country. (*b*) The permanent executive and secretarial work of this Committee should be under the direction of a senior officer with appropriate technical qualifications stationed in London, who would be known as the British Commonwealth geological liaison officer. His duties would include: acting as a liaison officer in matters pertaining to geology and mineral resources for all participating members of the British Commonwealth; taking appropriate action to give effect to the recommendations of the present Conference; and making the preliminary arrangements for the periodical meetings of the Committee.

Dr. W. J. Pugh, director of the Geological Survey of Great Britain, was elected chairman and will now hold office until the Committee meets again, which will be when a suitable and appropriate occasion offers. The Committee reviewed and discussed the annual report of the Geological Liaison Officer, and the progress made in translating into action the original recommendations, and endorsed the action taken; as a result, it recommended the continuance of the Geological Liaison Office along the lines already laid down. The geological liaison officer is appointed for three years, at the end of which period he is replaced by another Commonwealth officer selected and appointed in the same manner. The first annual report of the Office was presented at a recent meeting of the Committee, and in it the scope and extent of the work of the Office were outlined.

As a background to the work of the Office, a series of reports are being prepared on the mineral resources of the British Commonwealth. These reports present the essential quantitative and qualitative information on the various mineral deposits in the Commonwealth and are based on the latest published information and on unpublished information, obtained by correspondence where necessary, with various Commonwealth Surveys. So far, nineteen metals and non-metals have been covered in this manner—namely, copper, lead, zinc, cobalt, nickel, antimony, manganese, tungsten, vanadium, molybdenum, chromium, beryllium, zirconium, titanium, niobium and tantalum, phosphates, sulphur and asbestos. These are circulated to the United Kingdom Ministries concerned, to members of the Commonwealth Committee on Mineral Resources and Geology, the Defence Advisory Committee on Commonwealth Mineral Resources and to the Commonwealth scientific liaison officers at Africa House, London. It is hoped to cover the entire field of industrial minerals and rocks and, with certain modifications, to publish these reports in the form of a single volume.

Some preliminary action is being taken on the subject of the presentations of mineral statistics, in order to explore the possibility of greater uniformity in the use of units and methods of presentation. The recommendation of the 1948 Specialist Conference asking all Commonwealth countries to prepare and issue an annual volume of abstracts of geological papers of the territories under their control has not yet been put into action by all the countries concerned. In order to assist in this work, the Geological Liaison Office has prepared such a volume of United Kingdom abstracts for 1951 for limited distribution, which will be followed by that for 1952. If this experiment is successful, an attempt will be made to extend this work to those countries of the British

Commonwealth which are not already preparing their own annual volumes of abstracts.

The geological liaison officer serves on a number of committees concerned with mineral resources, their development and utilization. The officer, as a specialist on the subject of geology and mineral resources, also acts in close liaison with the scientific liaison officers of the other Commonwealth countries, and at the same time close liaison is maintained with the Ministry of Materials, Department of Scientific and Industrial Research and other Ministries in Great Britain which are interested in the mineral resources and their availability throughout the Commonwealth. Reports and accounts of meetings and conferences concerned with geology and mineral resources are also prepared and circulated to the Commonwealth countries.

Close contact is maintained by the Geological Liaison Office with the Colonial Geological Surveys Directorate, as the two organizations are in a sense complementary; the latter links all the Colonial Geological Surveys, while the former is an attempt to link, in a less formal way, the Commonwealth Geological Surveys. The Geological Liaison Office is now charged, as a result of recommendations by the British Scientific Official Conference in Australia, with the formation of Commonwealth collaboration on geophysical prospecting, and the beneficiation and utilization of low-grade ores. The Office is now firmly established as an intrinsic part of the British Commonwealth Scientific Office, and, as an experiment in a purely Commonwealth organization, appears to be functioning with some measure of success.

# RECORDING OF RESEARCH AND ITS PATENT ASPECTS

MANY research workers, more usually the younger ones, dislike keeping adequate records of their investigations, but the fact has to be faced that the keeping of proper records is probably much more important, and a much less simple obvious matter, than is often supposed. Various aspects of the subject were discussed last year by a joint committee of the Franklin Institute and of the American Patent Law Association in a programme entitled "Who is the First Inventor?"; and further consideration has been given in a recent timely and interesting article by J. G. Jackson, on "Records of Research" (*J. Franklin Inst.*, 254, 355; 1952).

There are, of course, several sound reasons for keeping good records, many of which are sufficiently obvious without undue elaboration. (*a*) Avoidance of duplication, especially in prolonged research, when problems may again crop up that have been already studied and not recorded. (*b*) Taking full advantage of negative results, which also may prevent duplication if properly noted at the time. (*c*) Assisting the development of a fundamental approach, for very often at the start the workers are somewhat in the dark, or are taking part in one small section of a comprehensive programme, so that they think their results are relatively unimportant and not worth reporting; but such data later on prove essential in developing a theory or fundamental approach. (*d*) Publication; when work is published or reported at a meeting, supplementary questions arise which cannot be answered because full data have not been recorded. (*e*) Patent requirements; for example, insufficient record prevents the inventor from establishing that he was the first inventor, and it may thus happen that the company which developed the subject-matter may be forced to take a licence under someone else's patent.

The very minimum of information that should be recorded is the date of commencement of work, by whom it is done, detailed account of the work (with date of each important step) and the results. Such recording may often be the proper function of the research director or group supervisor. For patent purposes it is absolutely essential that provision be made for corroboration, and this is discussed at some length by Mr. Jackson. Some useful practical notes on this part of the subject can be found elsewhere[1,2].

Certain milestones in connexion with research in industry should be formalized, to enable firms to determine the progress being made and the status at each stage. These formal steps are very helpful in tying together various records for patent purposes; and assigning project numbers is, for the same reason, of great assistance.

Several valuable suggestions on the keeping of laboratory notebooks are given: step-by-step records in order of time; making of sketches and drawings; issuing a specification on an item under development before it is standardized (which constitutes a valuable record of research); photographs and samples; and codes and abbreviations. These last-named may often be the cause of much trouble and confusion, some curious examples of which are given. Special records may sometimes be required from the point of view of patents, on which much useful advice is provided. Finally, it is pointed out that publications perform certain functions as research records, and have a special significance in patent matters.

[1] Kapp, "Laboratory Notebooks", 33 JPOS (*J. Pat. Off. Soc.*, 502 (1951)).

[2] Tuska, "Patent Notes for Engineers", 3rd edit. (Radio Corp. America, 1947).

# ELECTRONIC DIGITAL COMPUTERS

## CONFERENCE IN THE UNITED STATES

IN 1950 a meeting was held in Atlantic City, N.J., to discuss electron tubes for computers. The meeting was initiated by Dr. A. L. Samuel, as representative of the Research Development Board, and was sponsored by the American Institute of Electrical Engineers and the Institute of Radio Engineers. The success of this initial meeting led Prof. J. G. Brainerd to suggest the formation of a joint computer conference committee between these two last-named bodies in order to consider whether further meetings should be held and, if so, on what subjects. It was decided that the subjects which required urgent attention were electronic digital computers, input and output equipment, high-speed memory and choice of number system. Accordingly, the joint conference held in Philadelphia, Penn., during December 10–12, 1951, dealt with the first topic, and a recent conference, during December 10–12, 1952, at New York City, was concerned with input and output equipment.

The 1951 meeting, at which the Association for Computing Machinery also co-operated, attracted an attendance of 877 members, and the eighteen papers and discussions that were presented have recently been published*. Ten different large-scale electronic computers of varying design and performance are separately described. These are the UNIVAC, ORDVAC, EDSAC, SEAC, ERA 1101, Burroughs Laboratory, Whirlwind I and the University of Manchester computers, and the IBM card-programmed and the Mark III electronic calculators. In other papers detailed operating and component experience on certain of these instruments is discussed. In addition, a report on the use of computing machines in aircraft engineering is given by C. R. Strong, of the Douglas Aircraft Co., the seven digital computers designed and built by the Bell Telephone Co. are described by E. G. Andrews, and the application of transistors to digital computation is discussed by J. H. Felker.

Finally, a summary of the present status and future trends of digital computers is given by J. W. Forrester, in which he states that it is clear that the pioneering days are over and that enough experience of the various models has now been gained to judge the adequacy of the designs. Though there are quite definite lines of development—for example, towards machines of still higher speed—it is worth while to note the concluding sentences of Mr. Forrester's summary which aptly summed up the position at the end of 1951: "Machine speed has increased by several orders of magnitude over the last ten years. In the future we can perhaps get another decade in speed, but I doubt that more can be accomplished without a fundamentally new type of computer. The great steps in the near future will be in the direction of simplification without losing performance. It seems clear that the complexity of computers can and must be reduced."

* Review of Electronic Digital Computers: Joint AIEE–IRE Computer Conference. Papers and Discussions presented at the Joint AIEE–IRE Computer Conference, Philadelphia, December 10–12, 1951. Pp. 114. (Amer. Inst. Elec. Eng., 33 West 39th Street, New York 18, 1952.) 3.50 dollars.

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# PRODUCTION OF HIGH VACUA BY IONIZATION

A LITTLE while ago, Dr. A. von Engel directed attention to the method of obtaining high vacua by ionization (*Vacuum*, 1, No. 4; Oct. 1951); it is therefore of interest to note that a discussion of the principles and limitations of such pumping action, together with a description of an electronic pump which was the subject of a German patent in 1943, is given in a paper by H. Schwarz*.

The idea of obtaining high vacua by ionization is, of course, quite old and well known, and the clean-up, that is, absorption of gases or vapours, in an electrical discharge is a common experience and fairly well understood. Dr. Schwarz, however, shows theoretically that it is not possible, even under the most favourable conditions, to construct a high-vacuum pump with reasonable dimensions utilizing a normal D.C. gas discharge. A real pumping action can only result when there is such a high ion-current that the number of ionized gas molecules transported in one direction is greater than the number of gas molecules diffusing back in the opposite direction. It is necessary, therefore, to increase the path of the electrons without increasing the length of the tube, and this may be accomplished either by making the electrons oscillate on screw paths about the tube axis, or by using an external magnetic field which forces the electrons to travel in spiral paths within a cylindrical electrode system, as in the magnetron or cyclotron.

The model of an electronic pump which Dr. Schwarz describes consists of an incandescent cathode, a ring-shaped anode at about 2,000 V. and a third annular electrode at cathode potential. The 10-mA. electron current is kept oscillating through the anode, and a magnetic field parallel to the tube axis keeps the electrons on spiral paths at the centre of the tube away from the anode. Special arrangements are made to remove absorbed gas from the glass walls of the tube and to prevent ions from diffusing back into the high-vacuum side. As a test of the pump, a volume of half a litre was pumped down from a pressure of $10^{-3}$ to $10^{-5}$ mm. of mercury in less than one second.

* Centro Brasileiro de Pesquisas Fisicas. Notas de Fisica No. 5: Methods of obtaining High Vacuum by Ionization; Construction of an 'Electronic Pump'. By Helmut Schwarz. Pp. 9. (Rio de Janeiro: Centro Brasileiro de Pesquisas Fisicas, 1952.)

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# CULTIVATION OF SULPHATE-REDUCING BACTERIA

By JOY P. GROSSMAN and DR. JOHN R. POSTGATE

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STUDIES on the bacteriology and biochemistry of the sulphate-reducing bacteria have long been obscured by inconsistencies in the behaviour of these organisms. For example, tests on the ability of a single strain to utilize various sources of carbon may give different results on different occasions; subcultures sometimes fail to grow, or grow with a very long lag, for no obvious reason; dilution counts on a motile and obviously healthy population indicate that rarely more than 10 per cent and often as little as 0·01 per cent of these cells are apparently viable; strains grown with excess of ferrous ions in the medium often do not grow readily without this; and so on. Though the capriciousness of these bacteria has not often been described explicitly in the literature, it is common experience among workers in the field. The observations described below to some extent clarify the situation. Since they bear closely on the work of other laboratories studying these bacteria, and since they have required a re-assessment of earlier work in this laboratory, we have felt that this preliminary report is desirable.

The fundamental observation, that reducing agents stimulate the activities of these bacteria, has been reported by many sources, including this laboratory[1–4], and the importance of a negative redox potential for their effect in anaerobic corrosion was emphasized by Starkey and Wight[5].

*Methods.* Strains of *Desulphovibrio desulphuricans* were cultured at 30° C. in anaerobic jars containing hydrogen plus 5 per cent carbon dioxide or in sealed test-tubes containing a plug soaked in pyrogallol with strong sodium carbonate. For normal subcultures a 1/100 dilution of a grown culture was made into fresh medium. Dilution counts were performed in duplicate by making serial 1/10 dilutions in the appropriate medium using a fresh pipette at each stage. Direct counts were made through the microscope using a 0·02-mm. depth Thoma hæmocytometer; dilutions for this purpose were prepared in 0·8 per cent saline and were either counted at once or after storage in ice to prevent cell multiplication.

*Results.* Sodium sulphide (5 µmol./ml.) added to either a peptone–yeast–glucose medium[5] or to Starkey's medium supplemented with yeast extract[4] permitted full growth of *D. desulphuricans* (Hildenborough strain) in 16–24 hr. with the conventional inoculum. Without sulphide, growth required 2–3 days, though it could be accelerated by using a larger inoculum. The stimulant effect of sodium sulphide has been observed with at least eight other strains; lower concentrations of sulphide were not effective in our experiments.

Dilution counts in either of these media supplemented with sodium sulphide gave results in agreement with the direct count. For example, in a glucose–peptone–yeast medium, dilution counts on a culture containing $(3 \pm 1) \times 10^8$ cells/ml. (direct count) gave counts indicating $10^8$ viable bacteria/ml. if sodium sulphide were present, though in its absence counts of $10^4$, $10^7$ and $10^8$ viable cells/ml. were found in three separate series. Sulphide could be replaced by cysteine, ascorbic acid or glutathione, so its effect on growth and viability was due to its reducing properties. Ascorbic acid and glutathione appeared less effective than cysteine or sulphide, and cysteine had the advantage that it could be used in the presence of excess ferrous ions to enable one to detect growth by blackening of the culture due to formation of ferrous sulphide. Dilution counts in media containing cysteine (5 µmol./ml.) plus ferrous ammonium sulphate (1 µmol./ml.) gave results in satisfactory agreement with the direct count using a pure strain of *D. desulphuricans*, and counts on polluted waters indicated populations considerably in excess of those found with unsupplemented media. In two cases sulphate reducers were detected only with cysteine–iron media. In certain natural waters and soils, however, there is a risk that bacteria able to decompose cysteine will liberate hydrogen sulphide and give false results. This counting procedure is being studied further and will be reported in detail elsewhere. The effect of cysteine or sulphide is not directly connected with sulphate reduction, since strains that can grow without sulphate[7] are stimulated if cysteine or sulphide is added to sulphate-free pyruvate media.

*Conclusions.* Sulphate-reducing bacteria grow much more rapidly if a sufficient concentration of a reducing agent such as cysteine or sulphide is added to the medium. Small populations will often not grow at all without these supplements, so dilution counts, even of large populations, do not measure the population being counted unless a reducing agent is added to each dilution.

Besides providing a reliable method of counting pure populations of *D. desulphuricans*, these observations have several practical consequences relevant to the routine handling of these bacteria.

(i) *Irregularities of growth.* Since sulphide is an end-product of growth in ordinary media, the carry-over of sulphide in the inoculum will determine the rate at which the subculture will grow. In certain cases (a moribund culture, or one from which all sulphide has been removed by alkali in the plug, lead acetate or ferrous salt), the carry-over may be insufficient to allow growth at all. A particular case in which this is important is in the revival of lyophilized cultures, which grow most irregularly unless cysteine or sulphide is added.

(ii) *Effect of ferrous ions.* Excess ferrous salt is often added to a medium in order to detect growth by blackening due to ferrous sulphide, and many workers have noticed casually that growth may occur more readily with excess ferrous ions than without, though this phenomenon does not occur regularly. Since the ferrous ion is a reducing agent, it could act as a stimulant like sodium sulphide or cysteine, and, if the carry-over of sulphide from the parent culture were low, it might have sufficient reducing effect to stimulate growth.

(iii) *Apparent populations of sulphate reducers.* The population of sulphate reducers indicated by dilution counts with unsupplemented media cannot be expected to equal the actual population, and in our experience bears no constant relation to it. Allen[6] mentioned this discrepancy in his studies on sulphate-reducers in sewage, but Heukelekian[8] considered that his counts represented actual populations.

(iv) *Inoculum size.* The rate at which a culture grows in an unsupplemented medium depends on the carry-over both of sulphide and of cells; in media supplemented with cysteine or sulphide it depends only on the number of cells. Hence, in supplemented media, the large inoculum conventionally used with these bacteria is unnecessary. For quantitative work this can be important, as the carry-over of metabolites and end-products in the conventional inoculum must be absurdly large compared with the carry-over in work on other bacteria.

(v) *Aerobic growth.* Butlin, Adams and Thomas[4] showed that addition of ascorbic acid to cultures would permit growth of these bacteria in air. By producing sulphide the sulphate-reducing bacteria create reducing and anaerobic conditions wherever they are active, and, though obligate anaerobes, are thus capable of growth in air if access of air to their immediate environment is slow. They can be grown in air in deep tubes or flasks if a large inoculum is used, or if sulphide is added, and once growth starts it follows diffusion of sulphide throughout the medium. This fact may account for reports of aerobic growth of this organism such as that of Shturm[9].

(vi) *Growth in agar.* The effect of sulphide or cysteine is equally pronounced in media set with agar, and, if sodium sulphide (20 µmol./ml.) is added to the appropriate agar medium, these bacteria can be maintained on the surface of agar slopes protected from oxygen by a pyrogallol plug. Normally it is extremely difficult to grow them on agar slopes. In deep agar 'shake' cultures without sodium sulphide or cysteine, growth of colonies tends to occur in masses: colonies grow more readily if other colonies are near at hand. This phenomenon was noted by Baumann and Denk[10], who ascribed it to diffusion of nutrients from colony to colony. The phenomenon is more likely to be due to diffusion of sulphide, since it can be abolished by addition of cysteine or sulphide to the agar.

The isolation of pure strains can be difficult, since, though in an enrichment the population of *D. desulphuricans* may outnumber the population of contaminants, the proportion that grow in an unsupplemented agar 'shake' may often be less than the proportion of contaminants. The addition of cysteine and iron to agar media has greatly facilitated isolations in our laboratory, since it ensures that all the sulphate reducers present actually form colonies.

In consequence, colonies well separated from contaminant organisms are more readily obtained.

(vii) *Requirement for a reducing agent.* One strain in our laboratory (New Jersey S.W.8, kindly provided by Prof. R. L. Starkey) appears to be unable to grow without a reducing agent. It grows normally in media containing excess ferrous ammonium sulphate, and this can be replaced by cysteine, sodium sulphide or ascorbic acid. We have not succeeded in maintaining it in media without a reducing supplement, even with the conventional large inoculum.

(viii) *Growth with various carbon sources.* The ability of *D. desulphuricans* to grow with various sources of carbon was described exhaustively in the classical work of Baars[11]; Stephenson and Stickland[12] regarded their strain as different from Baars's because of its different 'spectrum' of carbon utilization. Senez[13] studied a strain which would utilize only a few carbon compounds, and Pochon and Chalvignac[14] showed that the ability to utilize carbon sources depended on: (*a*) how long the organism had been subcultured with a single carbon source, and (*b*) whether yeast extract was present in the test media. Our studies have confirmed Pochon and Chalvignac's second point, but have also shown that the presence or absence of sulphide in the test medium influences the results. This observation is well exemplified by tests of carbon utilization by our strain El Agheila *Z*[7,15] which are recorded in Table 1. When cultured with neither yeast extract nor sulphide, the strain grew with very few substrates and required the conventional large inoculum. Addition of sodium sulphide increased the number of substrates utilized and permitted the use of a small inoculum. Addition of yeast extract did not abolish the need for a large inoculum, but increased the range of substrates attacked. With both yeast extract and sodium sulphide, using a small inoculum, a much wider range of substances was attacked. With certain of the carbohydrates, limited growth (presumably utilizing oxidizable carbon in the yeast extract) occurred immediately, but full growth was delayed for many days.

These observations show clearly that growth tests with various sources of carbon in unsupplemented media cannot be used satisfactorily for distinguishing between strains and species of *Desulphovibrio* unless the carry-over of sulphide and nutrients in the inoculum is very carefully defined, and also the presence or absence of other reducing agents such as ferrous ions.

Table 1. GROWTH OF *D. desulphuricans* (STRAIN EL AGHEILA *Z*), NORMALLY CULTURED IN LACTATE MEDIUM, IN MEDIA CONTAINING VARIOUS SOURCES OF CARBON IN PLACE OF LACTATE

All media contained sodium chloride (2·5 per cent), sodium sulphate and other salts at *p*H 7·6 (see ref. 7). Carbon sources 1 per cent except lactate, pyruvate, malate and ethanol (81 µmol./ml.). Sodium sulphide 5 µmol./ml. when present, yeast extract ('Difco') 0·1 per cent when present. Incubation, 30° C. for 14 days in nitrogen

| | No supplement | Sodium sulphide | Yeast extract* | Yeast extract* + sodium sulphide |
|---|---|---|---|---|
| Inoculum (dry wt./ml.) | 2 µgm./ml. | 10 mµgm./ml. | 2 µgm./ml. | 10 mµgm./ml. |
| Lactate | + | + | + | + |
| Pyruvate | + | + | + | + |
| Malate | . | . . | + | + |
| Ethanol | . | . . | + | + |
| Glycerol | – | + | + | + |
| Glucose | – | – | – | + |
| Galactose | – | – | – | + |
| Lactose | – | – | – | + |
| Maltose | – | – | – | + |
| Mannitol | – | – | – | – |
| Acetate | – | – | – | – |
| No substrate | – | – | – | – |

* '+' in these columns indicates growth in excess of that supported by the yeast extract present.

(ix) *Cysteine requirement.* Postgate[6] reported that the growth of the Hildenborough strain of *D. desulphuricans* was stimulated by a mixture of four amino-acids, of which cysteine was the most important as their effect could not be observed in its absence. In the light of the observations reported above, it was possible that cysteine was not acting as a nutrient at all, but merely stimulating growth with the other three amino-acids through its reducing properties. We have shown that this is, in fact, true: Table 2 indicates that the improved growth found in an allotrophic medium supplemented with cysteine, serine, ornithine and *iso*-leucine was also obtained if cysteine was replaced by approximately equimolar sodium sulphide.

Table 2. GROWTH OF *D. desulphuricans* (STRAIN HILDENBOROUGH) IN AN AMINO-ACID MEDIUM WITH SULPHIDE IN PLACE OF CYSTEINE

The medium contained glucose (1 per cent), sodium sulphate and other salts (ref. 6) and was inoculated with 1 µgm. dry weight cells/ml. washed by centrifugation in 0·8 per cent sodium chloride. All amino-acids 1 mgm./ml. except cysteine (2 mgm./ml.); sodium sulphide, $10^{-3}$ *M*. Incubation, 30° C. for four days in hydrogen + 5 per cent carbon dioxide

| Supplement | Growth (µgm. dry wt./ml.) |
|---|---|
| — | 0 |
| Cysteine, serine, ornithine + *iso*-leucine | 115 |
| Sodium sulphide, serine, ornithine + *iso*-leucine | 120 |

We are indebted to Mr. K. R. Butlin for his advice and interest. This paper is published by permission of the Director, Chemical Research Laboratory.

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# NARCOTICS AND BIOLOGICAL ACETYLATIONS

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MUCH evidence[1] has accumulated to show that narcotics, at the low concentrations that produce narcosis *in vivo*, inhibit certain respiratory processes, particularly those involved in carbohydrate oxidation, in the nervous system and in other tissues. This has led to the view that narcosis may result from a suppression of certain respiratory events at the nervous centres where the narcotics are absorbed. On the other hand, Larrabee *et al.*[2] have pointed out that in experiments on resting neurones the functional effects of narcotics are apparently unaccompanied by a measurable retardation of the rate of oxygen consumption. With stimulated nerves, however, the inhibitory effects of a narcotic, such as chloretone, on the increased oxygen uptake are in proportion to their inhibitory effects on synaptic transmission. Bronk and Brink[3] have shown that the rate of oxygen uptake by resting (frog) nerve is reduced 15 per cent by 0·002 *M* chloretone, but that the increment in the rate of oxygen uptake obtained with nerves carrying impulses at the rate of 50 impulses/sec. is decreased by 50 per cent by the same quantity of narcotic. They conclude that the narcotic inhibits an enzyme in a reaction located between the oxidative reaction directly affected by the impulses and the reaction using oxygen.

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It is important to realize, in our attempts to interpret the effects of drugs on metabolic processes, that it may be possible to impede a step in a chain of respiratory events, each of which contributes to the total quantity of oxygen consumed, without a large, or even measurable, effect on the rate of oxygen consumption by the cell, so long as the enzymes involved in the reactions following the impeded step are still saturated with their substrates. The step impeded, however, may be closely associated with a metabolic reaction directly involved in the functional activity of the cell.

It is proposed to show in this article that narcotics at low concentrations impede the oxidative synthesis of adenosinetriphosphate and, thereby, affect the rates of acetylation processes dependent on the presence of this substance. Eiler and McEwen[4] have already shown that pentobarbital inhibits the generation of high-energy phosphate bonds to the extent that it interferes with oxygen utilization. Brody and Bain[5] have, indeed, postulated that uncoupling of phosphorylation from oxidation may be connected with the narcotic action of barbiturates; but it will be shown, elsewhere[6], that the effects of narcotics on phosphorylations are quite different from those of a typical uncoupling agent such as 2 : 4 dinitrophenol.

## Experimental Procedure

The experimental work, carried out with the conventional Warburg apparatus at 37° C., involved a study of the effects of narcotics on rates of biological acetylations. These were brought about by various tissue preparations described as follows.

*Pigeon liver acetone powder.* Livers from freshly killed pigeons were minced and homogenized in the presence of acetone for 60 sec. in a Waring blendor. The homogenate was added to ten volumes of acetone (at 0° C.). After five minutes the dehydrated material was filtered on a Buchner funnel and washed with cold acetone. Drying of the powder was completed in a vacuum desiccator (over calcium chloride), where it was stored at 0° C.

*Pigeon liver extract.* The acetone-dried powder was extracted by grinding it for five minutes with 0·15 *M* potassium fluoride in the proportion of 60 mgm. of powder to 0·8 ml. of extraction medium. After centrifugation at 19,000 *g* for five minutes, the supernatant was filtered through glass wool, and 0·8 ml. of extract was pipetted directly into a manometer vessel.

*Rat brain homogenate.* A 25 per cent homogenate of rat brain was prepared by homogenizing the cerebral hemispheres in a solution composed of 0·06 *M* potassium chloride, 0·04 *M* nicotinamide, and 0·04 *M* magnesium chloride. 0 5 ml. homogenate was added to the manometer vessel.

In addition to pigeon liver extract and rat brain homogenate, the vessels contained 200 μgm. sulphanilamide, 0·02 *M* sodium phosphate buffer, *p*H 7 5, and other additions, as will be indicated, to a total volume of 3 ml. After five minutes of thermal equilibration, the measurement of oxygen uptake was commenced, carbon dioxide being absorbed by potassium hydroxide in the centre well of the manometric vessel. All the experiments were carried out in the presence of air.

*Rat brain mince.* Rat brain (cerebral hemispheres) was minced with a small Latapie mincer and suspended in a solution of 0 006 *M* nicotinamide, 0·15 *M* potassium chloride, and 0·02 *M* magnesium chloride, to make a 50 per cent suspension. 1 ml. of suspension was added to the manometric vessels after all other additions had been made. All the vessels contained the following substances (final concentrations) to a total volume of 3 ml.: sodium phosphate buffer, *p*H 7·4, 0·02 *M*; sodium fluoride, 0·03 *M*; choline chloride, 0·001 *M*; eserine sulphate, 0 0004 *M*; 0·2 ml. of 20 per cent potassium hydroxide in the centre well.

*Extracts of beef brain.* Acetone-dried beef brain was prepared according to the methods of Harpur and Quastel[7]. The acetone-dried brain powder was extracted by grinding it in a mortar with the following solution: nicotinamide, 0 08 *M*; neutral cysteine, 0·03 *M*; potassium chloride, 0·09 *M*; and magnesium sulphate, 0·012 *M*. After centrifuging for five minutes at 19,000 *g*, the supernatant was filtered through glass wool, and 1 ml. of the extract (equivalent to 60 mgm. of powder) was added to the manometric vessel after all other additions had been made. The vessels also contained the following salts (final concentrations) to a total volume of 3 ml.: sodium bicarbonate, 0·047 *M*; choline chloride, 0·0008 *M*; sodium phosphate buffer, *p*H 7·5, 0·01 *M*; eserine sulphate, 0·0003 *M*.

*Methods of analysis.* Acetylcholine was estimated by measuring the contractions of the dorsal muscle of the leech suspended in an aerated medium[8] of the following composition: sodium chloride, 0·71 per cent; potassium chloride, 0·032 per cent; calcium chloride, 0·018 per cent; sodium bicarbonate, 0·012 per cent; and glucose, 0·077 per cent. All the results are in terms of acetylcholine chloride. Phosphate esters were removed from the samples to be assayed by the procedure of Harpur and Quastel[7].

Sulphanilamide was estimated by the method of Bratton and Marshall[9]. Acetylated sulphanilamide was determined by difference.

## Effects of Narcotics on Acetylation

*Effects of chloretone and adenosinetriphosphate.* The addition of pigeon liver extract to rat brain homogenate produces a system which readily acetylates sulphanilamide under aerobic conditions. Rat brain homogenate alone is incapable of sulphanilamide acetylation, and does not hydrolyse acetylsulphanilamide. The results of a typical experiment, shown in Table 1, indicate the increase in acetylation obtained when acetate or pyruvate is added to the brain–liver system. It will be seen that pyruvate is more effective than acetate as an acetyl precursor for sulphanilamide acetylation, and that pyruvate, unlike acetate, gives rise to increased oxygen uptake. The addition of chloretone (0·004 *M*) reduces both

Table 1. Effect of chloretone on respiration and sulphanilamide acetylation by a mixture of rat brain homogenate and pigeon liver extract at 37° C. in air

| Additions | Oxygen uptake (µl.) | Inhibition of respiration (per cent) | Sulphanilamide acetylated (µgm.) | Inhibition of acetylation (per cent) |
|---|---|---|---|---|
| Nil | 183 | — | 36 | — |
| Chloretone (0·004 *M*) | 52 | 71 | 27 | 25 |
| Sodium acetate (0·02 *M*) | 185 | — | 81 | — |
| Sodium acetate (0·02 *M*) + chloretone (0·004 *M*) | 36 | 81 | 27 | 66 |
| Sodium pyruvate (0·02 *M*) | 345 | — | 108 | — |
| Sodium pyruvate (0·02 *M*) + chloretone (0·004 *M*) | 37 | 90 | 27 | 75 |

Vessel contents: 0·6 ml. rat brain homogenate and 0·8 ml. pigeon liver extract; sodium phosphate buffer, pH 7·5 (0·02 *M*); 200 µgm. sulphanilamide; and additions shown in table. Total volume, 3 ml.

Table 2. Effect of adenosinetriphosphate (ATP) in relieving the chloretone inhibition of sulphanilamide acetylation in a mixture of rat brain homogenate and pigeon liver extract in the presence of sodium acetate (0·02 *M*) at 37° C.

| Additions | Oxygen uptake (µl.) | Chloretone inhibition of oxygen uptake (per cent) | Sulphanilamide acetylated (µgm.) | Chloretone inhibition of acetylation (per cent) |
|---|---|---|---|---|
| Nil | 356 | — | 87 | — |
| Chloretone (0·004 *M*) | 143 | 60 | 27 | 70 |
| ATP (0·003 *M*) | 345 | — | 121 | — |
| Chloretone (0·004 *M*) + ATP (0·003 *M*) | 158 | 54 | 87 | 28 |

Vessel contents: as in Table 1, with diphosphopyridine nucleotide (0·00025 *M*) and additions shown above. Total volume, 3 ml. Experimental time, 90 min.

respiration and acetylation to low levels (Tables 1 and 2).

In the presence of added adenosinetriphosphate the extent of chloretone inhibition of acetylation is considerably diminished, while the rate of respiration is much less affected. A typical experimental result is shown in Table 2. It seems, therefore, that chloretone, by its inhibitive action on a respiratory process, inhibits the formation of adenosinetriphosphate and, therefore, the rate of synthesis of acetylsulphanilamide. The actual acetylating process is clearly far less affected by the narcotic, otherwise a relieving effect of adenosinetriphosphate would not be demonstrable.

Whereas adenosinetriphosphate, however, is effective in mainly overcoming the narcotic inhibition of acetylation in the presence of acetate, this is not the case when acetate is replaced by pyruvate (Table 3). Only a relatively small relief of the inhibition takes place. This is understandable, for as narcotics inhibit the pyruvic oxidase system in brain tissue[10–12], less oxidation of pyruvate occurs in the presence of the chloretone. There results, therefore, a diminution in the rate of formation of 'active acetate' required for acetylation purposes. The limiting factor becomes the availability of 'active acetate', and the addition of adenosinetriphosphate, under the given experimental conditions, influences this availability only to a small extent.

*Sulphanilamide acetylation by pigeon liver extracts.* Crude cell-free extracts of acetone-dried pigeon liver give rise to a high rate of sulphanilamide acetylation in the presence of acetate and adenosinetriphosphate. These extracts are also capable of a dismutation of pyruvate whereby 'active acetate' can be generated from pyruvate and produce acetylations in the absence of added adenosinetriphosphate. The acetylation is not due to residual adenosinetriphosphate in the crude extract, since the addition of acetate alone to the extract produces no appreciable increase in the rate of acetylation.

The results given in Table 4 show the effects of narcotics on the anaerobic acetylation of sulphanilamide by the cell-free extracts. No respiration takes place in these systems. The results indicate that the narcotics employed have no measurable effect on the rate of sulphanilamide acetylation. It may be concluded that the enzymes involved in the acetylation of sulphanilamide are not inhibited by narcotics even when these are present at relatively high concentrations. Furthermore, it is apparent that narcotics do not interfere with the utilization of adenosinetriphosphate. This is consistent with the fact that narcotics do not impede glycolysis, a process involving the utilization of this high-energy phosphate (Table 6).

*Aerobic acetylation of choline by rat brain mince.* Typical results of experiments dealing with the effects of narcotics on respiration and the acetylation of choline by rat brain mince are shown in Table 5. The addition of pyruvate increases the oxygen uptake, for example, by 109 per cent, this being accompanied by a 70 per cent increase in the rate of synthesis of acetylcholine. In all cases, the addition of the narcotic gives rise to a marked inhibition of the rates of oxidation and acetylation. It will be seen that the addition of adenosinetriphosphate increases the rate of acetylation of choline in the presence of the narcotic. It is clear, therefore, that the narcotic does not impede the utilization of the added adenosinetriphosphate; nor does it affect the choline acetylating system. The inhibition of choline acetylation by the aerobic respiring system is due, probably, to the suppression of adenosinetriphosphate formation, thus accounting for the parallelism between the percentage inhibitions of respiration and acetylation shown in the results given in Table 5.

*Acetylcholine synthesis by beef brain extracts.* The lack of inhibitory effect of narcotics on acetylcholine synthesis by cell-free extracts of beef brain is illustrated by the typical experimental results given in Table 6. It will be seen that a high concentration of 'Narconumal' (5-allyl-5-*iso*propyl-N-methyl barbituric acid) has no effect on acetylcholine synthesis by an extract of beef brain undergoing a high rate of glycolysis. This is also apparent in experiments where citrate is used as the acetyl donor and where the only high-energy phosphate available to the system is the adenosinetriphosphate initially added.

Harpur and Quastel[7] have shown that glucose does not inhibit acetylcholine synthesis by brain extracts,

Table 3. Effect of chloretone and adenosinetriphosphate on oxidation and sulphanilamide acetylation by a mixture of rat brain homogenate and pigeon liver extract in the presence of sodium pyruvate (0·02 *M*) at 37° C.

| Additions | Oxygen uptake (µl.) | Inhibition of oxygen uptake (per cent) | Sulphanilamide acetylated (µgm.) | Inhibition of acetylation (per cent) |
|---|---|---|---|---|
| Nil | 425 | — | 95 | — |
| Chloretone (0·004 *M*) | 103 | 76 | 14 | 85 |
| ATP (0·002 *M*) | 443 | — | 122 | — |
| Chloretone (0·004 *M*) + ATP (0·002 *M*) | 153 | 65 | 32 | 77 |

Vessel contents: as in Table 1, with sodium pyruvate (0·02 *M*), and additions shown above. Total volume, 3 ml. Experimental time, 90 min.

Table 4. Effect of narcotics on the acetylation of sulphanilamide by pigeon liver extract at 37° C.

| Expt. | Gas phase | Substrate | Narcotic | ATP conc. | Sulphanil-amide initially added (μgm.) | Sulphanilamide acetylated (μgm.) without narcotic | Sulphanilamide acetylated (μgm.) with narcotic |
|---|---|---|---|---|---|---|---|
| 1 | Air | Pyruvate (0·02 *M*) | Nembutal (9·6 × $10^{-4}$ *M*) | — | 202 | 76 | 76 |
| 2 | $N_2/CO_2$ | Pyruvate (0·02 *M*) | Chloretone (4 × $10^{-3}$ *M*) | — | 211 | 121 | 108 |
| 3 | Air | Pyruvate (0·02 *M*) | Chloretone (4 × $10^{-3}$ *M*) | 0·003 *M* | 213 | 137 | 137 |
| 4 | Air | Acetate (0·02 *M*) | Chloretone (4 × $10^{-3}$ *M*) | 0·003 *M* | 101 | 93 | 95 |
| 5 | $N_2/CO_2$ | Acetate (0·02 *M*) | Chloretone (5 × $10^{-3}$ *M*) | 0·0045 *M* | 211 | 193 | 195 |
| 6 | $N_2/CO_2$ | Acetate (0·02 *M*) | Nembutal (1·2 × $10^{-3}$ *M*) | 0·003 *M* | 200 | 155 | 146 |
| 7 | Air | Acetate (0·02 *M*) | Pentothal (8 × $10^{-4}$ *M*) | 0·003 *M* | 202 | 139 | 130 |
|  |  | Acetate (0·02 *M*) | Amytal (8 × $10^{-4}$ *M*) | 0·003 *M* | 202 | 139 | 132 |
| 8 | $N_2/CO_2$ | Acetate (0·02 *M*) | Hyoscine (5 × $10^{-3}$ *M*) | 0·003 *M* | 202 | 153 | 148 |

Pigeon liver powder extracted with potassium fluoride (0·15 *M*) and magnesium chloride (0·02 *M*). Media: 1 ml. of liver extract (≡ 60 mgm powder). Sodium phosphate buffer, *p*H 7·5 (0·02 *M*); diphosphopyridine nucleotide (5 × $10^{-4}$ *M*) added in experiments 2 and 3. When the gas phase is $N_2/CO_2$, sodium bicarbonate (0·028 *M*) is added, and vessels gassed for 10 min. with 93 per cent $N_2$/7 per cent $CO_2$. Total volume, 3 ml. Experimental time, 90 min.

Table 5. Effects of narcotics on respiration, and acetylation of choline, by rat brain mince at 37° C.

| Expt. | Pyruvate concentration | Narcotic | ATP conc. | Oxygen uptake μl. | Per cent inhibition of respiration by narcotic | Choline acetylated μgm./gm. tissue | Per cent inhibition of acetylation by narcotic |
|---|---|---|---|---|---|---|---|
| 1 | Nil | — | — | 420 | — | 10 | — |
|  | 0·01 *M* | — | — | 866 | — | 17 | — |
|  | 0·01 *M* | 'Narconumal' |  | 498 | 43 | 11 | 35 |
|  | 0·01 *M* | — | 0·002 *M* | 745 | — | 20 | — |
|  | 0·01 *M* | 'Narconumal' | 0·002 *M* | 539 | 28 | 18 | 10 |
| 2 | 0·03 *M* | — | — | 928 | — | 12 | — |
|  | 0·03 *M* | Chloretone | — | 170 | 81 | 5 | 59 |
|  | 0·03 *M* | — | 0·002 *M* | 1,028 | — | 18 | — |
|  | 0·03 *M* | Chloretone | 0·002 *M* | 307 | 70 | 10 | 44 |

Experimental conditions as described in the text. 'Narconumal' concentration, 0·004 *M*, chloretone concentration, 0·005 *M*. Time, 2 hr. Gas phase, air.

providing that conditions are present which allow glycolysis to take place. Under these conditions, the adenosinetriphosphate used in phosphorylating glucose is more than returned to the system. However, any interference with the phosphorylation mechanism associated with glycolysis would be reflected in a reduced acetylcholine synthesis. The fact that no inhibition of acetylcholine synthesis takes place indicates that the generation of adenosinetriphosphate in the course of anaerobic glycolysis is unaffected by the narcotic at the relatively high concentration used.

## Conclusions

These results show that an inhibition of respiration brought about by a narcotic is accompanied by a decreased rate of acetylation, and that the addition of adenosinetriphosphate to an aerobic system alleviates the narcotic effect on acetylation. The effect of added adenosinetriphosphate indicates that the narcotic inhibition of acetylation is the result of a suppression of the oxidative synthesis of this ester. Furthermore, it is apparent that narcotics at high concentrations affect neither the acetylating enzymes *per se*, nor the pyruvate dismutation system, nor the glycolytic sequence in beef brain extract. Thus, the narcotics do not inhibit the utilization of adenosinetriphosphate in these metabolic processes.

McLennan and Elliott[13] have postulated a direct effect of narcotics on the choline acetylating system to account for their results on acetylcholine synthesis, but our findings are opposed to such a conclusion. The underlying effect, which accounts satisfactorily for the results that have been described, is a narcotic-induced inhibition of the oxidative synthesis of adenosinetriphosphate. This is a phenomenon that must be concerned with the functional activity of the nerve cell, if acetylcholine, for example, plays the essential part in the nervous system which is claimed for it.

Table 6. Effect of narcotics on the anaerobic acetylation of choline by beef brain extracts at 37° C.

| Expt. | Additions | μ*M* carbon dioxide output (glycolysis) | Acetylcholine synthesis (μgm./gm. powder) |
|---|---|---|---|
| 1 | Nil | 0·2 | 28 |
|  | 'Narconumal' (0·006 *M*) | 0·3 | 28 |
|  | Glucose (0·03 *M*) | 43·5 | 134 |
|  | Glucose + 'Narconumal' | 43·5 | 134 |
| 2 | ATP (0·002 *M*) |  | 35 |
|  | Sodium citrate (0·02 *M*) + ATP |  | 150 |
|  | 'Narconumal' (0·006 *M*) + ATP |  | 35 |
|  | Sodium citrate (0·02 *M*) + ATP + 'Narconumal' |  | 150 |

Vessel contents: 1 ml. of beef brain extract (≡ 60 mgm. powder) prepared as described in the text. Sodium bicarbonate (0·047 *M*), sodium phosphate buffer, *p*H 7·5 (0·01 *M*), choline chloride (0·0008 *M*), eserine sulphate (0·0003 *M*). Expt. 1 also contained diphosphopyridine nucleotide (5 × $10^{-4}$ *M*) and ATP (0·001 *M*); expt. 2 contained sodium fluoride (0·03 *M*). All gassed for 10 min. with 93 per cent $N_2$ and 7 per cent $CO_2$. Time, 1 hr. + 15 min. equilibration.

We are indebted to the Banting Research Foundation and to the Rockefeller Foundation for grants which made this work possible.

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# LETTERS TO THE EDITORS

*The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications*

## Sulphur-containing Amino-acids of Nisin

In a recent publication[1], we reported that a preparation of the antibiotic nisin could be resolved into at least four active polypeptides, which all yielded on hydrolysis two sulphur-containing amino-acids not normally found in proteins. These amino-acids behaved like lanthionine and cystathionine on two-dimensional paper chromatograms, and treatment of a mixture of them with Raney nickel yielded two substances which behaved like alanine and α-amino-*n*-butyric acid.

The amino-acid which behaved like cystathionine has now been isolated and found to differ from cystathionine.

An acid hydrolysate of crude nisin was evaporated to dryness, the residue dissolved in water and the *p*H of the solution adjusted to 5·0. On standing at 4° C. a precipitate appeared which consisted mainly of leucine and valine. Addition of ethanol to the supernatant resulted in the precipitation of mixtures of lanthionine and the cystathionine-like substance. Fractional crystallization of these precipitates from water gave mainly lanthionine, while the other amino-acid remained in solution. The latter was precipitated by addition of ethanol and recrystallized from aqueous ethanol. Found: C, 35·4; H, 6·5; N, 11·3 per cent. $C_7H_{14}O_4N_2S,H_2O$ requires: C, 35·0; H, 6·7; N, 11·6 per cent.

Although this substance behaved like cystathionine on two-dimensional paper chromatograms, it was much more soluble than L-cystathionine in water. Dr. F. Gibson, of the Department of Microbiology, Oxford, found that it did not support the growth of mutant strains of *Bact. coli* which grew under similar conditions in the presence of a mixture of synthetic L-cystathionine and L-*allo*cystathionine. Moreover, it did not behave like cystathionine on a column of 'Dowex-50' (15 cm. × 0·9 cm.) when elution was carried out with the buffers used by Stein and Moore[2]. Lanthionine and cystathionine were readily separable on this column, the former emerging after only 12 ml. of the first buffer (*p*H 3·42) had passed through, and the latter requiring the passage of all the first buffer (34 ml.) and 13 ml. of the second buffer (*p*H 4·25) for elution. When a mixture of the two sulphur-containing amino-acids from nisin (precipitated from a hydrolysate as already described, but not fractionated) was run on the column, a well-isolated strong band corresponding to lanthionine was eluted; but no cystathionine appeared. Paper chromatography indicated that the cystathionine-like amino-acid was still present in the band containing the lanthionine.

These facts indicated that the substance was a structural isomer of cystathionine. This view was supported by the finding that it resembled lanthionine and differed from cystathionine in yielding a coloured solution ($E_{\text{max.}}$ = 450 mμ), when treated with the Chinard reagent[3]. This reagent has been used as a test for ornithine ($E_{\text{max.}}$ = 515 mμ); but it shows a weaker colour with lysine ($E_{\text{max.}}$ = 450 mμ), and it is of interest that lysine and lanthionine contain the same number of atoms between their two amino-groups.

The nisin polypeptides resemble the antibiotic subtilin, which has been shown to contain lanthionine and an amino-acid having the formula[4,5] $C_7H_{14}O_4N_2S$. We are grateful to Dr. J. C. Lewis, of the Western Regional Research Laboratory, U.S.A., for a specimen of this compound. X-ray powder photographs, kindly taken by Dr. D. Hodgkin and Mrs. M. Webster, of the Department of Crystallography, Oxford, have shown that it is identical with the corresponding amino-acid from nisin.

The $C_7$ amino amino-acid from subtilin has been found by Alderton[6] to yield L-alanine and D-α-amino-*n*-butyric acid on treatment with Raney nickel. However, the compound differs from L-*allo*cystathionine in having a higher optical rotation[5]. Alderton has therefore proposed that it is one of the β-methyllanthionines[6]. We conclude that this is also the structure of the amino-acid from nisin which was not distinguished from cystathionine by paper chromatography. It is of interest that nisin and subtilin both appear to contain β-methyllanthionine and lanthionine in the ratio of 4 : 1, although they differ in their content of other amino-acids[1,5]. These sulphur-containing amino-acids may also be present in a third polypeptide antibiotic, called cynnamycin, which has been obtained from *Streptomyces cinnamoneus*[7].

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## The Fibrin Serum Factor

Until recent years, it was rather generally believed that the structure of a fibrin clot is held together by primary chemical bonds, as indicated, for example, by its failure to dissolve in concentrated neutral urea solutions. It is now known that fibrin can be prepared in two different forms, one of which contains much stronger bonds than the other. The latter is obtained from highly purified fibrinogen and thrombin; the former is prepared in the presence of small amounts of calcium salt and a yet unidentified component of serum. The fibrin prepared from purified components is soluble in dilute acid[1], neutral urea or neutral guanidine hydrochloride solution[2], or neutral solutions of lithium chloride, lithium bromide, sodium bromide and sodium iodide[3,4]. The fibrin with calcium and serum factor is resistant to all these reagents. The greater bond-strengths found in this fibrin compared with those in the clot obtained in the absence of calcium and serum factor are also shown by its higher rigidity and much slower stress relaxation[5]. This serum factor seems to be of protein nature, and is precipitated with fibrinogen in half-saturated ammonium sulphate, but not on isoelectric (*p*H 5·2–5·4) precipitation[6]. The purpose of the present communication is to report that this factor can be removed from fibrinogen preparations by exposure to several reagents, and that it can be restored by use of a purified albumin fraction.

Bovine Fraction I (Armour) was refractionated by a method essentially that described by Laki[7]; this consists of taking the supernatant solution from a low temperature, low ionic strength treatment and precipitating with 23 per cent saturation of ammonium sulphate. The *p*H is at all times above 5·9. The product generally has a clottability of 94–98 per cent; but, even at the highest degree of purity, serum factor is still present, since addition of calcium alone, usually employed at 0·001 *M*, will make the fibrin insoluble in urea solution. If the fibrinogen solution is exposed by dialysis to 3·0 *M* urea or to 2·0 *M* sodium bromide, the serum factor is destroyed, and addition of even 0·01 *M* calcium will not make the clot insoluble in urea. It should be mentioned that Loewy and Edsall have also observed the inactivation of factor activity by urea[8]. The experimental details are as follows. The buffer used as diluent and as solvent for the various proteins and the urea consists of 0·40 ionic strength sodium chloride plus 0·05 ionic strength sodium phosphate, giving *p*H 6·2. The sodium bromide reagent is dissolved in water. A 1–2 per cent fibrinogen solution is dialysed with constant stirring, against a large volume (changed once) of 3·0 *M* urea or 2·0 *M* sodium bromide for 6–8 hr. or 1–2 hr., respectively, at room temperature (23–26° C.), following which the reagent is removed by dialysis at 0° C. for 15–20 hr. against several changes of the 0·45 ionic strength buffer. Control samples are dialysed in a similar manner against the 0·45 ionic strength buffer. During none of these dialyses does precipitation or even opalescence appear in the samples. Ultracentrifugal patterns of material treated similarly show no change in the appearance of the single sharp peak seen[3,4]. Hence no appreciable damage seems to occur to the fibrinogen. Samples are then clotted at 4 gm./l. fibrinogen, 1 unit/ml. thrombin, *p*H 6·2, ionic strength 0·45, and with or without 0·001 *M* calcium chloride. Each clot is tested by addition of an equal volume of 3·0 *M* urea, giving a final urea concentration of 1·5 *M*. Of the clots containing calcium, the control samples remain unchanged, whereas the samples formed from treated fibrinogen dissolve.

Since the serum factor cannot be found in the supernatant solution resulting from an isoelectric precipitation of factor-free fibrinogen[6], it may be deduced that this procedure also results in destruction of the factor rather than separation. In agreement with this conclusion is the additional finding that isoelectric precipitation frequently fails to give factor-free fibrinogen[6]. This may simply reflect a variability in the extent of exposure to the acidic environment. This factor is thus very delicate, being destroyed by mild exposure to acid, urea or sodium bromide.

It was also discovered that the serum factor activity could be restored merely by addition of a solution of bovine serum albumin (Armour Fraction V). So little as 0·05–0·10 per cent albumin in the final clot suffices to render it insoluble in urea. It was found, however, that the addition of albumin was sometimes ineffective, and this seemed to be the result of having over-exposed the fibrinogen to the reagent. This is especially a difficulty in using the sodium bromide. It suggests either that serum factor contains two components, one of which is more stable and does not occur in the albumin fraction, or that some minor alteration finally occurs in the fibrinogen, eliminating sites where reaction with serum factor occurs.

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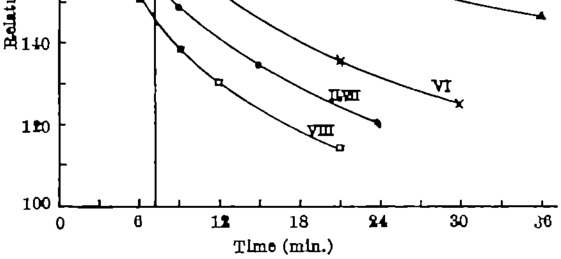
## Inhibition and Activation of Lysozyme

In a previous communication, Pantlitschko and I discussed the inhibition and activation of the hyaluronic acid – hyaluronidase system[1]. It was possible to demonstrate the inhibiting action of electronegatively charged chain molecules (heparin, sulphonated hyaluronic acid, sulphonated carboxy-cellulose, etc.) on one hand and the activating action of electropositively charged macromolecules (histone, protamine, peptone, etc.) on the depolymerization of hyaluronic acid under the influence of hyaluronidase, on the other hand. Bergamini and Ferrari[2] discussed in 1948 the inhibiting action of sulphonated macromolecules (heparin, 'Liquoid', etc.) on lysozyme activity, employing a turbidimetric method. It was thought of interest to verify the results of these authors with the much more accurate viscosimetric method developed by Meyer and Hahnel[3], and to investigate at the same time the influence of electropositively charged macromolecules.



Influence of heparin and histone on the activity of lysozyme. Substrate: carbohydrate fraction from *Micrococcus lysodeikticus* (0·2 per cent solution in water); buffer: McIlvaine (*p*H 5·8) + 0·85 per cent sodium chloride, enzyme: lysozyme (Armour, Inc.); Ostwald viscosimeter, – 37°. I, Initial viscosity (substrate with and without heparin, histone, respectively); II, normal depolymerization curve; III, heparin $1·4 \times 10^{-1}$; IV, heparin $5·0 \times 10^{-4}$, V, heparin $1·0 \times 10^{-4}$; VI, heparin $5·0 \times 10^{-5}$; VII, histone $1·0 \times 10^{-3}$, VIII, histone $1 \times 10^{-3}$

| Substance | Lysozyme | | Hyaluronidase | |
|---|---|---|---|---|
| | Inhibition (per cent) | Activation (per cent) | Inhibition (per cent) | Activation (per cent) |
| Heparin | | | | |
| $1 \cdot 4 \times 10^{-1}$ | 100·0 | — | 100·0 | — |
| $5 \cdot 0 \times 10^{-4}$ | 80·0 | — | 65·0 | — |
| $1 \cdot 0 \times 10^{-4}$ | 45·3 | — | 37·5 | — |
| $5 \cdot 0 \times 10^{-5}$ | 19·1 | — | 6·1 | — |
| Histone | | | | |
| $1 \cdot 0 \times 10^{-2}$ | — | 22·2 | — | 42·0 |
| $7 \cdot 0 \times 10^{-3}$ | — | 0 | — | 32·1 |
| $1 \cdot 0 \times 10^{-3}$ | — | 0 | — | 4·0 |

Enzyme activity was studied by the viscosimetric method described by Meyer and Hahnel[3] (see graph). Heparin inhibits lysozyme activity up to a concentration of about $5 \times 10^{-5}$. Histone, protamine and peptone are active as activators up to a concentration of about $1 \times 10^{-2}$; smaller concentrations are without influence.

When inhibition and activation are calculated by the formulæ developed earlier by us[1], a quantitative estimate is possible (see table; for comparison the respective values for hyaluronidase are also given).

It can be seen from the table that the inhibiting action of heparin on lysozyme and hyaluronidase is of the same order, though the action of lysozyme is inhibited somewhat more. The activating effect of histone and protamine on lysozyme is less pronounced. Concentrations of $1 \cdot 0 \times 10^{-3}$ and $7 \cdot 0 \times 10^{-3}$ show 4 and 32 per cent activation of action of hyaluronidase. These concentrations are without influence on the activity of lysozyme. A concentration of $1 \cdot 0 \times 10^{-2}$ histone is required to show activation of lysozyme.

We are indebted to the State of New York Department of Health (Albany) and to Prof. Favilli (Bologna) for cultures of *Micrococcus lysodeikticus*. For procuring the necessary amount of crystalline lysozyme preparation our thanks are due to Mr. Engelakind, representative in Vienna of the Armour Laboratories.

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## Influence of Sulphaguanidine on the Intestinal Flora and Thiamine Synthesis brought about by Curd Feeding

Sulpha drugs bring about a marked change in the composition of fæcal flora[1]. A reduction in the number of *B. coli*, and also in their efficiency for synthesizing thiamine, have been observed by many workers[2]. We have shown that curd feeding enhanced the coliform organisms in the intestines and also the synthesis of thiamine[3]. It was therefore of interest to study the effects of sulpha drugs when administered along with curds.

Eighteen albino rats, consisting of equal numbers of males and females and weighing 80–100 gm., were fed a vitamin $B_1$-free basal diet for one week, after which period the urine and fæces of the individual rats were collected with the usual precautions and thiamine was determined[4]. The rats were then given sulphaguanidine (0·25 gm. per rat daily) along with the thiamine-free basal diet. A week later, urine and fæces were collected for three days to assess the lowering in thiamine synthesis due to sulphaguanidine feeding.

After a week's rest to overcome the effects of the sulpha drug, the rats were divided into two comparable groups; one group was given 10 γ of synthetic vitamin $B_1$ and the other 13 gm. of curd containing 5 γ vitamin $B_1$ plus 5 γ synthetic vitamin $B_1$. Three rats in each group were employed for determining the *B. coli* content of the fæces, and the other six rats were used for thiamine-excretion studies. When the rats had been on the diet for a week, urinary and fæcal collections were made. Both groups then received sulphaguanidine (0·25 gm. per rat daily), and a week later urine and fæces were collected. The *B. coli* in the fæces were also enumerated. The average values of thiamine excreted in the different cases stated above and the *B. coli* count are presented in the accompanying table.

| Period of the diet | Total daily thiamine excretion (γ) in Urine | Fæces | *B. coli* count |
|---|---|---|---|
| Basal $B_1$-free diet | 1·14 | 1·08 | — |
| Basal $B_1$-free diet + 0·25 gm. sulphaguanidine | 0·42 | 0·06 | — |
| Basal diet + 10 γ synthetic $B_1$ | 1·97 | 1·48 | $2 \cdot 8 \times 10^{8}$ |
| Basal diet + 13 gm. curd + 5 γ synthetic $B_1$ | 3·18 | 3·62 | $9 \cdot 6 \times 10^{6}$ |
| Basal diet + 10 γ synthetic $B_1$ + 0·25 gm. sulphaguanidine | 1·33 | 0·24 | $1 \cdot 5 \times 10^{8}$ |
| Basal diet + 13 gm. curd + 5 γ synthetic $B_1$ + 0·25 gm. sulphaguanidine | 2·67 | 2·76 | $6 \cdot 0 \times 10^{5}$ |

The results clearly show that with 13 gm. of curds, accounting for only 5 γ of vitamin $B_1$, the urinary and fæcal excretion of thiamine is considerably more than in the corresponding animals receiving 10 γ of synthetic vitamin. This is in conformity with our earlier findings. The reduction in thiamine excretion when sulphaguanidine is fed is much higher in the synthetic thiamine group than in the curd group. The coliform organisms in the curd group have not suffered so great a decrease as the other group, indicating that curd-feeding results in developing sulpha drug antagonism similar to that when *p*-aminobenzoic acid is administered. These observations have a fundamental and practical importance in nutrition, more especially in the case of persons who generally take curds or buttermilk with every meal.

Further work is being carried out. We desire to record our thanks to Dr. K. V. Giri for his interest in this investigation.

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## Recovery of Caprinized and Lapinized Rinderpest Viruses from Condensed Water Vapour removed during Desiccation

Stein and Rogers[1] demonstrated the presence of Newcastle disease virus in the condensed water vapour removed during desiccation of material containing that virus. They failed to demonstrate the presence of vesicular stomatitis, equine encephalomyelitis, equine infectious anæmia and swine fever viruses under similar conditions.

The necessity arose for the desiccation of material containing virulent rinderpest virus in an Edwards's centrifugal freeze-dryer, normally used for desiccation of caprinized and lapinized rinderpest virus vaccines for field use. Possible contamination of the machine by virulent virus in the condensed water vapour was a factor which had to be considered. Caprinized and lapinized viruses were used to study the problem.

Spleen pulp, harvested from reacting goats, was processed in wide-mouthed tubes covered with single-layer lint sterility caps. After ten hours processing, the refrigerated coils were permitted to warm up and the condensed water vapour was collected as it drained from the exhaust valve of the condenser chamber. 5 ml. of this condensate was inoculated subcutaneously into each of four susceptible bullocks. These animals showed typical caprinized virus reactions after four to five days. One animal died on the eleventh day due to intercurrent disease. Fourteen days after inoculation the remaining animals were challenged with caprinized virus. They showed no reaction to the challenge dose whereas two susceptible controls reacted typically. The experiment was repeated with four more bullocks. Three gave typical thermal reactions while the remaining one was unaffected. On challenge, all four proved to be immune and three control animals responded thermally.

In both experiments the results indicated the presence of caprinized rinderpest virus in the condensate.

Similar results were obtained using lapinized rinderpest virus. Of six rabbits inoculated intravenously with 1 ml. of condensate, five showed the usual temperature rise within 60 hr.; the remaining one showed no reaction. Two of the reacting rabbits were killed after 96 hr. and were found to have typical lesions on post-mortem examination. After ten days the remaining four rabbits were challenged with lapinized virus. Three showed no reaction, whereas the fourth responded with a mild rise in temperature. Two control animals reacted normally. The results show that lapinized virus was present in the condensed water vapour removed during desiccation.

This work has not been repeated with virulent rinderpest virus; but it seems most probable that it could be recovered in the same manner. The necessity for collecting the condensed water vapour into disinfectant and for disinfection of the machine are apparent. It is thought that the major part of the virus in the condensate is carried over during the period of evaporative freezing when dissolved gases and water vapour are removed rapidly as indicated by the rise of condenser temperature from − 45° C. to the region of − 20° C. or higher. In this period approximately 20 per cent of the original water content is removed. Once frozen, desiccation of the material becomes considerably slower.

It has not proved possible to demonstrate the presence of either of the test viruses in material obtained by swabbing the walls of the desiccating chamber after processing.

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## Indirect Determination of Water Retention in Cattle as a means of estimating Energy Exchange

The starch equivalent or net energy system, which is the basis of livestock rationing in Great Britain, measures the nutritive value of feeds in terms of the body storage of energy which occurs when they are given to fattening cattle. Only a small number of respiration chambers and calorimeters are available for work with large animals, and the expense and labour involved in their operation limit the number of experiments which can be carried out. Consequently, published values[1] are either the original ones of Kellner[2] or crude estimates based on determinations of digestibility of the feed by sheep.

An attempt has therefore been made to determine indirectly the fat storage of cattle. Protein and ash retention may be estimated by the balance method. The remaining components of a gain of weight of an animal are fat and water, and thus an accurate determination of water retention would permit an estimate of the storage of body fat. The small amount of carbohydrate stored can be ignored. In our hands, water retention could not be accurately computed from determinations of total body water by the antipyrine dilution technique[3] before and after a period of subsistence on a constant diet. Nevertheless, gross changes in the water content of the body over long periods could be estimated in this way, and the method may therefore be used for evaluating the composition of gains in body-weight of cattle at pasture.

A method has now been developed which permits the accurate estimation of water retention from the retention of sodium and potassium. Analysis of the tissues of fœtal, young and mature cattle showed that their water content could be predicted from the equation

$$\text{Water (gm.)} = 0{\cdot}2922\,\text{Na (mgm.)} + 0{\cdot}1471\,\text{K (mgm.)}.$$

This equation was obtained by the method of least squares and applied to organs, tissue fluids and fat depots, varying in water content from 99 per cent (pericardial fluid) to less than 10 per cent (fat depots of mature animals). It also applied to the whole fœtus aged three months, to amniotic fluid and to the ingesta of the rumen, small intestine and cæcum. It did not apply to the contents of the abomasum, presumably due to the high concentration of hydrogen ions. The same equation applied to the tissues of sheep and rabbits. The standard error of estimate of water content was ± 2·0 per cent. Since the equation applied to the individual tissues, it must apply to the animal as a whole and to increments in the growth of the animal, in which water retention may be estimated from the simultaneous retention of sodium and potassium.

The validity of the equation was therefore tested in experiments with growing calves, given daily rations of 1 gallon of cows' whole milk, which permitted a moderate gain of body-weight. The calves were confined in a closed-circuit respiration chamber for periods of eight days, and the storage of carbon, energy, nitrogen, water, sodium, potassium and total ash determined. The storage of water was determined directly from the water intake, the water arising in metabolism as estimated from oxygen consumption, carbon dioxide production and urinary nitrogen excretion, and the excretion of water in the fæces and urine and from the lungs and skin. Water retention was also determined indirectly from the sodium and potassium balances. The results are compared in the accompanying table.

TOTAL WATER BALANCES OF CALVES DURING PERIODS OF 8 DAYS

| Calf No. | Days | Total intake of water + metabolic water (gm.) | Water retention determined from balance of intake and excretion (gm.) | Water retention estimated from balances of sodium and potassium (gm.) | Difference (estimated less determined) (gm.) | Difference (estimated less determined) (%) |
|---|---|---|---|---|---|---|
| 167 | 1 + 2 | | 552 | 547 | −5 | |
| | 3 + 4 | | 1,136 | 1,192 | +56 | |
| | 5 + 6 | | 878 | 819 | −59 | |
| | 7 + 8 | | 439 | 683 | +244 | |
| | 1–8 | 37,459 | 3,005 | 3,241 | +236 | +7·85 |
| 168 | 1 + 2 | | 386 | 740 | +354 | |
| | 3 + 4 | | 1,217 | 644 | −573 | |
| | 5 + 6 | | 690 | 842 | +152 | |
| | 7 + 8 | | 992 | 637 | −355 | |
| | 1–8 | 38,566 | 3,285 | 2,863 | −422 | −12·85 |
| 169 | 1 + 2 | | 896 | 1,096 | +200 | |
| | 3 + 4 | | 777 | 1,040 | +263 | |
| | 5 + 6 | | 1,124 | 897 | −227 | |
| | 7 + 8 | | 730 | 811 | +81 | |
| | 1–8 | 37,747 | 3,527 | 3,844 | +317 | +8·99 |
| Complete data | | 113,772 | 9,817 | 9,948 | +131 | +1·33 |

The mean discrepancy between the two estimates of water storage for the two-day balances is ± 214 gm. water and is of the same order as that observed for the total eight-day balances. This suggests that the discrepancy arises from the aperiodicity of excretion of water and of sodium and potassium and that the percentage error attached to a gain of water would decrease linearly with length of balance period (cf. the percentage discrepancy for the complete results). There remains the further possibility of reducing the error by smoothing out, by statistical means, the daily variation in excretion of water and of sodium and potassium.

The balance method described, which is independent of the respiration chamber technique and involves only the quantitative collection of urine and fæces, should therefore permit the accurate determination of storage of protein, mineral matter and water by cattle. Since retention of water in the ingesta of the gut is simultaneously estimated by the equation, the error of an estimate of fat retention by difference from body-weight is almost entirely dependent upon the accuracy with which the animal is weighed at the beginning and at the end of the experiment. Diurnal variation in body hydration dependent upon the pattern of water intake and the periodicity of urine and fæcal excretion are important in this respect.

These experiments are being continued and extended, and will be published in detail elsewhere.

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## An Action of Strongly Basic Anion-Exchange Resins and Solutions containing Sugars

In view of the expanding use of strongly basic ion-exchange resins in the isolation of plant acids[1,2], a recent experience in this laboratory emphasizes a need for caution in the application of such techniques.

Paper chromatograms, prepared from certain 'acid fractions' of extracts of immature apple fruits, run in butanol – formic acid – water (40 : 10 : 50 v/v), and sprayed with suitable indicator solutions, gave spots for several 'unknown' acids ($R_F$ 0·24, 0·29, 0·43, 0·50, 0·67, 0·81), the largest spot being at $R_F$ 0·67. The acid responsible for this spot was eventually identified as lactic acid. The 'acid fractions' had been prepared by passing an extract of the fruit, obtained as previously described[3], and freed from amino-acids but containing all the sugars of the fruit, down a column of 'Dowex 2' to absorb the acids, and then fractionally displacing them by means of 0·1 *N* hydrochloric acid.

The apparent isolation of appreciable amounts of lactic acid from fruit which before death had free access to oxygen was surprising, especially since no comparable amounts of pyruvic or other acids associated in metabolism with lactic acid were noted. It was found that if the acids of the apple were isolated by adsorption on, and displacement from, weakly basic resins such as 'Deacidite *E*', no lactic acid appeared.

It is well known that lactic acid is produced when sugars are treated with alkali, and it appeared possible that some at least of the lactic acid obtained arose from the action of the basic 'Dowex 2' resin on the sugars present in the apple extract as they passed down the column. A somewhat analogous case, the hydrolysis of glycosides and disaccharides by strongly acid resins, was studied by Wadham[4]. To test this hypothesis, a solution was made containing glucose, fructose, sucrose, malic acid and quinic acid in roughly the proportions present (6 per cent sugar and 1 per cent total acid) in the amino-acid free apple extracts. This solution was passed down a 'Dowex 2' column and treated in the same way as the apple extracts mentioned earlier. Paper chromatograms were prepared (run in both butanol – formic acid – water, and propanol – ammonia – water, 60 : 30 : 10 v/v) from the original solution and, after concentration to a small volume, from the various fractions displaced from the 'Dowex 2' column with 0·1 *N* hydrochloric acid. In all the first fractions from the column, clear evidence of lactic acid was obtained.

From a comparison of the size of the spots on the various chromatograms, it is certain that at least the greater part of the lactic acid apparently obtained from the apple was an artefact produced from the sugars present. A little may perhaps have been present in the original extract. Bryant and Overell[1], using the strongly basic resin 'Amberlite IRA 400', obtained traces of an 'unknown' acid from the juice of apples and carrots which had an $R_F$ in butanol – acetic acid – water similar to that of our lactic acid spots. They, however, used the resin in the less-alkaline carbonate form. In our experiments, in which a solution of sugars and acids similar to the one mentioned earlier was passed down 'Amberlite IRA 400 (OH)' in the carbonate form instead of 'Dowex 2', no sign of lactic acid was observed. It appears, therefore, that acids may be adsorbed with safety from plant extracts rich in sugars by strongly basic resins in the carbonate form. In this form, however, the resins have a low capacity, and the concentration of the acid in the solutions passing down them must be very low to prevent evolution of carbon dioxide, with subsequent break-up of the column.

For the separation and isolation of small amounts of acids in the presence of large amounts of other acids, it appears preferable to separate the acids *in toto* from the sugars by a preliminary adsorption on weakly basic ion-exchangers followed by displacement; followed by fractionation on strongly basic anion-exchangers in the 'hydroxyl' form in which they have their highest capacity and resolving power (because of 'tighter' bands) for acids.

The work described in this paper was carried out as part of the programme of the Food Investigation Organization of the Department of Scientific and Industrial Research.

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## Percentage of Binucleate Cells in the Livers of Adult Rats

SEVERAL workers have suggested that the percentage of binucleate cells seen in histological sections is not a true measure of the percentage of such cells in the liver. The cells of the liver are so large, varying between 12 and 25 μ in diameter, that a considerable number of the cells in a section 6–8 μ thick must have been cut through, and in some cases two nuclei may have been separated. Pfuhl[1] corrected for this error in counts made on the livers of rabbits by assuming that the percentages of binucleate cells in sections 5 and 7·5 μ thick were one-third and one-half the absolute value, respectively. Later, Müller[2] elaborated a formula for converting the observed counts to the real percentages. It would be preferable to count the binucleate cells in a suspension of liver cells; but the difficulty has been to prepare a suitable suspension. Recently, Bucher and Glinos[3] reported finding three times as many binucleate cells in a cell suspension as in a section 6–8 μ thick. This suspension had been prepared by agitation of tissue slices in saline (private communication by Dr. N. Bucher).

A simpler method for preparing a cell suspension has now been developed and was used for counting the binucleate cells in the livers of adult male and female hooded rats of the Lister strain. A sample of fresh liver was homogenized for one minute at a low speed in the machine described by Folley and Watson[4] with ten times its volume of the medium described by Robinson[5]. A drop of the suspension so obtained was then mounted and stained with toluidine blue, and the number of binucleate cells in at least 1,000 cells counted. Duplicate counts varied by less than 1 per cent, that is, by less than 3 per cent of their actual value. The results have been listed in the accompanying table together with values for the percentage of binucleate cells in histological sections of livers from rats of similar weight, age and strain. These sections were kindly prepared by Dr. A. M. Barrett, Department of Pathology, Cambridge.

PERCENTAGE OF BINUCLEATE CELLS IN THE LIVERS OF ADULT MALE AND FEMALE RATS

| Sex | Counts made on | | | |
|---|---|---|---|---|
| | (a) Cell suspension | | (b) Histological section | |
| | Weight of rat (gm.) | Binucleate cells (per cent) | Weight of rat (gm.) | Binucleate cells (per cent) |
| Male | 270 | 32 | 267 | 10 |
| | 266 | 30 | 273 | 11 |
| | 268 | 29 | | |
| | 290 | 29 | | |
| Female | 202 | 29 | 200 | 11 |
| | 220 | 29 | 216 | 12 |
| | 235 | 29 | | |
| | 200 | 31 | | |

Some cells were inevitably fractured in the preparation of the suspensions, but these formed only a small proportion of the liver cells, for drops of the suspensions contained mostly intact cells and remarkably little debris. The cells remained intact and separate for at least seven days when the suspensions were stored at 0–2° C. It seems reasonable, therefore, to assume that the mononucleate and binucleate cells had been broken in the same proportion in which they occurred in the liver.

Between 10 and 12 per cent of the cells in histological sections of the livers of both sexes appeared binucleate, in agreement with values reported by earlier workers. It was obvious that many of the cells in the sections had been cut, for all the lobules contained many 'cells' without any nuclei at all. Even though these non-nucleated 'cells' were not included in the counts, the proportion of binucleate cells in the sections was only one-third of that in the cell suspensions. There was no difference between the percentages of binucleate cells in the livers of adult male and female rats: and despite variations in the weights of the rats these values were almost constant at 30 per cent. This figure was required as a step in calculating the chemical composition of the average liver cell[6]; but its agreement with that found by Bucher and Glinos[3] for albino rats is worth recording.

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## Composition of Whales' Milk

It has been possible to obtain eight samples of whales' milk for analysis through the very willing co-operation and help of Dr. E. Downing and Mr. J. A. B. Athey, of Chr. Salvesen and Co., Leith, and Dr. J. G. Sharp, of the Low Temperature Research Station, Cambridge. Two of the samples were from blue whales (*Balaenoptera musculus*) and the remainder from fin whales (*Balaenoptera physalus*). The milks were collected after dissection of the mammary glands during the flensing operation on board Salvesen and Co.'s factory ships *Southern Venturer* and *Southern Harvester* engaged in pelagic whaling in the Antarctic. The period between the death of the whales and the collection of the milk varied from 6 hr. for sample 7 to 19 hr. for sample 4. The samples were stored in glass bottles at a temperature of − 20° C. while on board ship and ashore, before being conveyed to the Hannah Institute with as little rise in temperature as possible. At the Hannah Institute the samples were kept at 4° C. and analysed without delay. Samples 1–3 were at a temperature of − 20° C. for six to seven months and samples 4–8 for two to three months.

It should be noted that the killing of lactating whales, that is, those accompanied by a calf, is illegal and that the samples discussed here were obtained from whales accidentally separated from their calves during the chase or, much more likely, from whales whose young had finished weaning and left their dam. It therefore seems probable, as the data of Mackintosh and Wheeler[4] would also suggest, that the majority of lactating whales caught during the antarctic whaling season (late December – early March) are in the last stages of lactation or in the process of drying-off. Thus the composition of the eight samples obtained may not be typical of normal whale milk; on the other hand, one of Salvesen and Co.'s chemists who has experience of the time when no restrictions on killing were in force, informed me that the percentage of fat in the milk from a whale actively feeding a calf was about 39 per cent—a value similar to the fat content of five of the present samples. Over the four seasons, 1948–49, 1949–50, 1950–51 and 1951–52, the combined catch of the *Southern Venturer* and the *Southern Harvester* was 16,000–17,000 whales, of which only twenty four were lactating.

Composition of Whales' Milk

| Species of whale | Length (ft.) | Date caught | gm./100 gm. milk | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Water | Fat | Protein (N × 6·38) | Ash | Lactose (by diff.) | Lactose (detd.) |
| 1. Blue | 83 | 24.2.49 | 45·7 | 40·0 | 12·0 | 1·2 | 1·1 | — |
| 2. Blue | — | 10.3.49 | 48·6 | 39·1 | 11·3 | 1·5 | — | — |
| 3. Fin | 75 | 27.2.49 | 48·1 | 39·7 | 11·3 | 1·3 | — | — |
| 4. Fin | 77 | 5.1.52 | 61·8 | 18·5 | 13·1 | 1·8 | 4·8 | 4·5 |
| 5. Fin | — | 14.1.52 | 76·2 | 17·1 | 3·6 | 0·8 | 2·3 | 0·7 |
| 6. Fin | 72 | 27.1.52 | 38·0 | 51·0 | 8·5 | 0·8 | 1·7 | 2·0 |
| 7. Fin | 68 | 8.2.52 | 45·0 | 37·8 | 12·1 | 1·4 | 3·7 | 3·6 |
| 8. Fin | 69 | 22.2.52 | 50·0 | 37·8 | 10·2 | 0·8 | 1·2 | 1·0 |
| Average composition of milk from Ayrshire cows | | | 87·2 | 4·0 | 3·3 | 0·9* | — | 4·6 |

* By difference; includes approximately 0·2 per cent citrate

The milks were white or very pale cream in colour, had a slight fish-like odour reminiscent of cooked cod-roe and a consistency of thick cream at laboratory temperature; sample 5 had a thinner consistency and sample 4 was very slightly contaminated with blood from an external source. The samples were analysed by the methods usually employed for ordinary milk or concentrated milk products, with small modifications where necessary. The reducing sugar determined in samples 4–8 by a chloramine-*T* potassium iodide oxidation method was assumed to be lactose and was calculated as the anhydrous form. The sugar content of samples 4–7 was determined by Mr. Athey on board the *Southern Harvester* by the same analytical method. His results were not identical with those obtained under the much more favourable conditions at the Hannah Institute, but they suggest that no serious decomposition of lactose occurred during storage, except perhaps in sample 5.

The results in the accompanying table show that whales' milk is much richer in fat and protein and contains less lactose than cows' milk. In these respects, it is similar to the milk of the other cetaceans, the dolphins[1] and the porpoises[2], and also to seals' milk[3]. Rich milk of this type seems to be characteristic of mammals which live in a cold environment and whose young have a rapid rate of growth. The composition of the milk of the two species of whale is very similar; the differences among the samples are probably compounded of lactational effects, individuality and sampling errors, the lactational effects probably being of greatest importance.

With the help of Dr. F. C. Fraser of the British Museum (Natural History) a list of references to literature on the composition of whales' milk has been compiled. None of these reports gives as complete an analysis on as many samples as the present investigation. In general, the results in these publications for milk of several species of whale, including blue and fin whales, are similar to those presented here. Two of the most recent of these reports on whales' milk are by Rowland[5], who analysed three samples of milk from blue whales, and by Pedersen[6], who gives the composition of milk from a humpback whale (*Megaptera nodosa*).

This investigation will be reported in more detail elsewhere, when an account of some minor constituents of whales' milk will be given together with a review of the literature on the milk of this very valuable and largest mammal.

I am much indebted to Chr. Salvesen and Co. and Dr. Downing for the information they have given me about whaling.

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## Silver Impregnation of Nerve Fibres

THEORIES of the mechanism of staining of nerve fibres by impregnation with silver solutions have at various times been based on adsorption, and on the stoichiometric combination of the silver and the protein. It seems most probable in the light of recent work on protein – metal complexes[1] that the combination is stoichiometric, and the following investigation appears to support this view.

Spinal cord and sciatic nerve from the frog were fixed in 70 per cent alcohol for three days and then embedded in paraffin wax; sections were impregnated on the slide in a 1/20,000 silver nitrate solution at 37° C. After impregnation the slides were washed for 5 min. in three changes of distilled water to remove any uncombined silver and were then reduced in sodium sulphite – hydroquinone reducer according to the method of Holmes[2].

When the impregnation was carried out for 17 hr. in silver nitrate solution buffered over the range $p$H 4·0–9·0, it was found that very little silver was taken up below $p$H 7; but above this value the amount increased rapidly to $p$H 9. Since free carboxyl groups are fully ionized at $p$H 6, this suggests that such groups are not the sites of combination of the silver, but rather that some 'weak' grouping is responsible. Even at $p$H 9, silver uptake is small for less than 1¼ hr. impregnation, increasing most rapidly between 1½ and 2 hr. This slow reaction also indicates that the combination is due to some weak grouping or to the formation of silver complexes. Any reaction with amino or carboxyl groups would be relatively rapid, as in staining methods using acidic or basic dyes. Attempts were made to block end-groupings in the proteins by using some of the reagents suggested by Danielli[3] and Olcott and Fraenkel-Conrat[4]. The results are indicated in the accompanying table, showing the extent to which the silver impregnation was specific to the nerve fibres and the general level of intensity of the stain at $p$H 9.

| | Specificity to the nerve fibre | Intensity of impregnation |
|---|---|---|
| Control | ++ | ++ |
| *Amino groups* | | |
| Nitrous acid | ++ | + |
| Formaldehyde | ++ | ++ |
| Picric acid | ++ | ++ |
| Iodoacetic acid | ++ | ++ |
| *Carboxyl groups* | | |
| Esterification (MeOH+HCl) | + | ++ |
| Diazo-methane (in ether) | 0 | + |
| *Sulphydryl groups* | | |
| Iodoacetic acid | ++ | ++ |
| Hydrogen peroxide | ++ | + |
| Periodic acid | ++ | ++ |
| Performic acid | + | 0(+) |
| *Disulphide linkages* | | |
| Thioglycollic acid followed by iodoacetic acid | ++ | ++ |

Though it would thus appear that carboxyl groups play some part in the silvering process, the slow reaction and incomplete loss of specificity suggest that they are not the actual sites of silver uptake. The possibility of a reaction with aldehyde groupings can be eliminated, since these are not present in alcohol-fixed material[5]; the Feulgen test is, in fact, negative. Extraction of nucleic acids with trichloracetic acid[6] did not affect the impregnation. There remain to be considered the ring-containing amino-acids, tryptophane, tyrosine and histidine.

The specificity of performic acid as a blocking agent for tryptophane (as well as for sulphydryl groups) is useless, as the reagent employed contained a considerable amount of formic acid, which itself greatly reduces the intensity of the impregnation for some reason not known. Of the other two possible reagents, benzoyl chloride and 2.4-dinitrofluorobenzene both greatly reduce staining; the former 'blocks' tryptophane, tyrosine and histidine, the latter blocks tyrosine and to some extent histidine[7]. The fact that staining begins as low as $p$H 7 suggests the combination of silver with the —NH groups of histidine, which has a $p$K value of 6–7 (the $p$K of tyrosine is 10). Silver impregnation of smears of the four proteins

haemoglobin > fibrinogen > pepsin > protamine

showed a descending order of intensity of impregnation. This order parallels that of their histidine content[8] but not of their tyrosine content.

These results suggest that the silver impregnation of nerve fibres is due chiefly to the combination of histidine groups with the metal and confirms the recent work of Grassman and Kursch[9]. These authors conclude that at $p$H 6·2 the amount of silver combined with proteins of the collagen type is proportional to the histidine content.

I wish to thank Profs. J. E. Harris and J. F. Danielli for their criticism and advice.

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## Association of Glucose, Arabinose and Xylose in Jute

THE nature of the association between glucose, xylose and arabinose in the plant is extremely complex. Although a considerable amount of work on glucoxylan or cellulosan[1–7] and xyloaraban or araboxylan[8,9] has been done, the nature of their association has not been definitely established. In some quarters it is believed that the nature of the association between glucose and xylose in the plant might be that of a solid solution type or of mixed crystals[5]. Schmidt[3], Norman[4] and others suggest a chemical combination between glucose and xylose or the presence of cellulosan in the cellulosic materials, whereas Sarkar, Mazumdar and Pal[7] conclude that there is no cellulosan in jute. The present general belief[10] is that association between xylose and glucose is more of a physical than of a chemical nature.

The presence of cellulosan in the plant could not be definitely established due to the failure to isolate simple oligo-saccharides containing glucose and xylose or glucose and arabinose. This seems to be due to the fact that selective hydrolysis had not been tried. Recently, Das, Chaudhuri and Wareham[11] have therefore used a weak acid under controlled conditions for hydrolysis of jute holocellulose. This work has been extended by us[12] in hydrolysing the so-called jute α-cellulose, where it has been definitely shown, in contradiction to the finding of Sarkar *et al.*, that α-cellulose invariably contains xylose and that even by fractional hydrolysis pentose-free α-cellulose could not be obtained. Later on, it was found by us that arabinose is also present in jute α-cellulose together with xylose irrespective of the methods of its preparation and even when the last trace of lignin is removed by Norman and Jenkins's method[13].

Like xylose, arabinose also could not be separated from lignin-free α-cellulose even by fractional hydrolysis[12]. This seems to indicate the presence of cellulosan in jute and that the arabinose might be present in pyranose form. This finding, again, cannot be taken as conclusive in establishing the theory of cellulosan, since it is possible that xylan or araban are separate units and that the portion of α-cellulose which was accessible to formic acid was only hydrolysed, so that the association between cellulose and pentosan is only a question of their physical environment rather than chemical union. This is specially so, as it has been shown by Das, Chaudhuri and Wareham[11] by the paper chromatographic method that, in the first hydrolysate (fraction 1) of jute holocellulose, most of the pentosan is hydrolysed but no hexosan.

In order to resolve these conflicting views it was essential, therefore, to follow selective hydrolysis of so-called α-cellulose with formic acid so as to obtain simple oligo-saccharides on the hydrolysate and to identify by paper chromatography the gluco-xylose or gluco-arabinose linkages. For this purpose 1·5 gm. α-cellulose, prepared by treating chlorite jute holocellulose with 17·5 per cent caustic soda as recommended by the American Chemical Society method and modified by Sarkar[14], was hydrolysed with 30 c.c. formic acid (85 per cent) for twelve minutes at 135° C. and the hydrolysate was filtered, made free from acid and decolorized in the same way as done previously[11]. The neutral clear solution was then chromatographed with moist phenol and moist butanol as solvents. Besides the spots of xylose, glucose and arabinose which were isolated and identified in the same way as explained previously, in the case of holocellulose[11] the presence of a new prominent spot in between the spots of uronic acid and glucose has been detected which, however, disappears if the hydrolysis is continued for another three hours. This new complex sugar gives a brownish-pink colour with aniline oxalate spray which is quite distinguishable from the pink colour of xylose and arabinose or the yellow to brown colour of glucose, and travels much slower than maltose but just a little slower than xylotriose. This indicates that the new complex is most probably a triose or tetrose. In order to isolate this complex, the concentrated hydrolysate of jute α-cellulose was chromatographed on Whatman No. 1 filter paper with moist phenol as solvent for ninety hours and the band corresponding to the new spot was cut off. This strip was then extracted with water and evaporated under low temperature and pressure to a small volume. The complex gave only one spot and no trace of any other sugar was obtained even when the chromatograph was run for seventy hours. This was then hydrolysed again for one hour with 85 per cent formic acid at 135° C., the hydrolysate made free from acid, then chromatographed, which shows the spot of the original new complex sugar due to the incomplete hydrolysis and the spots of glucose, xylose and arabinose. The last three sugars were isolated and identified in a similar manner, as explained earlier. It is noticeable that while the parent substance is brownish-pink in colour, its components xylose and arabinose are very bright pink, whereas glucose is only faint yellow, when developed by aniline oxalate reagent.

The above finding conclusively proves the presence of cellulosan, or chemical union between α-cellulose and pentosans. It may be in the form of glucose–xylose–arabinose, glucose–arabinose–xylose or xylose–glucose–arabinose. The above results also suggest a union between xylose and arabinose either with each other or through glucose. This simple oligo-saccharide containing arabinose, xylose and glucose could not be isolated by previous workers probably due to the fact that arabinose generally exists in Nature in furanose form, whereas in this case arabinose seems to be present in pyranose form. Detailed work will be published elsewhere.

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## A New Photoperiodic Phenomenon in Short-Day Plants

THE classical researches of Hamner[1] on photoperiodism indicated that the flowering of short-day plants, such as Biloxi soybean, is dependent upon exposure to a certain minimum ('critical') dark period. Within certain limits, the length of the critical dark period is largely independent of the duration of the light period, but when the latter reaches 20 hr., flowering in Biloxi soybean will not occur even if the associated dark periods exceed the critical value. The possibility that the length of this limiting light period may vary with the duration of the dark period has apparently never been investigated.

During the course of some recent photoperiodic experiments, it was found that plants of 'Biloxi' soybean flowered when exposed to ten cycles in which the dark periods were of 22 hr. and the light periods of 8 hr. duration, but did not flower when the cycles included 22 hr. of dark and 14 hr. of light. In another experiment with the short-day species *Perilla*

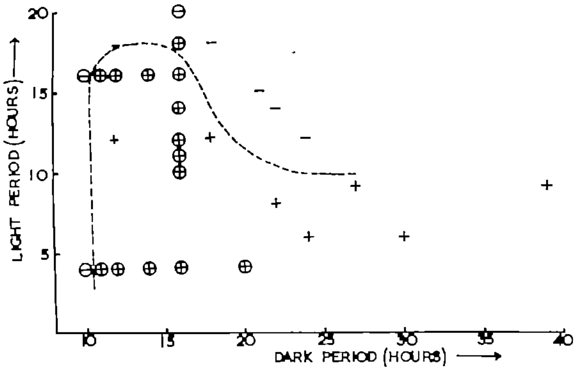
| Photoperiod (hr.) | Dark period (hr ) | Number of plants | | Mean number of flowering nodes per plant |
|---|---|---|---|---|
| | | Flowering | Vegetative | |
| 6 | 24 | 7 | 0 | 7 3 |
| 6 | 30 | 4 | 3 | 2 6 |
| 6 | 42 | –* | –* | —* |
| 9 | 27 | 6 | 0 | 4 2 |
| 9 | 39 | 7 | 0 | 5 9 |
| 12 | 12 | 9 | 0 | 12 8 |
| 12 | 18 | 6 | 3 | 1 1 |
| 12 | 24 | 0 | 8 | 0 |
| 15 | 21 | 0 | 8 | 0 |
| 18 | 12 | 0 | 9 | 0 |
| 18 | 18 | 0 | 8 | 0 |

* Plants died

*ocymoides*, it was found that flowering occurred with cycles of 6 hr. light and 30 hr. dark, but not with 12 hr. light and 24 hr. dark. These results suggested that, when the dark period is abnormally long, the length of the associated light periods must be reduced if flowering is to occur.

The following further experiment was carried out with Biloxi soybean in order to investigate this effect in greater detail. All plants were grown under 'long days' until the third trifoliate leaf was expanding and were then exposed to one of eleven different photoperiodic regimes, in which various lengths of dark period ranging from 12 to 39 hr. were used in conjunction with light periods ranging from 6 to 18 hr. (see table). The treatments were carried out in 'growth cabinets' in which lighting was provided by 'daylight' fluorescent lamps giving an intensity of approximately 1,000 foot-candles. The temperature during both the light and dark periods was thermostatically controlled at 21° C. Each treatment was continued for ten cycles, after which the plants were returned to long-day conditions for 16–18 days, when the plants were dissected for observation of flower-initiation. In those groups in which the light periods were of only 6 or 9 hr. duration, a few plants became moribund following the treatment and had to be discarded.

The results are summarized in the table. Maximum flowering occurred with a cycle of 12 hr. light and 12 hr. dark. The flowering response was reduced in all treatments in which the dark period was prolonged beyond 12 hr.; but this effect was much more marked in treatments in which photoperiods of 12 hr. or more were used, and indeed flowering was completely inhibited when light periods of 15 and 12 hr. were used in conjunction with dark periods of 21 and 24 hr. respectively.



Effect of duration of light and dark periods on flowering of Biloxi soybean
+ = flowering. – = not flowering Points from Hamner's results (ref. 1) enclosed in circles. In drawing the curve, consideration has been given to the magnitude of the positive flowering responses

The accompanying graph has been prepared from the results of the present experiments and from those of Hamner. A curve has been drawn to indicate what appear to be the limiting lengths of light and dark periods for flowering. From this curve it is seen that when the dark period exceeds 12 hr., the duration of the limiting light period falls rapidly to approximately 10 hr. with a dark period of 27 hr. Further extension of the dark period to 39 hr. leads to no further fall in the duration of the limiting light period, however.

The preliminary results obtained with *Perilla ocymoides* described above suggest that a similar effect will be found in that species. Moreover, there is some evidence from the results given by Schmitz[2] that the limiting light period falls in *Kalanchoe blossfeldiana* with a dark period of 32 hr.

An analogous result (though in the reverse sense) was obtained by Claes and Lang[3] with the long-day plant *Hyoscyamus niger*. When this species is grown on a 24-hr. cycle, flowering will only occur if the light period exceeds 10 hr.; but on a 48-hr. cycle, light periods of 9 and 10 hr. are effective in promoting flowering. Thus it appears that the effect observed in soybeans may occur in both short-day and long-day plants.

It is somewhat surprising that this important phenomenon seems to have escaped observation, due apparently to the fact that in past experiments either the dark periods used were not sufficiently long or the accompanying photoperiods were relatively short and did not attain the limiting value. In this connexion, we may note that the duration of dark period necessary to reveal the phenomenon is, in any event, apparently greater in Peking soybean[4] and *Kalanchoe blossfeldiana*[2] than in Biloxi soybean.

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## Saprophytic *Cladosporium* in Britain

It has been generally accepted that all the *Cladosporium* which occurs saprophytically in Britain belongs to the ubiquitous species *C. herbarum*. Brooks and Hansford[1] examined many isolates of *Cladosporium* from dead materials and concluded that they were all *C. herbarum*. The list of British Hyphomycetes[2] contains twenty-six names of species of this genus; but Bisby[3] considers the records of only four of these to be valid for Britain, namely, three parasites, *C. paeonia*, *C. fulvum* and *C. cucumerinum*; and one saprophyte, *C. herbarum*.

In investigations of airborne mould spores at this Unit, two distinct types of *Cladosporium* have appeared regularly on Petri dishes exposed to the outside air. Type *A* had branched chains of mainly small spores about 3–7 µ by 3–5 µ, oval or globose, with some larger but more elongate near the conidiophore. The small spores were mainly one-celled and the larger ones frequently two- or more celled. The spore walls were normally smooth. The macroscopic appearance of these colonies showed considerable variation in texture, colour and amount of sporing, etc., as described by Brooks and Hansford. These colonies were considered to be typical *C. herbarum*.

Type *B* produced large verrucose, oblong spores, mainly 13–19 μ by 7–8 μ, in short branched chains of usually three to five spores. The branches frequently consisted of one or two spores only. About 50 per cent or more of the spores were one-celled and the remainder two-celled, with a small proportion more than two-celled. The colonies were nearly always more woolly than the woolly variants of Type *A*, and the overgrowth of sterile hyphæ was white-grey rather than olive in colour. The features of this mould could not be reconciled with the description of any British species of *Cladosporium*.

The distinction between these two types had previously been noticed by Hyde and Williams (personal communication) in their studies on air-borne spores at Llandough Hospital[4]. Through the help of Dr. M. B. Ellis, a culture was examined by Dr. G. A. de Vries at the Centralbureau voor Schimmelcultures, Holland, and identified as *C. macrocarpum* Preuss. This species is recorded by Saccardo[5] from moribund plants in France, Germany and Italy.

On the Petri dishes of Sabouraud's agar exposed daily in this Hospital in a shelter of the Hyde and Williams pattern[6], *C. macrocarpum* is rarely observed during the months October to April, but considerable numbers are seen on the plates during June, July and August. During these months also, about 75 per cent of the whole year's catch of *C. herbarum* appears on our plates. During 1951 from a pair of plates exposed every week-day, 3,047 colonies of *Cladosporium* were counted. Of these, 364 (12 per cent) were *C. macrocarpum* and the remainder *C. herbarum*.

Hyde and Williams find that at Llandough in 1950 the large-spored *Cladosporium* formed about 12 per cent of their total catch of *Cladosporium* (to be published).

In a current investigation, collaborators are exposing Petri dishes of Sabouraud's agar daily at Cambridge, Edinburgh, Llandough, Southampton, London and Liverpool in parallel with our exposures at Cardiff, and returning them to Cardiff for examination. *C. macrocarpum* has appeared on plates from all these places. Dr. P. H. Gregory and Mr. Edward Yuill, carrying out a parallel series of exposures at Rothamsted (Harpenden) and Acomb (York), respectively, have both observed this species on their plates. In view of its widespread and abundant occurrence in Great Britain, it is surprising that there appears to be no previous record of *C. macrocarpum* in the British literature.

These investigations were pursued during my tenure of a full-time research grant from the Asthma Research Council.

MERVYN RICHARDS
Asthma and Allergy Research Unit,
St. David's Hospital,
Cardiff.
Sept. 8.

---

[1] Brooks, F. T., and Hansford, C. G., *Trans. Brit. Mycol. Soc.*, 8, 113 (1923).

[2] Wakefield, E. M., and Bisby, G. R., *Trans. Brit. Mycol. Soc.*, 25, 49 (1941).

[3] Bisby, G. R., *Trans. Brit. Mycol. Soc.*, 27, 101 (1944).

[4] Hyde, H. A., and Williams, D. A., *Nature*, 164, 668 (1949).

[5] Saccardo, P. A., "Sylloge Fungorum", 4 (1886).

[6] Hyde, H. A., *New Phytol.*, 49, 398 (1950).

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## Randomly Stacked Layers in Clay Minerals

CLAY minerals having a lamellar structure commonly show a particular type of random stacking, in which only a limited number of definite interlayer spacings exist, but these are distributed with various degrees of randomness. Examples are: mica of 10 A. spacing, with a certain proportion of 14 A. hydrated layers; glycerol-saturated montmorillonite (17·7 A.) in which a certain proportion of layers of lower glycerol content (14 A.) is present; partly dehydrated halloysite[1] (mixture of 10·0 A. and 7·2 A. layers).

It is desirable in such cases to have a means of determining which spacings are present in the mixture, and in what proportions. Formulæ have been derived, enabling the scattering given by random, and partly random, mixtures to be calculated[2]. It is possible, using these, to make a set of curves showing the type of scattering to be expected from various mixtures likely to be met with in practice[3], and these can be used for identifying such mixtures when they occur. However, with mixtures of more than two components, and those which are not completely random but show various degrees of segregation, this method requires the calculation of a very large number of curves. It is therefore very desirable to have a direct method of getting the required information from the measured data.

It has been pointed out by Méring[4] that in principle the Fourier transform of the diffraction diagram gives this information. The transform is difficult to calculate in practice because the totality of the diffraction diagram is not available for study. Generally, the low-intensity regions are masked by the background, and quite often the whole diagram is complicated by the presence of accessory lines, from the same or from different minerals (it is to be remembered that only the part of the diagram arising from the basal reflexions is of interest).

Examination of calculated diffraction curves for mixtures (and of actual diffraction diagrams) shows that the diffraction from such mixtures commonly consists of relatively sharp lines, which, however, do not form an integral series of orders. The information readily available consists of the effective spacings and intensities of these lines. It is possible to show that a Fourier transform may be calculated, using only these data, which will, in general, give the required information. The cosine transform

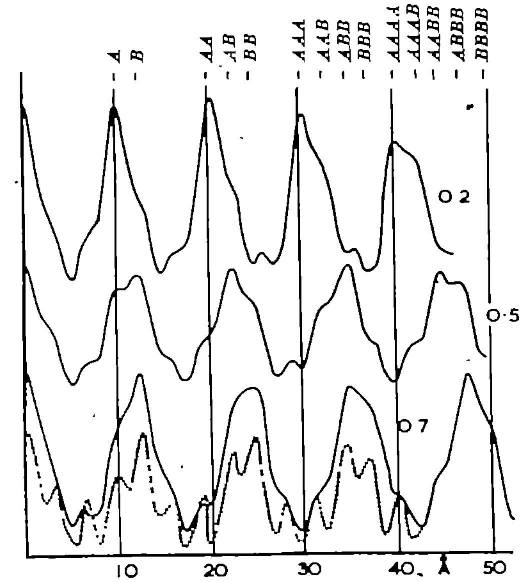
$$\int_0^\infty \frac{I(\mu)}{\Theta\,|F_l|^2} \cos 2\pi\mu R\,d\mu$$

is a function which is proportional to the mean number of layers at a distance $R$ from any arbitrary layer chosen as origin. Here $\mu$ is reciprocal spacing. $\Theta$ the Lorentz-polarization factor and $F_l$ the scattering factor of a single layer (all the layers are supposed to be the same, and the scattering by the interlamellar material is supposed to be small). This form of function, which gives a peak at the origin, is more convenient to use than the transform of $\frac{I(\mu)}{\Theta\,|F_l|^2} - 1$ (James[5], p. 478), which requires a knowledge of absolute intensities.

In the case of a diagram composed of isolated, fairly sharp peaks with reciprocal spacing $\mu_r$ and integrated intensity $I_r$, we may approximate to the above transform by the sum :

$$\Sigma_r \frac{I_r}{\theta\,|F_l|^2} \cos 2\pi\mu_r R.$$

This sum makes use only of the observable data ($I_r$ and $\mu_r$), and has a number of terms equal to the number of lines, and therefore not usually more than ten or so. It seems in general (even when some of the lines are rather broad) to give a very good idea of the composition of a mixture. A test of this is to use the peak positions and intensities calculated by G. Brown and myself[3] for a series of random structures and to calculate the above series for them. The accompanying diagram shows the result for three random mixtures of 10- and 12·4- A. spacings with mica-type layers. The actual value of the spacings and their proportions are well shown, and it is possible from the 'combination peaks' of spacing greater than 12·4 A. to obtain an idea of the degree of randomness of the mixture : the method, which is relatively straightforward, cannot be discussed in detail here.



Calculated series for mixtures of 10 A. and 12·4 A. spacings with mica-type layers. The number attached to each curve gives the proportion of the higher spacing The ordinates of these curves are proportional to the probability of finding a layer at a given distance from any layer chosen as origin : the (arbitrary) zero level is not shown. The letters indicate the significance of the peaks, *A* meaning a 10 A. spacing, and *B* a 12·4 A. spacing; thus *AAB* is a peak which arises from two spacings of the first type plus one of the second (in any order). The meaning of the dotted curve is explained in the text

The series shown were calculated using only three lines. For such a series diffraction effects may give rise to spurious peaks. These series were therefore calculated after artificially diminishing the high-order terms, and the resulting 'smoothed' series, although not showing spurious peaks to any considerable extent, tends to confuse neighbouring peaks so as to make it difficult to determine the actual spacings present. These can, however, be accurately determined by calculating an 'unsmoothed' series as well ; by comparison with the 'smoothed' series the spurious peaks can be readily detected, and the spacings of the genuine peaks measured accurately. The dotted curve in the diagram shows an 'unsmoothed' series corresponding to the lower 'smoothed' curve, and will serve to illustrate the afore-mentioned points.

DOUGLAS M. C. MACEWAN

Pedology Department,
Rothamsted Experimental Station,
Harpenden, Herts.
Oct. 16.

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[1] Brindley, G. W., and Goodyear, J., *Min. Mag.*, 28, 407 (1948).

[2] Hendricks, S. B., and Teller, E., *J. Chem. Phys.*, 10, 147 (1942)

[3] Brown, G., and MacEwan, D. M. C., *J. Soil Sci.*, 1, 230 (1949).

[4] Méring, J., *Acta Cryst.*, 2, 371 (1949).

[5] James, R. W., "The Optical Principles of the Diffraction of X-Rays" (G. Bell and Sons, London, 1948).

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## Multiple Bursts of Signal in Long-Distance Very-High-Frequency Propagation

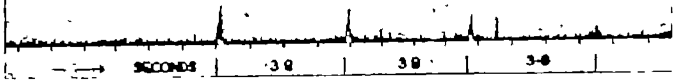
DURING the course of recent investigations into the behaviour of radio wave propagation within the 40–60 Mc./s. television band, new phenomena have been observed. For these investigations use has been made, during normal programme hours, of the continuous wave transmission from the B.B.C. television station at Kirk-o-Shotts operating on a frequency of 53·25 Mc./s. (sound), at a distance of 330 miles from the observing station at Great Baddow, Essex.

Normally, a continuous signal of slowly varying amplitude is observed having a mean value of 20 db. below 1 μV./m. but well above narrow-band receiver noise. Superimposed upon this signal is a succession of signal bursts of between 0·1 and 1·0 sec. duration with amplitudes up to 30 db. greater than the mean level of continuous signal ; the frequency of occurrence of these bursts varies from about 3 to 20 per min.

Many of these bursts exhibit characteristic Doppler frequency shifts and are identified with meteors and their trails ; but among the remaining bursts are many examples of a clearly related pair having a time separation varying from 0·7 to more than 6 sec., this time separation being constant for many pairs over periods of observation of about 15 min. Furthermore, trains of three and four bursts having a constant time separation have also been recorded ; the accompanying record shows one such quadruple train, having a time separation of approximately 3·8 sec., in which the bursts occur in descending order of magnitude.

The greatest frequency of occurrence of multiple trains was during the thunderstorm of October 24, 1952, when clear evidence was recorded that separate bursts and pairs of bursts frequently followed a lightning flash. At no time has there been any evidence that succeeding bursts in a train are in any way echoes of the first. Considering that the transmitted signal is an uninterrupted continuous wave, it is suggested, therefore, that the mechanism causing multiple bursts is a relatively local recurrent condition of the medium consequent upon a lightning flash.

It is interesting to recall that T. L. Eckersley has described[1] a peculiar class of atmospheric which he terms a 'whistler'. These whistlers, received by means of a long aerial and an audio-frequency amplifier, are preceded by a click which has since been identified



with a lightning flash. Eckersley furthermore describes trains of whistlers having a time separation of about 3·8 sec. between each succeeding whistler. It seems probable, therefore, that the phenomena of multiple signal bursts and whistlers are closely associated.

A more detailed account of these observations will be published later.

G. A. ISTED

Research Division,
Marconi's Wireless Telegraph Co., Ltd.
Jan. 21.

[1] *Nature*, 122, 708 (1928)

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## A Theoretical Model for Arches in the Solar Corona

IN recent years, the belief has grown among solar physicists that magnetic fields play an essential part in the phenomena of solar prominences. The study of the static equilibrium of an ionized atmosphere in a gravitational field with some magnetic field also present is expected to shed light on the more difficult dynamical problems, but may also provide models for quiescent prominences, which appear to be almost in static equilibrium. The condition for static equilibrium is that the resultant of the pressure gradient and the gravitational and electromagnetic force densities should vanish.

The simple model has been studied in which (i) the temperature and composition of the atmosphere are uniform; (ii) the gravitational field is uniform, the $z$-axis pointing upwards; and (iii) the magnetic field is two-dimensional, that is, $H_y = 0$; $\partial H_x/\partial y = \partial H_z/\partial y = 0$; the current density $\mathbf{j}$ then has only a $y$-component.

The condition for static equilibrium can only be satisfied by magnetic fields for which $\mathbf{j} \exp z/h$ is constant on a line of force, where $h$ is the scale height. Given such a field, the pressure is determined apart from an arbitrary constant. A particularly useful family of solutions is provided by a set of lines of force, such that any magnetic field having these lines of force satisfies the above condition.

These lines of force are the lines of constant $F$, where

$$F = \exp(-z/h) - 2\exp(-z/2h)\cos(x/2h) + 1 \qquad (1)$$

and are shown in the diagram. For $F < 1$, they are closed curves, and the advantage of this family of solutions is that the magnetic field can be taken to vanish outside one of these closed lines of force, so avoiding any difficulty with boundary conditions. The horizontal width of the closed curves does not exceed $2\pi h$.

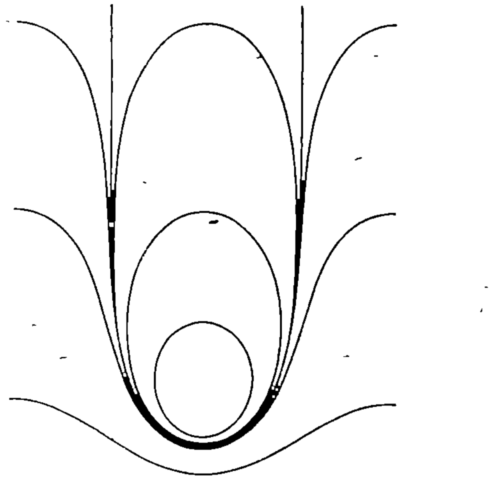
The effect of the magnetic field on the gas pressure $p$ can be expressed in terms of the magnetic pressure $p_H$ given by:

$$p_H = H^2/8\pi. \qquad (2)$$

Both $p \exp z/h$ and $p_H \exp z/h$ are constant on a line of force for this family of solutions, and the variation of pressure is given by:

$$\frac{d}{dF}[\{\exp(z/h)\}(p + p_H)] = (-\exp z/h)\, p_H/F, \qquad (3)$$

which shows that $(\exp z/h)(p + p_H)$ increases towards the inside of the closed curves.



The two-dimensional form of these solutions makes them appropriate for those prominences which appear as filaments on the disk of the sun, and the effect expressed by (3) may explain the high pressure of prominences relative to the surrounding gas; but, because prominences are much cooler than the corona, the isothermal model must be seriously wrong in some respects. There seems to be much better justification for applying this model to the arches seen in the corona above prominences, as these may well be nearly isothermal. They are seen in white light at eclipses and are difficult to photograph; but a drawing reproduced in the "Handbuch der Astrophysik", 4, 200 (1929), shows arches which resemble the theoretical curves. The outer arches appear to be near the limiting width, $2\pi h$; the width of the outer arch is about a quarter of the solar radius, and the temperature required to make these fit is about $10^6$ K., which is the accepted value for the temperature in the corona.

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Oct. 2.

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## The Lorentz Transformation

ON the basis of rather less restrictive postulates concerning the behaviour of light than are customary in special relativity theory, Capildeo has recently[1] given the transformation equations

$$\alpha x' = x - Vt, \quad y' = y, \quad z' = z, \quad \alpha t' = t - Vx/c^2, \qquad (1)$$

connecting two frames of reference $S$ and $S'$ (with suitably oriented axes) in uniform relative motion, where, it is suggested, the value of $\alpha$ cannot be uniquely determined without additional evidence. If, however, we consider three frames of reference $S$, $S_1$, $S_2$, where the velocities of $S_1$, $S_2$ relative to $S$ are $V_1$, $V_2$ along $Ox$, $Oy$, respectively, then, with the obvious notation,

$$\alpha_1 x_1 = x - V_1 t, \quad y_1 = y, \quad z_1 = z, \quad \alpha_1 t_1 = t - V_1 x/c^2,$$

and

$$x_2 = x, \quad \alpha_2 y_2 = y - V_2 t, \quad z_2 = z, \quad \alpha_2 t_2 = t - V_2 y/c^2,$$

and it will be found after rotating the $x$-axes of $S_1$ and $S_2$ into the direction of their mutual relative velocity that the new co-ordinates in $S_1$ and $S_2$ are connected by equations of the form (1) for all $V_1$ and $V_2$ if, and only if,

$$\alpha_t = \sqrt{1 - V_t^2/c^2}.$$

It thus appears that the Lorentz transformation is the only one consistent with Capildeo's assumptions.

In fact, it is possible, using similar reasoning, to derive the Lorentz transformation on very much weaker assumptions which do not involve any assertions about the behaviour of light. Suppose we assume merely that any two frames of reference $S$ and $S'$ in uniform relative motion are connected (with the usual choice of axes) by a transformation of the form

$$\alpha x' = x - Vt, \quad y' = y, \quad z' = z, \quad \gamma t' = t - \mu x, \quad (2)$$

where $V$ is the velocity of $S'$ relative to $S$ according to an observer fixed in $S$. It then follows, by considering frames of reference moving relative to $S$ in two perpendicular directions as before, that:

$$\text{(i)} \quad \alpha = \sqrt{1 - V^2/c^2}, \qquad \mu = V/c^2,$$

where $c$ is an absolute velocity for an observer fixed in $S$, independent of the magnitude and direction of the relative velocity of $S'$;

$$\text{(ii)} \quad \alpha/\gamma = c/c' = V/V',$$

where $c'$ is the absolute velocity in $S'$ and $V'$ is the magnitude of the relative velocity according to an observer fixed in $S'$; and

(iii) a velocity $c$ in any direction relative to $S$ is transformed into a velocity $c'$ relative to $S'$.

Thus (2) represents a Lorentz transformation combined with the introduction of an arbitrary factor in the scale of time in $S'$; and, in order to obtain the Lorentz transformation exactly, it is necessary to postulate further only that the time-scales in $S$ and $S'$ are such that both assign the same magnitude either to the absolute velocity or to their mutual relative velocity.

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Dec. 29.

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[1] Capildeo, R., *Nature*, 170, 936 (1952).

## Exchange of Carbon-13 Dioxide between Calcite Crystals and Gaseous Carbon Dioxide

FROM previous results[1], it is apparent that considerable exchange occurred between gaseous carbon dioxide and calcite crystals at high temperatures. This effect has been studied further.

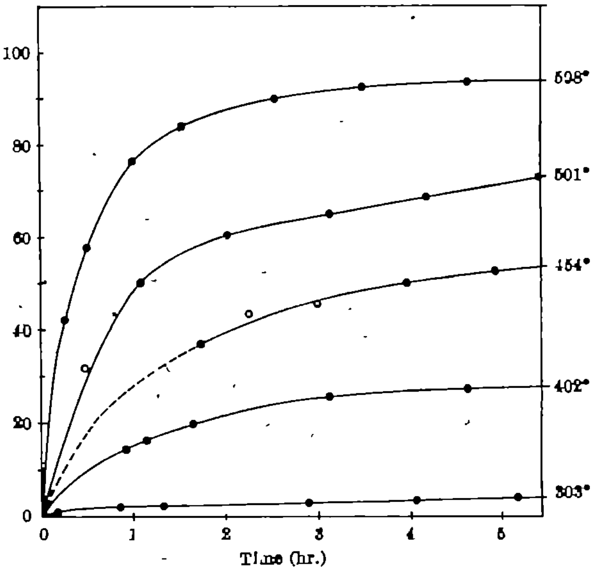
Calcite samples (100 mgm.) of known area were heated in a silica vessel containing enriched carbon dioxide (about 15 per cent $^{13}CO_2$) in the temperature range 300–800° C. The carbon dioxide pressure was at all times maintained well above the corresponding dissociation pressure. The reaction vessel was directly attached to a Consolidated–Nier type mass-spectrometer and the degree of exchange in the crystal was followed by measuring the decrease of carbon-13 in the gas. By a special mixing technique, small representative samples were drawn off and recycled after analysis. Constant temperatures were maintained with an electronic relay and the temperatures were automatically recorded.

It has been reported that, in the presence of water vapour, carbon dioxide exchanges with solid barium carbonate[2]. In the present investigation, with calcite, it was also found that water vapour enhanced the exchange appreciably. Even at room temperature, 3 per cent exchange occurred with the sample of largest surface area. Rigidly dry conditions were therefore maintained in all the experiments reported.

Results indicated that an initial rapid exchange, obviously due to surface and boundary effects, was followed by a slower process. This surface effect was confirmed by measuring exchange at 600° C. on samples prepared by sedimentation of finely ground Iceland spar and on a sample of precipitated calcite ('Witcarb *R*'). The specific surface areas (permeability method) were $5 \cdot 4 \times 10^3$, $3 \cdot 9 \times 10^4$, $10 \cdot 1 \times 10^4$ and $6 \cdot 9 \times 10^5$ cm.$^{-1}$, with a corresponding exchange after five hours of 3, 6, 8·5 and 93 per cent, respectively. Although these results are not quantitatively related, the trend of greater exchange with increasing area is definite. It is known that for larger particles permeability areas may be considerably lower than the reactive surface and, since isotopic exchange between gases and solids is a structure-sensitive phenomenon, discrepancies are to be expected.

Results obtained with 'Witcarb *R*' at temperatures from 300° to 600° C. are presented graphically. The degree of initial exchange increases considerably with temperature, indicating a greater penetration of the crystals. Exchange at 700° and 800° C. was, surprisingly, somewhat lower than at 600° C. (90 instead of 93 per cent). This may, however, be explained by assuming that annealing of the crystals occurs at these temperatures, with a consequent decrease in reactive surface.

For the 303° C. experiment, assuming complete exchange in the surface region and using the surface area determined by Brunauer, Emmett and Teller, it was calculated that a thickness of 2·7 A. was affected. This corresponds to a monolayer and is in agreement with Winter's findings[3] on the exchange between oxygen-18 and aluminium oxide. At higher temperatures, however, the affected thickness is



much larger and the calculation fails, since there is no distinction between an initial surface exchange and exchange within the crystal.

For the investigation of the slower process which succeeded the surface exchange, the sample of specific surface area $5 \cdot 4 \times 10^3$ cm.$^{-1}$ was chosen. This sample gave a readily measurable degree of exchange without being too deeply penetrated, even at high temperatures. The diffusion process could thus be treated as a one-dimensional problem, and a straight line should result when the decrease in carbon-13 dioxide concentration is plotted against the square root of time. Two distinct straight lines were, in fact, obtained, corresponding to the initial surface exchange and to the slower diffusion within the lattice. Diffusion coefficients were calculated from the related curves for 600°, 700° and 800° C. and resulted in values of 2·37, 10·8 and $41 \cdot 7 \times 10^{-17}$ cm.$^2$/sec. This corresponds to a value of $D_0$ of $1 \cdot 81 \times 10^{-10}$ cm.$^2$/sec. and an activation energy of 27,700 cal./mole, which is 0·67 of the heat of decomposition of calcite.

It appears that exchange may occur by a mechanism in which a carbonate ion momentarily breaks up into a carbon dioxide molecule, leaving an oxygen ion in the site. This carbon dioxide molecule then passes to a neighbouring site similarly vacated and combines with the oxygen ion to reform a carbonate ion. This mechanism is more likely than a process involving the movement of the larger carbonate ions as a whole, since the charge distribution in the lattice remains undisturbed.

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R. A. W. Haul
L. H. Stein
National Chemical Research Laboratory,
J. W. L. de Villiers
National Physical Laboratory,
South African Council for
Scientific and Industrial Research,
Pretoria.
Oct. 8.

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[1] Haul, R. A. W., Stein, L. H., and Louw, J. D., *Nature*, 167, 241 and 727 (1951).

[2] Armstrong, W. D., and Schubert, J., *Science*, 106, 403 (1947). Yankwich, P. E., *Science*, 107, 681 (1948).

[3] Winter, E. R. S., *J. Chem. Soc.*, 1170 (1950).

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## Graphitic Acid from Aromatic Compounds by Peroxide Treatment

Hydrogen peroxide in hot dilute aqueous solution, buffered by dilute acid such as sulphuric or boric acid, in the presence of either cupric or ferric ions, is capable of oxidizing a wide variety of aromatic (and aliphatic) compounds to carbon dioxide and water. Benzene, diphenyl, naphthalene, benzoic acid, toluic acids, phthalic acids, phenols, as well as a considerable number of amino-, nitro-, chloro- and bromo-derivatives of benzene and naphthalene, are all converted to carbon dioxide, water, ammonium salts, nitrate and halide ion in yields approaching 100 per cent under optimum conditions.

During an investigation of the kinetics and stoichiometry of these reactions, it has been observed repeatedly that as the original mixture disappears a transient brown coloration develops in the solution. The typical behaviour is shown when 0·1 gm. of phenol in 20 c.c. of strong solution of boric acid is treated with 5 c.c. of 100-vol. peroxide and 0·1 c.c. of 0·1 *M* copper sulphate solution. When this solution is heated to about 90° C., it rapidly darkens to a dense brown colour, oxygen and carbon dioxide being evolved vigorously. On continued heating, with the addition of further peroxide if necessary, the brown colour fades completely. Considerable variations in the concentrations have little effect on the general changes, although the presence of the trace metal is essential[1].

The brown material is colloidal in nature as indicated by the ultra-microscope and the Tyndall cone; but its coagulation is very difficult indeed. Larger quantities of the material have been prepared by allowing hydrogen peroxide to react with benzene refluxing in a Soxhlet extraction apparatus. In this way the brown material can be prepared dispersed in an organic phase with little inorganic contamination.

Solid samples prepared by evaporation of the benzene had the following analysis: C, 55·91; H, 4·0; O, 40·1 per cent; but no melting point observable. The chemical and physical properties of the material indicate that it is of the same general type as 'graphitic acid'. It is insoluble in inorganic acids and reagents, but is peptized in very dilute ammonium or alkali hydroxide. It is insoluble in the majority of organic solvents, but from either glacial acetic acid or concentrated sulphuric acid (in both of which it appears to disperse) it may be recovered unchanged by evaporation of the acid from a hot slide. There are no detectable functional groups, the only reagents which show the slightest action being powerful oxidizing agents such as acid-permanganate or hydrogen peroxide (130-vol.), in which it dissolves with evolution of carbon dioxide.

Specimens of 'graphitic acid' have been prepared from various specimens of graphite with nitric–sulphuric acid mixtures to which potassium chlorate is added in small quantities over a period of time. The samples are purified by centrifugation and dialysis. The physical and chemical properties of the materials from peroxide appear identical with the standard specimens. Ultra-violet spectroscopy fails to discriminate between the two series. It is hoped to carry out X-ray and thermal analysis shortly.

It is rather difficult to visualize the transformation of benzene into a graphitic acid; but it is presumably via the addition or polymerization of aromatic radicals into the necessary two-dimensional structure between which oxygen atoms are trapped.

The formation of 'graphitic acid' analogues by the peroxide oxidation of aromatic compounds may have connexions with the synthesis of humic acid, peat and coal under natural conditions.

The formation of the brown material from aromatic compounds is not limited to peroxide oxidations. Analogous reactions can be brought about by prolonged anodic oxidation, electrodeless discharge, X-rays or photo-radiation and by various chemical reagents such as persulphate[1]. The parallelism with the hydrogen peroxide process is remarkable, suggesting that the same active entity, OH or $HO_2$, might be operative in all such cases.

G. A. Bottomley
J. G. Blackman
University of Otago,
Dunedin,
New Zealand.
Oct. 14.

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[1] Bottomley, G. A., *Anal. Chim. Acta*, 4, 566 (1950).

# FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

### Tuesday, April 7

Society of Chemical Industry, Plastics and Polymer Group (at the Royal Society of Tropical Medicine and Hygiene, Manson House, 26 Portland Place, London, W.1), at 6.30 p.m.—Dr. M. Gordon and Mr. J. S Taylor: "Recent Advances in the Ionic Reactions of Rubber". (Members of the Institution of the Rubber Industry are invited.)

### Wednesday, April 8

Institute of Petroleum (at Manson House, 26 Portland Place, London, W.1), at 5 30 p.m.—Dr. W. C. Dickerman, jun.: "The Present Status of the Art of Cracking".*

Royal Statistical Society, Study Section (at the E.L.M.A. Lighting Service Bureau, 2 Savoy Hill, London W.C.2), at 6 p.m.—Mr. E. Shankleman Summary of the results of a Survey on the Forecasting of Economic Indices by Economists.

British Institution of Radio Engineers (at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 6.30 p.m.—Lieut.-Colonel J. P. A. Martindale: "Lens Aerials for Centimetric Wave-lengths".

### Wednesday, April 8—Saturday, April 11

Mathematical Association (at the University, Sheffield).—Annual General Meeting.

### Thursday, April 9

Bone and Tooth Society (at the Institute of Orthopaedics, 234 Great Portland Street, London, W.1), at 5 p.m.—Symposium on "Vitamin C and Bone".

Society of Dyers and Colourists (at the Royal Institution, 21 Albemarle Street, London, W 1), at 7.30 p.m.—Mr. J. R. Blockey and Mr. D. H. Tuck: "The Coloration of Leather" (Tenth Mercer Lecture).*

### Thursday, April 9—Monday, April 13

British Psychological Society (at Nottingham).—Annual General Meeting.

### Friday, April 10

Royal Astronomical Society (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m—Scientific Papers.

Institution of Mechanical Engineers (joint meeting with the Education Group, at Storey's Gate, St. James's Park, London, S.W.1), at 5.30 p.m.—Dr. W. Abbott: "The Athlone Fellowship Scheme for the Practical Training in Industry of Canadian Engineering Graduates in Great Britain".

### Saturday, April 11

Biochemical Society (joint meeting with the Société Belge de Biochimie, in the Faculty of Medicine, The University, 115 Boulevard de Waterloo, Brussels), at 9 a.m.—Scientific Papers.

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# APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Assistant Advisory Officer in Grassland Husbandry, and an Assistant Lecturer in Agricultural Engineering—The Secretary, North of Scotland College of Agriculture, 41½ Union Street, Aberdeen (April 11).

Biochemist (honours science graduate) primarily for research duties in the Geriatric Department of the Sunderland Hospital group—The Senior Administrative Officer, Newcastle Regional Hospital Board, Blythswood South, Osborne Road, Newcastle-upon-Tyne 8 (April 11).

Senior Lecturer or Lecturer to teach Electrical Engineering to ordinary national certificate and higher national certificate standards—The Principal, School of Electronics, Malvern, Worcs (April 11).

Physicist (Senior Experimental Officer grade) to organize and supervise operations involving processing of radioactive materials, and responsible for accounting and movement control of active materials used by research and development group (Ref. A.68/53A), and Physicists (Assistant Experimental Officer grade) for radiological work, and for work involving various types of radiation measurement (Ref. A.69/53A), at the Ministry of Supply Establishment, Aldermaston—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting the appropriate Ref No. (April 18).

Chair of Geography in the University College of Khartoum, Sudan—The Secretary, Inter-University Council for Higher Education in the Colonies, 1 Gordon Square, London, W.C.1 (April 25).

Lecturer in Engineering (with qualifications in civil engineering, and special interests in structures or hydraulics)—The Registrar, The University, Manchester 13 (April 25).

Principal Research Officer or Senior Research Officer (with university honours degree in science or agriculture or equivalent qualification, proved ability in leadership, and considerable experience in tropical agriculture or field experience in geology, pedology or ecology) to lead a scientific unit that will include a geologist, geomorphologist, pedologist, ecologist, and systematic botanist, to carry out surveys in Papua and New Guinea (headquarters at Canberra)—The Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting No. 570/23 (April 25).

Scientific Technical Officer, Grade II (with a good general training in chemistry, preferably up to degree standard, experience in fuel technology and fuel analysis an advantage), at the Coal Survey Laboratory at Nottingham—The National Coal Board, Establishments (Personnel), Hobart House, Grosvenor Place, London. S.W.1, quoting TT/612 (April 25)

Assistant Lecturer or Lecturer in Mechanical Engineering—The Registrar, The University, Leeds 2 (April 27).

Lecturer in Zoology—The Registrar, Queen Mary College, Mile End Road, London, E.1 (April 27).

Assistant Lecturer in Chemistry (with a special interest in physical or inorganic chemistry), an Assistant Lecturer in Geology, Assistant Lecturers in Mathematics (one with special qualifications in applied mathematics), an Assistant Lecturer in Physics, and an Assistant Lecturer in Psychology—The Secretary, Birkbeck College, Malet Street, London, W.C.1 (April 30).

Assistant Lecturer or Lecturer in Pure Mathematics—The Registrar, University College of North Staffordshire, Keele, Staffs (April 30).

Lecturer or Assistant Lecturer in Anatomy—The Secretary of the Medical School, St. Thomas's Hospital, London, S.E.1 (May 1).

Director of the National Botanic Gardens of South Africa, Newlands, Cape Province—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (Newlands, May 15).

Royal Dutch Shell Studentship in Geophysics—The Registrar, Imperial College of Science and Technology, South Kensington, London, S.W.7 (May 30).

Melville Trust Fellowships in Cancer Research, tenable in Edinburgh—Messrs. Tods, Murray and Jamieson, W.S., 66 Queen Street, Edinburgh 2 (May 31).

Assistant in the Department of Engineering—The Secretary, The University, Edinburgh (June 1).

Assistant (with degree or equivalent in metallurgy, chemistry, physics or engineering) in the Information Department—The Secretary, British Non-Ferrous Metals Research Association, 81–91 Euston Street, London, N.W.1.

Assistant Chief Engineer (Design) to take charge of teams of engineers and draughtsmen engaged on design and detailing of special mechanical and chemical plant—The Ministry of Supply, Division of Atomic Energy (Production), Risley, Warrington, Lancs, quoting 442.

Graduates in Medicine or Veterinary Medicine for post-graduate training in bacteriology and immunology—The Defence Research Member, Canadian Joint Staff London, Moncorvo House, 66 Ennismore Gardens, London, S.W.7, or The Director of Research Personnel, Defence Research Board, Department of National Defence, 'A' Building, Ottawa, Ontario, Canada.

Livestock Officer (with degree in agriculture or related subject with experience of animal husbandry) in the Veterinary Department, Nyasaland—The Director of Recruitment, Colonial Office, Great Smith Street, London, S.W.1, quoting CDE.67/4/03.

Metallurgist at the Royal Aircraft Establishment, Farnborough, to work in team engaged on titanium alloy development—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S W.1, quoting F.108/53A.

Microwave and Electronics Engineer or Physicist (with six to ten years experience) to carry out research and development on guided missiles, a Servo-Mechanisms Engineer to carry out research and development on guided missiles, an Electrical Engineer or Engineering Physicist (with experience in electronic computation) to carry out development work on aircraft fire control computers, an Electrical Engineer or Engineering Physicist to direct electronic designs and electronic systems production engineering for guided missile development, an Electronic Instrumentation Engineer to carry out instrumentation work on guided missiles, and Mechanical Engineers (with six to ten years experience) to carry out design and development on armament systems—The Defence Research Member, Canadian Joint Staff London, Moncorvo House, 66 Ennismore Gardens, London, S.W.7, or P.O. Box 1427, Quebec City, Quebec, Canada.

Physical Chemist for work on the oxidation of cellulosic materials—The Secretary, British Rayon Research Association, Barton Dock Road, Urmston, Manchester.

Physical Metallurgist (at Sheffield) to carry out research on the ageing of mild steel—The Personnel Officer British Iron and Steel Research Association, 11 Park Lane, London, W.1, quoting 'Ageing of Steel'.

Research Officer (chemist or chemical engineer, with a first- or second-class honours degree or an associateship of the R I C.)—The Director, British Paper and Board Industry Research Association, Welcomes Road, Kenley, Surrey.

Soil Physicist (with good honours degree in physics or chemistry, including physical chemistry, with at least two years postgraduate experience or training in soils physics)—The Director of Recruitment, Colonial Office, Great Smith Street, London, S.W.1, quoting 27106/52.

Specialist Technical Editor (with honours degree in mathematics, physics or engineering and ability to deal with mathematics up to at least degree standard) in the Ministry of Supply, Chessington, to prepare instructional text-books on guided weapons, involving collation of information and editing contributions—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S W.1, quoting A.70/53A.

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*(not included in the monthly Books Supplement*

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# PROBLEMS OF EMPLOYMENT IN AN AGEING POPULATION

THE thoughtful address on the employment of the older worker which Sir Frederic Bartlett delivered in October 1951 in the Centenary Lectures given under the auspices of the Ministry of Labour attracted comparatively little attention at the time. Its significance is emphasized by the report of the Royal Commission on Population, and is apparent from current discussions of the trend of population in Britain in the next few decades provoked by that report. It is now widely recognized that, in a society with an ageing population, it is desirable and even essential that the elderly should remain longer at work. As Sir Frederic Bartlett suggested, the increasing needs of humanity can only be met if all fit people, from youth to age, play their parts; and only if those parts, moreover, are planned in accordance with the natural flowering and growth throughout life of human abilities.

It is against this background that the importance and value of the work of the Nuffield Research Unit on the Problems of Ageing, established by the Foundation in the Psychological Laboratory of the University of Cambridge under Sir Frederic Bartlett, and Mr. F. Le Gros Clark's research on the continued employment of the elderly, are best appreciated. Some attention, it is true, was given to it at the Conference on Human Relations in Industry arranged by the Ministry of Labour and National Service in March 1952*, and the Labour Party's pamphlet "The Welfare State" recognizes that it is becoming imperative for old people to stay in employment, even if not in their recognized jobs or in a full-time capacity. The question of a later retiring age is frankly faced in this pamphlet, and, whereas it has generally become difficult even for those past forty to obtain fresh posts, the Post Office has become the first government department to practise the policy—which successive Governments have advocated since the War—of deliberately encouraging the elderly to apply for work. The maximum age of recruitment for postmen, van-drivers and telephonists has been raised from forty-five to sixty, and the Union of Post Office Workers has shown humanity and a proper understanding of national needs in agreeing to co-operate in working the new scheme.

While this scheme sets an example for industry generally to follow, the Chancellor of the Exchequer has tackled boldly the problem of retirement in the Civil Service, and ruled that Civil servants who are still capable of doing their job, and who wish to continue, need not retire at sixty. This, of course, means deferred promotion, and probably deferred increases in pay for others; but it is understandable that Mr. Butler has rejected a request from the Civil Service unions that those older than sixty who remain at work should be transferred to grades that do not block promotion. The Treasury will not wish to be forced to transfer a man from some post where he is particularly useful, and it should be recognized, as the Minister of Labour points out in a pamphlet entitled "Employment of Older Men and Women", that while blocked retirement presents real difficulties for younger people, the increased expectation of life, as well as the raising of the retirement age, both tend to ensure that the ultimate tenure of senior posts by those whose path is temporarily blocked will not be shorter than under schemes of compulsory retirement.

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* Ministry of Labour and National Service. Report of the Human Relations in Industry Conference, held at the Institution of Civil Engineers, London, March 18–20, 1952. Pp. vi+128. (London: H.M.S.O., 1952.) 3s. 6d. net.

That does not, of course, entirely dispose of the difficulty; but it could also be mitigated by measures for increasing salaries on merit, without necessarily waiting for promotion. Furthermore, there are men who would be happy enough to stay at work in a position of less responsibility, and, even in the Civil Service, it should not be impossible to deal with such cases without making hard-and-fast rules. Particularly where the most senior positions are concerned, this might indeed come to be the most usual situation for, as has been pointed out by H. R. Hill in a recent American book, "Some Observations on Executive Retirement", in a society where not only the population is ageing but also business and administration are becoming more complex, the strain of executive responsibility more onerous, and adaptability more important, age is a growing handicap less and less compensated by length of experience.

In such circumstances, it should be the normal rather than the exceptional practice for those who remain at work on passing what is at present regarded as the customary age of retirement, to step down or aside into other positions rather than continue in their existing posts. Such a practice very clearly involves considerable administrative problems, but it is manifestly one in the national interest and is fully supported by the trend of the research work to which Sir Frederic Bartlett referred. Opposition to the raising of the retirement age, such as that voiced by Mr. J. Haworth, treasurer of the National Federation of Professional Workers, appears to be out of keeping with both the trend of the change in age-structure of the population and the changes in national and social interests which must result.

Sir Frederic Bartlett's observations in the address noted were based upon the general results of the work of the Unit for Research into Problems of Ageing. Available evidence, he pointed out, implies that the great majority of a contemporary healthy population could continue efficiently and economically to meet the main demands of industry, at least up to what is still taken to be the normal span of life. There is no doubt, however, that for all manner of skills, from simple combined bodily movements to complex high-level mental skills requiring executive and administrative decisions based upon evidence collected from many sources, the overall preferred speed of work diminishes as age increases. If the speed of work is set by the conditions of work themselves, the cost of maintaining this speed, unless the methods of work are changed, may become much more punishing, especially over fifty.

This difficulty of speed, and especially impos speed, cannot, Sir Frederic pointed out, be remov entirely by regard for what are called 'hum relations', or by systems of management alone. Bo can help, but the basic requirement is to pl operations, and especially the design of display ar control, with the view of the most widely distribut natural range of abilities in whatever workin populations are concerned, and in doing this to ma age-group an important consideration. To do this and Sir Frederic is certain it will have to be done would make the problems of re-orientation, re-learnin and perhaps switch of occupation in the mo advanced age-groups, acute and critical; but he se no insuperable obstacles to such an extension planned occupational design.

The Nuffield Unit is already providing a fir factual basis for policy, given the goodwill and t co-operation required to make any such poli effective. Moreover, as Mr. J. Marsh, director of t Industrial Welfare Society, noted, in dealing wi the subject at the Human Relations Conference March last year, industry needs to remember co stantly the great help which the medical professio could give. It is already clear that men can car on with manual skills for many years, though it less certain that they can carry on with mental ski for so long. The main thing is to alter our attitu towards occupation and old age. Mr. Marsh su gested that, particularly in the administrative a clerical grades, we might need to explore the po sibilities of interchangeable pension schemes so as facilitate the movement of men between forty a fifty-five to jobs which gave them fuller scope, a that we also need to explore more fully the po sibilities of what might be called 'demotion witho disgrace'.

Discussions on the subject at this Conferen pointed to the desirability of terminating ol fashioned artificial age-restrictions for certain emplo ments, many of which are out of date to-day a only create ill-feeling and frustration. Neverthele the undesirability of persons remaining in positio of responsibility after they have passed the sta when they are fully effective was recognized; thou to implement a policy of 'demotion without disgra a change of attitude is required, not only on the pa of management but also of workers, if they are accept that it may be necessary in old age to tak job of lower status and salary. So far as man workers are concerned, there was agreement that t aim must be to secure that older persons willing a able to work should not be denied this opportuni on grounds of age alone. The test should be abili to do the job and not date of birth; but no co pulsion to go on working should be applied to work if they wish to retire.

It was agreed at this Conference that there is widespread desire on the part of many workers continue work past their present retiring age, a that employers should aim at transferring workers more suitable work at any time when their a becomes a handicap. Skilled workers can genera be expected to carry on into old age in their norm work, and the transfer process would affect only a mall proportion of all manual workers. The posibility of making the change in middle life to jobs which could be carried on in old age merits consideration, and wherever possible the change should be made within the organization.

It is thus high time that more attention was given to the whole question of retirement and its implications in our changing population structure. It is not sufficient for industry generally to follow the example which has already been set by the Post Office and by Mr. Butler in the Civil Service; nor can we be content to continue or to extend the work already being carried out by the Nuffield Research Unit. What is wrong with our present arrangements is, as Mr. W. A. B. Hopkins, of the National Institute of Economic and Social Research, pointed out in a recent article on "The Economics of an Ageing Population" (*Lloyds Bank Review*, January 1953), not that the pension is conditional on retirement, but that retirement with a pension is available, and often compulsory, to people very many of whom would be quite capable of staying at work for some time longer. As already seen, in recent years a good deal of evidence has accumulated to show that it is rather the exception than the rule for a man to be genuinely past work at sixty-five.

Even if there were no adverse demographic tendency to combat, it would be sensible to try to alter the arrangements which cause waste of productive economic resources; but the first and most essential step, Mr. Hopkins argues, is to eliminate from the national insurance system the commitment to provide a retirement pension at a definite age laid down years, or even decades, in advance. Mr. Hopkins recognizes that the presentation of the scheme to the public in the past has been such as to cause false impressions and to create expectations which may well lead to resentment when a government is compelled, as he believes is inevitable, to raise the pension age. Nevertheless, he believes it is necessary that the principle should be publicly established that the age at which retirement pension may be claimed is variable, and will probably be raised as time goes on. As he admits, a government which made such an announcement would obtain no immediate credit, and would probably incur some immediate odium. It would, however, earn the gratitude of its successors by establishing the conditions in which pension arrangements could eventually be adjusted to changes in the demographic and economic circumstances of the country. No political party has, however, yet given any signs of the courage demanded in taking such a step; and it is therefore the more important that private as well as public industry should follow the example already set by government departments and at least experiment in this direction.

Such experiments in themselves encourage the development of a climate of opinion favourable to the pronouncement for which Mr. Hopkins calls. It should be recognized, however, that for a policy of later retirement to act fairly and effectively, uncertainty must be removed so far as possible. Save where it depends on experimental work such as the Nuffield Research Unit is conducting, the experimental period should be short. This point was well put by the Master of Sydney Sussex College, Cambridge, Mr. Thomas Knox-Shaw, in discussing the question of university retirement in the *Universities Quarterly* of August 1952. Compulsory retirement in a university at sixty-five, he thought, is often wasteful as well as painful; but while clearly time is required to explore the different possibilities and alternatives to which he points, it is essential to terminate as early as possible the uncertainties which such discussions are bound to raise in the minds of those immediately affected. The question of retiring age is undoubtedly one which requires urgent and full discussion, not only by the universities but also by professional bodies generally as well as by industry. Such discussion, even more than unilateral action, can promote the formation of the public understanding which is so essential. That it should be regarded as a matter of urgency is dictated both by individual and the national interest.

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# CHEMISTRY'S DEBT TO RADIOACTIVITY

## Radioactivity applied to Chemistry

Arthur C. Wahl (editor), Norman A. Bonner (associate editor). Pp. xv+604. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1951.) 60*s*. net.

Although it is not yet sixty years since Henri Becquerel discovered the uranium rays, the rapid growth of the science of radioactivity has completely changed physics, profoundly influenced chemistry, and provided biology and medicine with new methods. It has become more and more difficult to keep pace with the radioactive studies even in one of these fields, and many chemists will be very glad that, so far as their science is concerned, an extremely useful survey of the literature up to 1950 is now available.

Twelve men of science have collaborated in producing a stately volume of six hundred pages, but the presentation of the subject could not be more consistent if it had been the work of a single author —a sign of the great care exercised by the editors in co-ordinating the work of the contributors. As the title of the book indicates, it was not their aim to deal with all aspects of radioactivity which might well be of interest to the chemists, but only with its application to the solution of chemical problems. 'Radiation chemistry' is only very briefly dealt with, and some branches of 'radiochemistry' are not mentioned. No reference is made to radiochemical techniques, or to the preparation of tagged compounds; but within the self-imposed limits the editors have aimed at completeness, and it seems that they have very well achieved their goal. Even recondite references of small importance have been found to be included. In Part 1 of the book—some three hundred pages—the usefulness of radioactive indicators is shown by a description of their application to a great variety of chemical problems; it will be found very useful by all interested in the subjects mentioned but not acquainted with the radioactive method of their investigation. About two hundred pages of Part 2 give a summary of the relevant literature, and the rest contains the bibliography and the index.

In the preface the principal editor states that the contributors to this book became interested in the application of radioactivity to chemistry only during the Second World War, that they were then unfamiliar with most of the earlier work, and that the book is the outcome of their effort to correct this situation. It is therefore not astonishing that, in spite of the thoroughness of their search through the literature, they did not always gain the historical perspective which would come naturally to authors who were contemporaries of the earlier radiochemical investigations. Sometimes one would have preferred a different grouping. For example, in the days when no bismuth hydride was known, its discovery by the use of a radioactive isotope was interesting as a contribution by a new method to preparative inorganic chemistry, but scarcely as an example of "evaporation from solution", the heading under which it is here classified. A strange historical slip could not have happened to a veteran in the field; it is stated that neon, krypton, xenon, europium, lutetium, hafnium and rhenium were found in the period 1898–1925 by the method of X-ray spectroscopy; but Moseley's fundamental work on which X-ray spectroscopy is based was done only in 1913, and even after that date its application to the discovery of inert gases can scarcely be imagined. Hafnium and rhenium are the only examples where X-ray spectroscopy was used; for the discovery of the other five elements, the old-fashioned optical spectroscopy was decisive.

This point, however, concerns only the history of chemistry and is entirely unconnected with the main contents of the book, which is outstanding in its reliability. It is easy to predict that the book will become an indispensable standard work in all laboratories interested in radiochemical work.

F. A. PANETH

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# ORTHOPTEROID INSECTS OF FRANCE

Faune de France

56: Orthoptéroïdes. Par Prof. Lucien Chopard. (Fédération Française des Sociétés de Sciences naturelles: Office central de Faunistique.) Pp. 359. (Paris: Paul Lechevalier, 1951.) n.p.

THIS work by Prof. L. Chopard is more than a mere revision of the third volume ("Orthoptères et Dermaptères" by the same author, published 1922) of this well-known series: it has been expanded to include more detailed information and covers a wider field. Under the heading "Orthoptéroïdes", Prof. Chopard includes Orthoptera (s. str.), Dictyoptera, Isoptera, Cheleutoptera, Dermaptera, Embioptera and Plecoptera. The last of these groups (all of which the author, in accordance with modern views, regards as orders) has been treated separately by R. Despax in Vol. 55 of the series. The present volume is a guide to the identification of the French representatives of the remaining orders, and includes all information, both systematic and biological, which is likely to be useful for this purpose.

The work is arranged on the same plan as the other "Faune de France" volumes, with concise determination keys leading to brief descriptions. An importan improvement on the earlier edition is the inclusion o numerous drawings of whole insects (about one pe genus); among these are a number of figures o immature stages. Most of the remaining drawings serve to illustrate many of the finer distinctions used in the determination keys. They are reproduced from Vol. 8 of the series and are rather less accurate than those drawn specially for the present volume Altogether there are more than five hundred figures

The text is on the whole up to the usual high standard of this well-known authority; but it i difficult to accept some of the extreme measures taken in the classification of some of the groups For example, no fewer than sixteen Saltatorian groups generally regarded as subfamilies have been given family status, thus doubling the number o families ascribed to the Saltatoria by other recent workers. Although the formation of new families will be inevitable as the groups become better known, it would perhaps be wiser to adopt a rather more cautious attitude until greater attention has been given to studies on their comparative morphology and anatomy.

The biological notes given with the more common species are largely new and have very much increased the value of the book. In particular, the descriptions of the 'songs' of many of the species will be found very useful in confirming their identity. Ample references are given to the work of other authors on the biology of a number of the species.

It is clear that in recent years much progress has been made in the study of European Orthoptera. Since the earlier volume of 1922 there have been some twenty additions to the French list, and some of these have been newly described species. There have been considerable advances in the study o their biology and distribution, and in many cases the time is ripe for the application of the polytypic species concept. In presenting with the utmost clarity much of this new and varied information in a single volume, Prof. Chopard has met a real need by workers on the European fauna, and his book is likely to stimulate further interest in a group o insects which has hitherto been denied its fair share of attention.

DAVID R. RAGGE

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# PREVENTION OF TUBERCULOSIS

Causes and Prevention of Tuberculosis

By Dr. Brice R. Clarke; with a Chapter on Mass Miniature Radiography, by Joseph Ritchie. Pp viii+288. (Edinburgh and London: E. and S Livingstone, Ltd., 1952.) 32*s*. 6*d*. net.

DURING the past quarter of a century, remarkable changes have occurred in the general outlook on nearly every aspect of the tuberculosis problem. Twenty-five years ago views on the pathogenesis o pulmonary tuberculosis were dominated by the theories of European pathologists. Ranke's three stages of the tuberculous infection, comparable with the three stages of syphilis, were commonly accepted at least as a useful way of thinking. Childhood infection was, in most countries, almost universal and was accepted by many as inevitable. In these circumstances, environmental and nutritional factors assumed an over-riding importance in the development of tuberculosis; and the most profitable method of preventing the disease seemed to be the encouragement of the general level of resistance to infection among the population. The prevention of massive infection was acknowledged to be important, but, in general, measures directed towards improved social and economic conditions seemed likely to be more immediately rewarding in their results than any possible attempt at the elimination of infection. The clinical application of vaccination by BCG was only just starting to be investigated on a considerable scale. In treatment of individual cases of the disease, rest and general hygienic measures were the only generally applicable methods. These were supplemented in suitable cases of pulmonary disease by various forms of medical and surgical collapse treatment, and in other forms of disease by surgical removal of diseased organs or operations designed to immobilize affected structures.

To-day in many countries a steadily diminishing incidence of childhood infection has led to more frequent primary infections of adolescents and young adults. The immediate effects of such infections are, on a statistical scale, different from those which follow childhood infection, progressive disease of the lungs following as an immediate sequel very much more frequently. Consequently, again on a statistical scale, the pathogenesis of pulmonary tuberculosis in the young adult has changed. In prevention, it follows that methods aimed at the avoidance of infection are more immediately rewarding than in the past, and the dangers to the adolescent and young adult of contact with open disease are more obvious. In treatment, the development of effective antibacterial drugs has revolutionized the position and, hand in hand with technical advances in surgery, has made possible forms of treatment which in combination may be so effective that for some patients they might almost warrant the description 'curative', a term which, in the past, no one has been bold enough to use in connexion with this disease. It is relevant to remark, however, that these recent developments in treatment have had a paradoxical effect on the demand for hospital accommodation and trained staff. Whereas the introduction of the sulphonamide drugs and of penicillin has resulted in a much smaller demand for hospital beds for the treatment of acute infections such as pneumonia, the treatment of tuberculosis by modern methods remains a lengthy affair, needing the co-operation of larger numbers of highly trained medical and ancillary workers than were necessary for the simpler methods of treatment available in the past. The problems of minimizing the economic effects of this long-continued disease upon the patient and his family, and of his rehabilitation to as normal a life as is possible for him at the end of his treatment, remain unchanged.

Dr. Brice Clarke's book discusses these problems, especially as they are related to the design and administration of tuberculosis services. It attempts to cover the vast field in a way that will be helpful to those working in these services, including in short compass not only the epidemiological aspects which are dealt with by McDougall's "Tuberculosis, a Global Study", but also, though less completely, the field of pathogenesis covered by A. R. Rich's monograph. Some aspects are of necessity dealt with rather briefly, and, in particular, the section dealing with bacteriology is so sketchy that it is difficult to decide for whom it is intended; but adequate bibliographies at the end of each chapter minimize such deficiencies. There are some *ex cathedra* statements with which not everyone will agree. Many of the tables and graphs are not provided with legends adequate to make them self-explanatory, and in any future edition this defect could well be remedied. On the whole, this is an adequate and useful summary of much work in the several fields of study relevant to the problems of those engaged in tuberculosis and public health services.

J. G. SCADDING

## THE EXTRA PHARMACOPŒIA (MARTINDALE)

**The Extra Pharmacopœia (Martindale), incorporating Squire's Companion**

Twenty-third edition. Vol. 1. Pp. xxii+1352. (London: Pharmaceutical Press, 1952.) 55*s*.

THE "Extra Pharmacopœia (Martindale)" has for long been the best book of reference for those who require quick access to the essential facts about medicines. The first edition appeared in 1883 and was followed by twenty-one more editions during the next sixty years. Publication was interrupted by the Second World War, and the world has had to wait eleven years for the twenty-third edition. Vol. 1, which has now appeared, is complete in itself and gives an account of practically all the drugs available in Great Britain and many foreign drugs as well. It contains more than a million words and looks like its immediate predecessor; but it is slightly larger in all dimensions and weighs about 40 per cent more. It incorporates an old rival in the form of "Squire's Companion to the British Pharmacopœia". This new edition includes four thousand abstracts, nearly three-quarters of which are from the past ten years, and a therapeutic index giving references to the medicines used in about seven hundred and fifty forms of illness.

Never has therapeutics advanced so rapidly as during the past ten years, and the editors are to be warmly congratulated on the way they have brought this book up to date. The official name of each drug is followed by its chemical name, molecular weight and trade names. Physical properties, such as solubility and stability, are briefly summarized. The dose is given and there are sections on toxic effects, antidotes, contra-indications and uses. The numerous abstracts give a clear idea of the value of the evidence about the effects of the different drugs in practical medicine. There are, for example, about forty abstracts on methonium compounds which give a clear picture of the rather uncertain state of our knowledge about them. Up-to-date information of this kind is given about all the latest drugs, the names of which are too numerous to mention. It has not been possible to give a list in the preface of all the new substances included, but a select list of about a hundred and fifty of them looks most impressive. Special sections are devoted to antibiotics (ninety-nine pages), immunological products (fifty pages), blood transfusion (thirty-one pages), ligatures and legislation.

This great work has been produced under the editorship of T. O. Denston, followed by K. R. Capper, with half a dozen assistants and a few expert advisers—S. L. Ward has been associated with this book since 1923. It is wonderful that so much has been done so well by so few.

J. H. GADDUM

# INTERNATIONAL SCIENTIFIC RADIO UNION

## MEETING IN SYDNEY

THE tenth general assembly of the International Scientific Radio Union (U.R.S.I.) was held in Sydney during August 11–21, 1952, followed by a visit, reception by the Commonwealth of Australia Government, and closing ceremonies at Canberra during August 22–23. This was followed by a two-day meeting of the Mixed Commission on the Ionosphere, also in Canberra, at which matters of common interest to the Union and the corresponding International Astronomical and Geophysical Unions were discussed. The proceedings of this Mixed Commission will be reported separately. Furthermore, advantage was taken of the presence of a number of British radio scientists to hold a meeting in Sydney of the Commonwealth Specialist Conference on Radio Research.

The assembly of the International Scientific Radio Union was attended by some seventy delegates representing fourteen countries, and by a large number of Australian scientific workers and engineers who, as observers, were interested in being present at the first meeting of an international scientific union to be held in Australia. The general organization of the work of the Union under seven Commissions, and the constitution of the British delegation have been given previously[1]. This article presents a general description of the Sydney meeting and a summary of the proceedings of the various Commissions.

### Measurements and Standards

The president of Commission 1 of the Union, Dr. J. H. Dellinger (United States), made an introductory statement on the progress of international work in the field of standards and measurements, and this was followed by two sessions of the Commission: the first on frequency and impedance measurement, under the chairmanship of Prof. M. Boella (Italy); and the second on power and special receiver measurements, under Dr. R. L. Smith-Rose (Great Britain). Twenty-eight papers, of which eleven were reports from national committees, were available and were considered according to the subject-matters of these sessions. Of great interest was a paper by C. J. Grebenkemper and J. P. Hagen (United States) which described the results of measurements on resonant cavities at very low temperatures, 1–3° K., in an investigation of superconductivity in metals at microwave frequencies. For a tin-plated resonator, the $Q$-value increased from $5 \times 10^4$ to more than $10^8$ as the temperature was reduced to the values mentioned. A discussion took place on the use of this technique for studying skin-effect in different metals, and on the influence of surface finish on the results.

Several papers dealt with various aspects of measuring power at ultra-high frequencies. These included a description by A. L. Cullen (Great Britain) of the radiation pressure method of measuring 10–60 W. at wave-lengths of 3 and 9 cm., and an account of a micro-calorimeter by A. C. Macpherson (United States) for the absolute measurement of a power of 1–15 mW. at a wave-length of 9 cm. A novel method of calibrating field-strength measuring equipment was described by H. E. Dinger and W. E. Garner (United States), in which the calibrating voltage from a signal generator is applied across the gap in the shield surrounding the loop antenna.

At the close of its work, Commission 1 confirmed its previous resolutions concerning the study of reception of standard-frequency transmissions and time signals, and the international comparison of methods of measuring power at radio frequencies. Also, mainly as a result of a paper by Dr. L. Essen (Great Britain), the following resolution was put forward and adopted by the general assembly of the Union: "As a result of investigations made in recent years by several different methods, it is recommended that the following value of the velocity of electromagnetic waves in vacuum be adopted for all scientific work: 299,792 ± 2 km./sec.".

### Troposphere and Wave Propagation

Under the presidency of Dr. C. R. Burrows, Commission 2 held four meetings at which some fifty papers and reports were discussed, dealing principally with the subjects of very-short-wave propagation both over optical paths and to distances beyond the horizon, and with the influence of meteorological conditions on this propagation. Particular note was taken of the requests made at the Geneva meeting (1951) of the International Radio Consultative Committee (C.C.I.R.) for co-operation in the study of tropospheric wave propagation in view of the importance of short radio waves (all wave-lengths less than 10 m.) in the development of broadcasting, television and communications generally. Results of the observation of fading on centimetre wave-lengths made in New Zealand, Sweden and the United States for distances up to about 100 km. were described and discussed, and it was generally agreed that it is difficult in many cases to explain the depth of fading in terms of the variations of the refractive index modulus over the whole path. Dr. J. B. Smyth (United States) emphasized the need for obtaining and studying micro-meteorological data, and claimed that in this way the main characteristics of radio-wave propagation over distances up to more than 100 km. could be predicted with a considerable measure of agreement with the experimental results.

Among the resolutions adopted by this Commission were recommendations that the scattering of radio waves by fluctuations in the lower atmosphere should be studied in different countries, with particular reference to the dependence of this scattering on latitude, climate and terrain. The statistical characteristics of fluctuations in atmospheric refractive index should also be explored, making use of recent developments in micro-meteorological measuring technique. In addition, it was recommended that at all frequencies above 30 Mc./s. research should be directed towards establishing a better understanding of the correlation between readily available synoptic meteorological data and radio propagation characteristics. While the Union takes all possible steps to ensure that national meteorological authorities are aware of the need of radio scientists for aerological observations, it has specially asked the Joint Commission of the International Geophysical Year (1957–58) to take into consideration the needs of radio meteorology when planning its programme of meteorological measurements.

## Ionosphere and Wave Propagation

Sir Edward Appleton presided over the sessions of Commission 3, which had about one hundred documents before it relating to various aspects of research on the ionosphere and the propagation of waves over a wide range of frequencies. A discussion on "Movements in the Ionosphere" was opened by Dr. G. H. Munro (Australia), followed by Dr. W. J. G. Beynon and Profs. L. G. H. Huxley and L. Manning among other speakers. It was clear that there is considerable interest in the study by radio methods of regular and irregular movements in the ionosphere. Knowledge of these movements is rapidly accumulating and is of great interest from the point of view of upper-atmospheric meteorology.

One of the most interesting topics discussed concerned the effective conductivity of the atmosphere. At the second session of the Commission, papers were presented by Drs. W. G. Baker and D. F. Martyn (Australia)[2], with additional contributions by Prof. T. G. Cowling and K. Hirono, all of whom showed how, in spite of the presence of the earth's magnetic field, the conductivity could reach a magnitude of the order required in the theory of geomagnetism. This was followed by a discussion on "Ionospheric Storm Phenomena", opened by Dr. Martyn[3] and continued by Sir Edward Appleton and others. This subject is of considerable interest not only to scientific workers interested in relating ionospheric disturbances to other geophysical phenomena, but also to the radio engineers who are seeking reliable forecasts on the progress of ionospheric storms around the world, so that they may anticipate the considerable interruption of communication circuits which accompanies such storms.

Considerable interest was also aroused in a discussion, opened by J. C. W. Scott (Canada), on the propagation of very-high-frequency radio waves over distances of the order of 1,000–1,500 km., by way of scattered reflexions in the ionosphere. The relationship between scattering at normal and at grazing incidence was emphasized, and it was pointed out that, for frequencies exceeding the normal maximum usable frequency, the reflexion coefficient may be determined by a very thin layer rather than by a general increase in ionization. Reference was made to the observations taken in Great Britain, Australia, New Zealand and the United States on the scattering of very-high-frequency radio waves due to the incidence of meteors in the ionosphere. It appears that meteor showers add to a fairly constant level of meteoric activity which is always present at a height of about 110 km., the diurnal variation resulting from such showers being much more marked in the winter than in the summer months, at any rate in the southern hemisphere.

A discussion on wave-interaction was opened by Mr. R. A. Smith (Australia), deputizing for Prof. V. A. Bailey, who was prevented by illness from being present, and was continued by Dr. M. Cutolo (Italy), Prof. L. G. H. Huxley (Australia) and Mr. J. A. Ratcliffe (Great Britain). This was followed by a presentation by Dr. R. A. Helliwell (United States) of some papers dealing with an investigation of the characteristics of the ionosphere at a frequency of 150 kc./s. and the corresponding propagation of low-frequency waves. Some of this work was concerned with a study of turbulence in the lower region of the ionosphere and with stratification in the sporadic-*E* layer.

The following resolutions were formulated as a result of the deliberations of Commission 3: a world-wide study of movements in the ionosphere should be made; attention should be given to the method of measuring ionospheric absorption using galactic noise signals; attention should be given to the study of aurorae by the radio-echo method and to the effects of aurorae on galactic noise radiations; there should be an extended study of the development and morphology of ionospheric storms; and experiments should be made in all parts of the world on the propagation of very-high-frequency waves by ionospheric scattering.

## International Geophysical Year

In 1950 the Mixed Commission on the Ionosphere put forward a proposal for a Third International Polar Year to be held during 1957–58, the previous Polar Years having been held during 1882 and 1932–33. Subsequent discussion had made it clear that the former emphasis on the polar nature of the project would need modification, since observations in tropical latitudes are now also of great interest. Accordingly, it has been agreed to change the title to "International Geophysical Year 1957–58"; and during the Sydney meeting the International Scientific Union established its own committee, under the chairmanship of Sir Edward Appleton, to advise on all aspects of radio work during this year. The Union also suggested that each country should establish a Geophysical Year Committee.

In connexion with proposals made for a new world determination of longitude during the Geophysical Year, a sub-commission of the Union, under the chairmanship of Prof. M. Boella, was appointed to study the propagation time of radio signals over long distances, and to collaborate with the International Union of Geodesy and Geophysics and with the International Astronomical Union.

## Terrestrial Atmospherics

In the absence of Prof. H. Norinder (Sweden) the meetings of Commission 4 were presided over by Mr. J. A. Ratcliffe (Great Britain) and were chiefly devoted to discussions on the wave-forms and mean level of atmospherics, and on the characteristics from which the interference to different types of communication system can be determined. On the first subject, Dr. R. Rivault (France) pointed out that the wave-form of atmospherics received over the same distances depend to some extent upon the geographical location of the lightning strokes from which they arise. Mr. Ratcliffe gave an account of recent work on 'whistling atmospherics' and of a tentative theoretical explanation of these. Dr. R. A. Helliwell (United States) said he had recorded such 'whistlers' simultaneously at two places about 1,500 km. apart.

On the measurement of the general level of atmospheric noise, the meeting agreed with the recommendation by the International Radio Consultative Committee to continue to use the subjective method of measurement due to H. A. Thomas until an objective method is in use and is found to be satisfactory. In this connexion, it was opportune that Mr. H. E. Dinger (United States) described the American plans for a world-wide measurement of atmospheric noise by an objective method at some fifty stations to be installed during the next two years. In the meantime, it was urged by the chairman that measurements in the high-frequency range by the subjective method should be resumed in Australia and New Zealand; and attention was directed to the British plans to extend the world survey to lower frequencies. Mr. F. F. Gardner (Australia) gave an account of noise measurements made on a frequency of 2 Mc./s. at a place remote from sources of man-made interference. He said that by day the only noise measured was that corresponding to the thermal noise from the ionosphere, while at night the prevailing noise arose from man-made sources in a city 50 km. away. Mr. Dinger stated that at high latitudes noise due to precipitation is very important and can interrupt traffic for several hours on frequencies between 18 kc./s. and 18 Mc./s. In addition, interference is often associated with storm clouds even when there is no actual precipitation.

Concerning the future, it was agreed that at the next general assembly of the Union discussions would be held on the following topics: wave-forms and propagation of atmospherics; meteorological aspects of atmospherics; world-wide 'noise surveys'; and atmospherics as a source of interference to communication systems.

National committees were asked to encourage research in these subjects, and in particular to endeavour to provide an answer to the following question posed by the International Radio Consultative Committee: "What are the most easily measured characteristics of terrestrial radio noise from which the interference to different types of communication system can be determined?" Finally, the Commission recommended that, during the International Geophysical Year, three lines of work should be undertaken: measurements, of a high standard, of the radio noise at as many places as possible, including the polar and auroral regions; observations of the wave-forms of atmospherics, including 'whistlers', at several places, including the equatorial and polar regions; and optimum use to be made of organizations set up for the location of thunderstorms and lightning flashes.

## Radio Astronomy

Commission 5 formerly defined its scope by the title "Extra-terrestrial Radio Noise"; but at the general assembly in Zurich during 1950 it was renamed as the Commission on Radio Astronomy, and its scope was extended to include such subjects as meteors and the moon when observed by radio techniques, as well as the investigation of radio emissions from the sun and stars. The meetings of this Commission in Sydney were of particular interest in view of the large amount of research in this field which has been conducted in Australia during the past few years under the auspices of the Commonwealth Scientific and Industrial Research Organization. The visit of the Union provided a most valuable opportunity for the research workers in this field in the northern and southern hemispheres to discuss their experiences and results.

At the first of four sessions, Mr. W. N. Christiansen (Australia) described observations of solar radiation made on a wave-length of 21 cm. (frequency 1,420 Mc./s.) using a linear array of thirty-two parabolic reflector aerials along an east–west line some 240 m. long. The radiation diagram of this system comprised lobes 3′-arc wide and 1·5° apart; and continuous record was obtained as the sun passe through several lobes. The observations showed th presence of disturbed areas on the sun, closely associated with sunspots and persisting for one o two revolutions of the sun. The distribution o radiation across the disk was deduced: this showe limb-brightening corresponding to a coronal temperature of $2{\cdot}5 \times 10^6$ °K. Dr. J. L. Steinberg (France) reported observations made on solar eclipses on wave-lengths of 178 m. and 3 cm., and these could only be explained on the assumption that the solar corona was not circularly symmetrical. These results were confirmed by other observers on various frequencies between 225 and 10,000 Mc./s., and in most cases there was evidence of limb brightness. Dr. F. G. Smith (Great Britain) described interferometric measurements of the distribution of brightness across the sun on four wave-lengths between 60 cm. and 7·9 m. in an attempt to determine the distribution of temperature in the corona. It was shown that no simple model of the solar atmosphere can explain results on these wave-lengths, it being difficult to interpret the observed radiation from regions at two or three times the solar radius from the centre of the disk.

At the second session, which, like the first, was presided over by Dr. D. F. Martyn, a discussion on the dynamics of ionized media was opened by Prof. H. S. W. Massey (Great Britain), followed by contributions by Dr. Martyn, by Drs. K. C. Westfold and J. H. Piddington (Australia) and by Dr. N. Herlofson (Sweden). Some of the particular problems considered were the nature of modes in a plasma and the setting-up of oscillations with consequent radiation from plasma. It was shown that reflexion from dense meteor trails when the electric vector is not along the trail is not fully understood.

The subject of the third session was interstellar gas, and at this meeting Dr. H. I. Ewen (United States) described his work on the reception of the line radiation at 1,420 Mc./s. originating in the neutral hydrogen atoms in the galaxy. The frequency and intensity of the line were shown in the early experiments to depend on the direction of the observation. Mr. Christiansen and Dr. C. A. Muller (Netherlands) described their investigations of the variations of frequency and of the deductions which could be made about the movements of the emitting portions of the galaxy.

At the last session, Dr. B. Y. Mills (Australia) surveyed the techniques which have been used for the observation of discrete sources of cosmic radio waves. Observations made in Sydney on a frequency of 100 Mc./s. show that the more intense radio stars are concentrated towards the galactic plane. R. Hanbury Brown (Great Britain) reported results obtained on a frequency of 160 Mc./s., in which a source was discovered near the position of the supernova observed by Tycho Brahe; other sources were tentatively identified with clusters of extragalactic nebulæ. Dr. J. G. Bolton (Australia) described an extension of the sea interferometer experiments, and a new instrument for determining azimuth. He has been able to show that the angular diameter of some radio stars can be resolved.

Among the thirty-three documents distributed to this commission were several reports from national committees which present useful surveys of the very rapid progress made in recent years in this general field of radio astronomy.

### Waves, Circuits and Electronics

The interests of Commission 6 are considered to cover such fields as theory of information; theory of non-linear oscillations; linear circuit theory; and diffraction theory, antennæ and wave-guides. Various working parties were set up at Sydney to report on progress in these fields, and national committees were recommended to give serious consideration to a number of matters relevant to the theory of information and its practical application to communication matters in which the International Radio Consultative Committee had expressed particular interest.

Three sessions of the Commission concerned with electronics were held, at the first of which new developments in vacuum tubes were discussed, while the second dealt with such subjects as the dielectric properties of solids, the thermionic constants of metals and the electrical properties of thin films. The final session dealt with the fundamentals of gas discharges, the interaction of electromagnetic waves with plasma, and the radiation of micro-wave noise from gas discharges.

### Publications

Hitherto the proceedings of the General Assemblies of the Union have been published with the detailed texts of all documents. On the present occasion, the executive committee of the Union decided to discontinue the publication of the individual papers, which are either incomplete summaries of the papers presented at the sessions or are papers which are or will be published in the recognized scientific journals. A more useful objective to be pursued is to publish additional special reports on selected radio topics, and to make these universally available. Two such reports have already been published, one on "Solar and Galactic Radio Noise" and the other on "Tidal Phenomena in the Ionosphere"; and a third, on "The Dynamics of Ionised Media", is in the press. Among the subjects proposed for future reports are ionospheric storms, radio investigation of meteors, ionospheric wave interaction, interstellar hydrogen, discrete sources, and the distribution of radio brightness on the solar disk.

### Officers

At the closing meeting of the general assembly, the following officers were elected: *Honorary presidents*, Sir Edward Appleton, Dr. J. H. Dellinger and Dr. B. van der Pol; *President*, Father P. Lejay; *Vice-Presidents*, Dr. C. R. Burrows, Dr. D. F. Martyn and Prof. B. D. H. Tellegen; *Treasurer*, Prof. C. Manneback; *Secretary General*, Col. E. Herbays; and *Chairmen of Commissions*, (1) Dr. R. L. Smith-Rose, (2) Dr. C. R. Burrows, (3) Sir Edward Appleton, (4) Mr. J. A. Ratcliffe, (5) Dr. M. Laffineur, (6) Dr. L. C. Von Atta, and (7) Prof. G. A. Woonton. Delegates of the Union were also appointed to serve on various other international organizations.

In addition to the scientific meetings described above, the delegates participated in an extensive programme of technical visits and social events which displayed both the intention and the ability of their Australian hosts to make the occasion as instructive and pleasant as possible. The University of Sydney, the National University at Canberra, the Commonwealth Observatory at Mt. Stromlo, the various laboratories and field stations of the radio and electrical divisions of the Commonwealth Scientific and Industrial Research Organization were all visited, as well as some of the laboratories and works of firms in the associated industry. On such occasions, chiefly at week-ends, when no formal business sessions were on the programme, all the delegates were provided with excellent opportunities for enjoying the beautiful scenery around Sydney and farther afield in New South Wales. The hospitality shown by the Commonwealth Government and by private organizations and individuals has left a memorable impression of this visit to the only continent which lies wholly in the southern hemisphere.

R. L. Smith-Rose

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[1] *Nature*, 170, 152 (1952).
[2] See *Nature*, 170, 1090 (1952).
[3] See *Nature*, 171, 14 (1953).

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# PLANKTON OF THE BENGUELA CURRENT

By Dr. T. J. HART

National Institute of Oceanography

During the two surveys of this area in 1950 that yielded the hydrological results described in a recent article by Currie[1], extensive plankton collections were made. Preliminary sorting of the zooplankton material is not yet complete—in addition to its being nearly as rich as that of polar waters in quantity, it is much more diverse in quality—and a greater expenditure of time than that required for this phase of the work on material from most other regions is therefore unavoidable. Moreover, the full value of the material can only be assessed when specialists working independently on the various groups have completed their reports. At this stage, therefore, only major features of group-distribution, rendered clear by the preliminary work on material from the first survey, have been considered.

With the phytoplankton we can already proceed much further. In dealing with it, a conservative choice of method was necessitated by practical considerations (to be stated in the main report), and our estimations for all stations on both surveys are now complete. These were made by Hensen methods from 100–0 m. hauls of the Gran net. When plotted logarithmically, they seem adequate to show up the grosser quantitative differences; for it was found that the concentrations of phytoplankton in this area were such that, whether dealing with important individual species, groups or grand totals, a 50 per cent alteration of values assigned to the contours in either direction made but little difference to their position on the chart. Moreover, scores of individual species, only one or two of which can be cited here, showed distributional patterns in good agreement with the hydrological features. The latter were, of course, quite independently assessed.

Close similarity to the conditions off Lower California in 1941, as described by Sargent and Walker[2], working from W. E. Allen's counts, is evident. They found a succession of three "plankton elements" in a large eddy of the upwelling current, with Chaetocerids predominating in the richest, most recently upwelled and coldest water, and a sparse warm-water element offshore. This last, however, was in the oldest surface water from the eddy, not in a distinct, more oceanic,

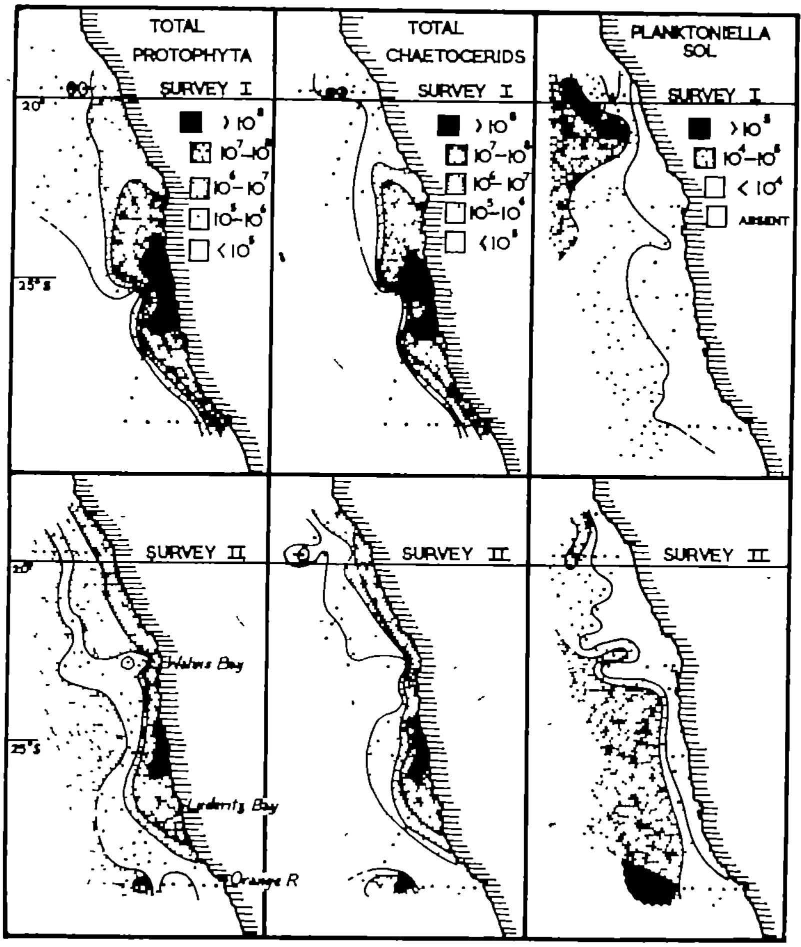

Fig. 1

body of surface water as here. It seems that in relatively narrow eddies set up in the Benguela Current, the whole circulation is more rapid, so that some 'ageing'—which involves heating—of the upwelled water must take place before peak phytoplankton production becomes possible. Even so, many of the cosmopolitan species we found so abundantly were present off California also, and though through lack of seasonal data we cannot generalize so far as Sargent and Walker have done, the close analogy between the two regions seems clear.

In the Benguela Current we found the rich catches concentrated on the shelf some 10–45 miles from the coast, in the central area from Luderitz Bay northwards, as shown to the left of Fig. 1. Species of *Chaetoceros* were so far dominant that their distribution (centre) forms an essentially similar pattern. They formed 60–90 per cent of the catch at most of the richer stations. Currie's[1] computations show that upwelling activity is normally greatest in this area.

Higher average values, and restriction of the rich area to the northward combined with a greater extension of it seaward, were features distinguishing the autumn observations (first survey) from the spring ones (second survey). Together with some marked qualitative differences, it is these which suggest that the slackening of upwelling in autumn (demonstrable from the physical data) allowed peak development of the succession. The hypothesis that such a peak may not be attained locally when the whole circulatory complex is speeded up follows as a corollary from the spring observations; for there must be a time-lag before the diatoms seeding the rich water newly arrived within the photic zone can proliferate sufficiently.

Of the various species, *Chaetoceros compressum*, *Ch. curvisetum* and *Ch. didymum* were most important, closely followed by several more (of the section Hyalochaete) of that difficult genus. *Asterionella japonica* was the most abundant pennate form able to flourish among them; but close inshore *Fragilaria karsteni* was more important. On the first survey *Eucampia zoodiacus* was quite numerous in the rich diatom zone; but on the second survey we saw none, though it was present farther south, and in colder water at that time. This may be an extreme example of the succession effect postulated above. Possibly a more directly seasonal effect was the great abundance of resting spores of *Chaetoceros didymum* in autumn, and a great scarcity of them in spring (though plenty of the normal vegetative phases were present).

The sparse phytoplankton of the offshore surface water contained relatively large numbers of *Planktoniella sol*. This distribution is shown to the right of Fig. 1. It fits the intrusions of offshore water determined by physical and chemical means very closely. The most striking example is the tongue of *Planktoniella*—rich water from the north, projecting southwards and shorewards towards the colder *Chaetoceros* zone during our first survey. Rayner (quoted by Gunther[3]) had found a similar relationship in the Peru Current, working from the same ship twenty years earlier. Clearly *Planktoniella* is a good indicator in such regions, provided that the phytoplankton is considered *in toto*.

Fig. 2 is partly a repetition emphasizing this point, but also showing another important feature. An isolated area with moderate quantities of Chaetocerids can be seen to the north of the intrusion from offshore, probably a relic of previous continuous distribution; but in the area between the two strongly contrasting diatom floras, the Dinophycean *Goniaulax spinifera* predominated. The phytoplankton here was not rich, but it is noteworthy that this was the only area sampled during the survey, more than twenty miles offshore, where Dinophyceae predominated over the diatoms. It is probably significant that here, where the distance between the two strongly contrasting types of surface water was least, one might expect lateral mixing between them to have been strongest.

On arrival at Walvis Bay during the first survey, we found that a fish mortality had occurred. Leaving

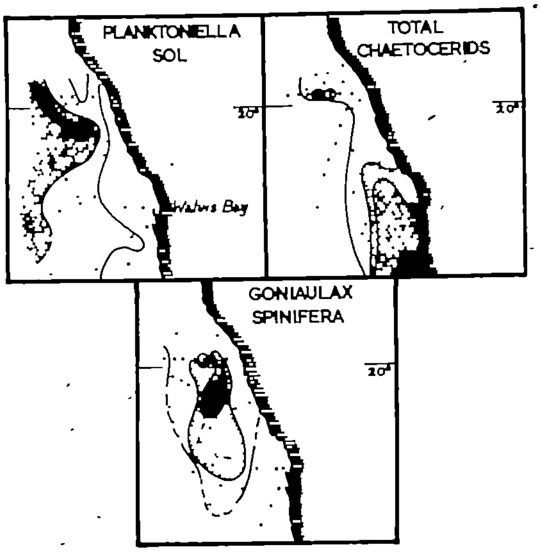

Fig. 2

next day on a south-west course we passed through large areas of discoloured water, some of them extending as far as fifteen miles seaward of Sandwich Harbour. Some of the more intensely coloured areas formed narrow bands with streaks of foam and Ctenophores disintegrating at the surface, like the wind lanes often formed in *Trichodesmium* blooms in warmer waters. Considerable congregations of sharks, sea-birds and seals were seen near by. They did not seem to be adversely affected. A series of surface samples was examined by centrifuge and drop method. *Gymnodinium* and *Gonioulax* spp. (two genera of Dinophyceæ already known to include 'lethal' species) were present, but only in very small numbers. Detailed counts of preserved material afterwards showed that a rich mixed plankton was present in the 'khaki' or 'olivaceous' areas. There were some half-million cells per litre: *Peridinium triquetrum* 39 per cent, the diatom *Asterionella japonica* 33 per cent, *Procentrum micans* 14 per cent, and most of the remainder quite large diatoms. Areas appearing more definitely brown or reddish at a distance showed *P. triquetrum* clearly dominant—more than 85 per cent of the numerical totals, which reached three to six million cells per litre. Equally heavy blooms of this very cosmopolitan, but usually more strictly neritic species, have been recorded from Scottish lochs and from inner Oslo Fjord, the latter in definitely polluted water (Marshall and Orr[5], Braarud[6]). Can it be that here this type of bloom follows rather than precedes mortalities? There is, however, one record associating this organism (under the name *Heterscapsa triquetra*) with a fish mortality at Rostock in the Baltic in 1917 (Lindemann, quoted by Brongersma-Sanders[4]). The Walvis Bay mortality had already occurred when we arrived there; but as we worked in towards the land by night, we do not know whether the bloom was already present offshore. However, it is now clear that water-blooms due to several quite different organisms may recur within this one sea area.

In some seas, blooms may be a direct cause of mortalities (as when caused by certain species of *Gymnodinium*, *Gonioulax* and other genera), but they are often quite harmless and not even coincident in point of time (*Prorocentrum*, *Amphidinium*). This is already clear from such work as that of Allen[7], Graham[8], and others. Thus Dr. Brongersma-Sanders's hypothesis[4], that mortalities near Walvis Bay are due to *Gymnodinium* poisoning, may prove quite justified, though none of the blooms I have yet been able to examine from the South African coast have belonged to that genus. We cannot yet say whether the relation between water-bloom and mortality here is causative, coincident or resultant. But we can say, from the evidence so admirably marshalled by Dr. Sanders, that bloom has often been seen at about the same time as a mortality.

For the present, Currie and I prefer to guess that the mortalities may be due to a combination of adverse factors, with oxygen shortage (below the extreme surface layer) perhaps the most important, the whole set in train by large-scale meteorological and hydrographic changes leading to slackening or temporary cessation of upwelling; the latter may involve incursions of warm surface water into the area from the north and west, though local heating must also figure largely under such conditions.

That the zooplankton of the Benguela Current is rich in quantity is obvious from the bulk appearance of the samples. Qualitatively it is much like that off Lower California and off Peru. Group sorting led to demonstration that considerable spawning of *Sardinops sagax* took place on the shelf, near the richest diatom area, early in March (Hart and Marshall[9]). Both economically and ecologically, this is the most important pelagic fish of the region. Post-larvæ reached a peak one station farther seaward than the egg-maximum on each line of stations, in accord with known water movement. Both eggs and young stages coincided with extraordinarily large catches of Cumacea in the plankton nets. Elsewhere, these mainly bottom-living crustaceans are usually subordinate to Mysidacea, except in some arctic localities. Their persistent presence here, in very large numbers, in the plankton, may have been due in part to oxygen deficiency in the lower water-layers. In March, Mysidacea predominated over the Cumacea at one station only—inshore off the Orange River.

While many cosmopolitan species abounded in the zooplankton, such as *Thalia democratica* and *Salpa fusiformis* among offshore Tunicates, and *Evadne nordmanni* among inshore Entomostraca, the important Euphausian species are more typically South Atlantic. Even so, Dr. Boden, who is now working up our Euphausians, and who has already studied Californian material, informs me that the distribution of genera and comparable species in the two areas seems most strikingly similar. The largest catches of Euphausians, especially the young stages, were taken with the richest phytoplankton (though not, of course, in the 'bloom' area) some 20–50 miles offshore.

The Ostracods from the first survey have already been reported on by W. J. Iles (in the press). They clearly formed an essentially mid-water, offshore group. Possibly their marked absence from stations over the continental shelf was due to the decrease in upwelling at that time. We already know that a few strayed farther in during the second survey.

Notable examples of group dominance were a great concentration of the Pteropod *Limacina bulimoides* offshore and near the shelf edge to the south, where we have some evidence that the phytoplankton had been heavily grazed. Large Aulacanthid radiolaria were very abundant offshore to the north, and *Acanthometron* at one shallow-water station to the south.

These examples are but a foretaste of the distributional data that we hope ultimately to extract from the material. The distribution charts I have included were redrawn for reproduction by Mr. Currie, to whom I am deeply grateful. Both of us are greatly indebted to the Director and staff of the Marine Biological Association's Plymouth Laboratory for providing unrivalled working facilities before the new premises of the National Institute of Oceanography were available.

[1] Currie, R. I., *Nature*, 171, 497 (1953).

[2] Sargent, Marston C., and Walker, Theodore J., *J. Mar. Res.*, 7, No. 29 490 (1948).

[3] Gunther, E. R., Discovery Repts., 13, 107 (1936).

[4] Brongersma-Sanders, Dr. Margaretha, Verh. Akad. Wet. Amst., 2nd Sect., D1, 45, No. 4, pp. 1–112 (1948).

[5] Marshall, S. M., and Orr, A. P., *J. Mar. Biol. Assoc.*, 14, 837 (1927).

[6] Braarud, T., Hvalradets Skrifter, No. 28 (1945).

[7] Allen, W. E., Contr. Scripps Inst. Oceanogr., N.S., No. 287 (1947).

[8] Graham, H. W., *Trans. Amer. Micro. Soc.*, 62, No. 3 (1943).

[9] Hart, T. J., and Marshall, N. B., *Nature*, 168, 272 (1951).

# OBITUARIES

## Prof. J. H. Orton, F.R.S.

James Herbert Orton, emeritus professor of zoology in the University of Liverpool, died on February 2, less than four years after his retirement from the Derby chair and the directorship of Port Erin Marine Biological Station.

Before going to Liverpool in 1929, Orton had spent nearly twenty years as naturalist (latterly, chief naturalist) at the Plymouth laboratory of the Marine Biological Association. Both at Plymouth and at Port Erin, Orton conducted vacation classes in marine biology and became known to large numbers of students, among whom his infectious enthusiasm proved a means of starting many on a career of marine biology.

During his tenure of the Liverpool chair of zoology, Orton was a popular figure with his students and the younger members of his staff. He did not, however, come into very close academic touch with his students, either by lecturing or otherwise, until their later honours or research years; but at this period they found him to be a wise guide and friendly counsellor in their studies. He was ever on the look-out for potential research workers in his chosen subject, and, having found them, never hesitated to demand from them the highest standards of technical ability and assiduity. These demands never went unheeded, for they never exceeded the standard he so obviously set for himself.

Though primarily a marine biologist, Orton was keenly alive to the importance of freshwater biology; he was an active member of the Dee Fishery Board, and had served on the Council of the Freshwater Biological Association. At Liverpool, he succeeded in establishing a lectureship in freshwater biology and an active school from which important studies in pollution problems and in the life-history of the salmon have issued.

In the marine sphere, Orton produced, over a period of forty years, a succession of papers, reports and notes covering a wide range; but it was upon the biology and economics of the marine mollusca that he became an acknowledged authority, whose opinion was sought by government departments and by commercial oyster-fishing interests alike. His papers on the biology of the 'native' or European flat oyster include studies of its growth, shell-formation, sex-change, food and feeding, environment, predators and culture-methods, and together form a corpus of knowledge for one species which has scarcely been equalled in the whole realm of zoology. His other molluscan papers include work on the cockle and the limpet, and on this latter he was engaged at the time of his death. The value of his researches was recognized, in 1948, by his election as a Fellow of the Royal Society.

Orton was appointed director of the Port Erin Marine Biological Station in 1939, ten years after his taking up the chair of zoology at Liverpool. The dual task, though a heavy one, was accepted gladly because it afforded him the opportunity of guiding the destinies of a marine station—a task for which his long experience at Plymouth had fitted him. At Port Erin, Orton was manifestly at his best—always eager and cheerful; but his well-laid plans for the establishment of 'Port Erin' as a first-rate centre of biological oceanography in the Irish Sea were delayed and partly frustrated by the onset of the Second World War, during which he took up active military service. After the War, limited expansion became possible, and this was greatly aided by the provision, from University funds aided by the Development Commission, of the M.V. *William Herdman*. Plans for structural changes in the buildings of the Port Erin station were also drawn up, but these have not yet been carried into effect.

The name of James Herbert Orton will remain honoured, at Port Erin as in his department at Liverpool, as that of a man who pursued his life-work with acknowledged success, tireless devotion and utter singleness of purpose. J. R. Bruce

## Dr. A. N. Zavaritzky

Alexander Nikolaevich Zavaritzky, who died at his home in Moscow on July 23, 1952, was one of the most prominent petrologists in the U.S.S.R. He was born on March 14, 1884, in the town of Ufa, being educated at the gymnasium (grammar school) there, and then he graduated in 1909 from the St. Petersburg (now Leningrad) Mining Institute. In his capacity as lecturer in the Mining Institute, he assisted E. S. Fedorov and K. T. Bogdanovich in the work on petrology and ore deposits, and much of his subsequent scientific career was devoted to welding these two subjects together.

In 1921 Zavaritzky became a professor in the Mining Institute, but, as is usual in Russia, he combined teaching with a very active participation in the work of the official Geological Survey. At first he concentrated on the study of the magnetite ores of the Ural Mountains, especially on the ores of Mount Magnitnaya, which eventually played such an important part in the development of Soviet industry. The results of his research on the occurrence and modes of origin of these ores were published in a three-volume work in 1922–27. This work was followed by a number of publications, dealing with a great variety of subjects, among which may be singled out the ultrabasic rocks of the Urals, platinum deposits, alkaline rocks and pyrite deposits. In 1931, Zavaritzky began the exploration of the distant and difficult region of Kamchatka. He not only published valuable papers on Kamchatka's volcanoes but also organized an extensive survey of this region, and he eventually became the head of the newly established Volcanological Laboratory in Moscow and of its branch in Kamchatka. He also studied the volcanic rocks of Armenia and Manchuria. From 1945, in collaboration with L. G. Kvasha, he began the reorganization of the extensive meteorite collections of the Soviet Union. He also published a number of papers dealing with minerals, microscopical methods and apparatus. In addition to several text-books, Zavaritzky published two important books dealing with the physico-chemical principles of the formation of igneous rocks (1926) and the petrochemistry of igneous rocks (1944). A general account of his scientific work has already appeared in *Nature* (157, 378; 1946), and a number of his works have been abstracted (*Min. Abstr. Min. Mag.*). A summary of recent work on the volcanoes of Kamchatka has been published in the *Bulletin Volcanologique* (Ser. 2, 8, 87; 1949).

In 1939 Zavaritzky was elected a member of the Academy of Sciences and moved to Moscow, where he occupied a number of important scientific posts, combining administration, research, editorship and teaching. All his published work is characterized by a remarkable thoroughness and by lucidity of exposition. He was a first-class petrologist and an outstanding specialist on ore deposits. As a teacher, research worker and organizer, Zavaritzky will long be remembered in the U.S.S.R. and his death lamented by his numerous friends, colleagues and pupils.

S. I. TOMKEIEFF

## Dr. J. A. Hewitt

THE death on March 10 of Dr. James Arthur Hewitt robs preclinical circles in the University of London of a figure well known for more than thirty years. He was born in 1889, and after being at Glasgow High School and Hutcheson's Grammar School, he took a B.Sc. in St. Andrews in 1911, with special honours in chemistry, natural history and physiology. He became assistant to Prof. P. T. Herring and later senior assistant, acting as head during the prolonged absence of the professor.

On the outbreak of war in 1914, he joined the Royal Artillery, in which he had a very varied career, being attached at first to the Royal Flying Corps. Later he became a staff officer, Southern Command, specially concerned with anti-gas warfare. He was himself seriously gassed earlier, a fact which led to much subsequent ill-health.

On his return from service, Hewitt joined Prof. W. D. Halliburton at King's College, University of London, and collaborated with him in the first production of *Physiological Abstracts*, a landmark in medical literature. At first, he was a biochemist, obtaining his D.Sc. for researches in carbohydrate metabolism, but he was so extremely versatile that he was able at a later date to take over the teaching of histology from the late Dr. Da Fano. As a teacher he was superb, and he picked up new material easily. At one time, he even gave a course of advanced lectures on the nervous system before the work of Sherrington was so generally appreciated. His election to the chairmanship of the Board of Physiology of the University of London was eloquent of the appreciation of his personal qualities. This was the first time a non-medical man had been elected. He was elected F.R.S.E. in 1947.

He became increasingly popular with young people. While evacuated to Birmingham during 1941, he became a squadron-leader in the A.T.C., and on leaving was given a complimentary dinner. Many will remember, too, his enthusiasm for motor-cars, especially old crocks which he loved to take to pieces and get into working order. Only two years ago he took part in an important rally.

Hewitt will be remembered by his kindly way with students. As adviser to medical students at King's College, he was ever zealous in their interests, and many owe their careers to his insistence with difficult authorities. We all regret his passing.

R. J. S. McDOWALL

# NEWS and VIEWS

### Presidency of the Royal Aeronautical Society: Sir William Farren, C.B., F.R.S.

SIR WILLIAM FARREN has been elected president of the Royal Aeronautical Society for the year 1953–54 and will take office at the annual general meeting of the Society to be held on May 7. Sir William was born in Cambridge in 1892 and was educated there at the Perse School and afterwards in the University at Trinity College. After a short spell as an electrical engineer, he joined the Royal Aircraft Factory at Farnborough in 1915 and was in charge of the experimental and design aspects of aerodynamics there until the end of the First World War. From 1920 until 1937 he worked in university circles, being a lecturer at various times in engineering, aerodynamics and aircraft structures at Cambridge and at the Royal College of Science, London. Sir William then abandoned academic work and became deputy director of scientific research at the Air Ministry, rising to the post of director of technical development at the Ministry of Aircraft Production in 1940. The succeeding year he returned to Farnborough as director of the Royal Aircraft Establishment, and the five and a half years during which he held this post (in which he incidentally found the time to take up active flying again) were marked by a great increase in the staff, buildings, equipment and general activity in the Establishment. After the War, it was fitting that Sir William should decide to employ his energies in the aircraft industry, and since 1947 he has been technical director of A. V. Roe and Co., Ltd. His many achievements were acknowledged by his election to the Royal Society in 1945 and by a knighthood last year.

### Royal Geographical Society: Awards

THE Queen has approved the award by the Royal Geographical Society of Royal Medals as follows: *Founder's Medal*, Mr. P. D. Baird, director of the Montreal office of the Arctic Institute of North America, for explorations in the Canadian Arctic; *Patron's Medal*, Count Eigil Knuth, leader of the Danish Expedition to Peary Land in 1948–50, for explorations in northern Greenland and for contributions to Eskimo archæology.

The Council of the Society has made the following awards: *Victoria Medal*, Sir John Myres, emeritus professor of ancient history in the University of Oxford, for contributions to the geographical history of Greek lands and for his services to the development of geography in education; ***Murchison Grant***, Mr. G. B. Stigant, hydrographic department of the Admiralty, for studies and mapping of the Japanese coasts; ***Back Grant***, Mr. G. de Q. Robin, senior British scientist on the Norwegian–British–Swedish Antarctic Expedition of 1949–52, for geophysical explorations in Queen Maud Land; ***Cuthbert Peek Grant***, Mr. Duncan Carse, leader of the South Georgia (Antarctic) Expedition of 1952, for exploratory surveys and mapping; ***Gill Memorial***, Mr. B. H. Farmer, Fellow of St. John's College, Cambridge, for studies of the use of land in Ceylon.

### Secondary Technical Schools and Industry

In his presidential address on March 21 to the Association of Heads of Secondary Schools, Mr. H. B. Brown, headmaster of the Bordesley Green Technical School, Birmingham, referred to the development and present position of secondary technical schools, and pointed out that these schools demand of their pupils a very exacting standard of mental activity with an application tending to combine a comprehensive theory with sound practice. He suggested that industry could feel that the time a pupil spent in such a school after the normal school-leaving age is a real contribution to his or her training and might provide the background for later employment in administration, supervision or design. He recommended that training of a young person for a responsible post in industry or commerce should be regarded as divided between full-time school attendance, instruction within industry and special training, either in industry or in further-education establishments, the whole directed towards developing suitability for a position requiring special skills, aptitudes and responsibility. Mr. Brown looked for more co-operation between industry and the technical schools and expressed concern at the inadequacy of the present supply of teachers of science, applied science and crafts, a shortage which threatens the whole of the science and craft teaching in schools, and which may have repercussions on industry itself. He insisted on the need for technical schools to keep their methods of teaching and curricula, their relations with industry and the needs of the cultural world constantly under review and to anticipate and meet changing demands. It is a principal function of the Association, he maintained, to assist in co-ordinating the professional outlook of its members.

### Investigation at Cambridge of the Feldspar Minerals

The Nuffield Foundation has offered a grant of £4,150 in aid of a research project on phase equilibrium relations and atomic structure of the feldspar group of minerals to be undertaken jointly by the Department of Mineralogy and Petrology and the Crystallographic Section of the Cavendish Laboratory at Cambridge. The application of recently developed techniques for feldspar synthesis under controlled conditions and for the rapid X-ray identification of crystalline phases, principally at the Geophysical Laboratory of the Carnegie Institution of Washington, has opened up a fruitful field of research of the first importance, not only for the understanding of the intimate relations within this great mineral group but also for the elucidation of the genetic history of feldspathic rocks, both igneous and metamorphic. The grant provided by the Nuffield Foundation will be utilized at Cambridge for the provision of equipment devised for the application of the new techniques in the investigation of the hydrothermal synthesis, polymorphism and unmixing relations of feldspar phases, and for fundamental crystal analysis studies, especially of synthetic feldspars of known thermal history.

### Enzymic Systems in Root Apices

An account of a method for determining the development of the enzyme complement in growing root cells has been given by E. Robinson and R. Brown (*J. Exp. Bot.*, 3, 9, 356; 1952). On corresponding successive segments from the root apex backwards, the water and protein contents and the activities of dipeptidase, glycine oxidase and invertase have been measured, together with the number of cells in each segment. From these data it has been possible to indicate how the quantities involved change during cell growth. Four phases can be distinguished in the early cellular development. During a cell's development in the meristematic region its volume increases slightly, the protein content probably decreases, and the activities of three of the enzymes studied decrease. During the second phase there is a large increase in cell volume and protein content, and all enzymic activities increase considerably. In the third phase, the cell increases in volume by increase in breadth, but its protein content and enzyme activities decrease. The fourth phase is marked by cessation of growth and a continued decrease in protein content and enzyme activity. In discussing their results, the authors point out that the enzyme activity varies directly with the protein level during all four phases, and that the enzymatic constituents account for, if not the whole, at least a considerable part of the total protein content. The possibility is considered that during cell growth there are changes in the composition and structure of the protein complex and that such changes are causally related to variation in the relative activities of the different enzymes. Whether cell growth is determined by changes in the protein contents and other related topics are discussed.

### Stop-watches and Chronographs

Instruments capable of measuring and recording intervals of time to a fine degree of accuracy are required in many walks of life and particularly by the engineer and scientific worker in modern industry. Stop-watches and chronographs are mainly used; but few people understand the underlying mechanism, the degree of accuracy that can be expected and how to select the most suitable type for the work to be measured. The completely revised and reprinted catalogue of high-precision Swiss stop-watches and chronographs, recently issued by the firm of Camerer Cuss and Co. (54–6 New Oxford Street, London, W.C.1), which has specialized in horology since 1788, is, in spite of its small size, particularly valuable because it contains, in a preface, just those details which will assist the purchaser in the selection of the correct instrument. The function and action of the escapement is explained, how inaccuracies are reduced by proper choice of materials and arrangement is discussed, and the necessity is stressed for a periodical overhaul if a watch is to maintain a steady state. Where it is necessary to have a certificate of accuracy, the Metrology Division of the National Physical Laboratory, Teddington, will undertake an independent test. Watches required for the testing of electric meters are tested under the Electricity Supply (Meters) Act, 1936, to a specification issued by the Ministry of Fuel and Power. The instruments illustrated and described in the catalogue are of various types, including three-pressure action, instantaneous fly-back and restart, and split-second stop-watches and chronographs with time of day and of the wrist pattern. All Camerer Cuss instruments contain the jewelled pallet-lever escapement, a superior pattern, and are jewelled in all the principal bearings.

### Wave-lengths for Radial-Velocity Determinations of Stars

A PAPER on "Wave-Lengths for Radial-Velocity Determinations based on Measures of One Hundred F- to M-type Stars" has been published by K. O. Wright in *Publications of the Dominion Astrophysical Observatory, Victoria, B.C.* (9, No. 3, 167–180; 1952. Ottawa: Queen's Printer. 25 cents), which gives the results of the author's investigations begun in 1936 when he went first to the Dominion Astrophysical Observatory. Most of the plates that were measured had been previously taken for the absolute magnitude programme of Young and Harper, an account of which appeared previously in the *Publications* (3, 1; 1924), and were well exposed in the range 4000–4500 A. As many of these observations covered epochs not observed elsewhere, it was decided that the plates should be measured for radial velocities. Unfortunately, Wright's activities were transferred elsewhere when he had completed the measurement of about one-half of the plates; but the results obtained have proved very useful. One object of the measurement was to check the wave-lengths used in radial-velocity measurements of late-type stars, and preliminary velocities were derived by using Petrie's system of wave-length standards (described in *Contrib. Dom. Astrophys. Obs.*, No. 4, 1946). The results for each line have been averaged for each spectral type from *F*4 to *M*8 on the Young and Harper system (*Pub. Dom. Astrophys. Obs.*, 3, 1; 1924), and the variation of velocity difference with spectral type has been the chief criterion in selecting the lines used in the investigation. The general results confirm that the "Lick Catalogue" (*Pub. Lick Obs.*, 18; 1932) and the "New General Catalogue" (*Pub. Lick Obs.*, 16; 1928) are, effectively, on the same scale and show that the velocities obtained are, on the average, 0·9 km./sec. more negative than the Mount Wilson velocities in the new catalogue. A list of nine stars is given of which the radial velocity may be variable, and only one of these has been previously announced by the Lick Observatory. The range of velocity in these stars is at least 8 km./sec., and, as an individual measurement should not be in error by more than 2 or 3 km./sec., it is considered probable that the variation in these stars is real.

### Conference on Organic Evolution

THE National Institute of Sciences of India, encouraged by Dr. S. S. Bhatnagar, recently celebrated the presence in India of the distinguished German biologist, Prof. Bernhard Rensch, by organizing a conference on organic evolution at New Delhi during March 6–8. The programme and abstracts issued by the convener, Dr. Sunder Lal Hora, show that more than fifty papers were read and discussed, half of them being by non-Indian contributors. Four of the papers are by Prof. Rensch and his colleagues on problems of relative growth; four more are by eminent Western scientists, including the veteran French zoologist, Dr. Louis Fage (on subterranean evolution), and the American pioneer on fœtal behaviour, Dr. Lester W. Sontag; and eighteen are by leading British biologists, including Prof. J. D. Bernal, Dr. W. E. China, Prof. J. B. S. Haldane, Mrs. Haldane (Dr. Helen Spurway), Dr. S. M. Manton, Prof. P. B. Medawar, Dr. Joseph Needham, Dr. C. F. A. Pantin, Dr. O. W. Richards, Dr. E. S. Russell, Dr. W. R. Thompson and Prof. F. E. Zeuner. The preface notes that all the British contributions, and some of the others, were secured by Mr. Cedric Dover. These names are by themselves a guarantee of a lively and important symposium, and the abstracts indicate that some of the most fundamental concepts of biology are directly attacked or implicitly discarded by the proposal of new approaches. Some papers, led by those of Drs. Pantin and Manton, are concerned with functional morphology; and several Indian contributions are obviously inspired by Dr. Hora's biogeographical theories. The gene theory is not favoured by some authors, while others have written within its conventions; and, though the idea of adaptations in one way or another is almost a keynote of the symposium, it is also seriously criticized and modified, especially by Drs. Russell and Thompson. Indian biologists are not as well represented as they might have been if the organization could have been more leisurely; but the abstracts suggest that papers of wide general interest have been provided by Drs. E. K. Janaki Ammal, C. P. Gnanamuthu, A. K. Ghosh and A. Bose, Sunder Lal Hora, K. and C. Jacob, H. K. Mookerjee, Sivatosh Mookerjee and M. L. Roonwal. A whole number of the *Bulletin of the National Institute of Sciences of India*, which will be published within the new few months, will be devoted to this symposium.

### Society for the Bibliography of Natural History

THE annual general meeting of the Society for the Bibliography of Natural History was held at the British Museum (Natural History) on March 30. Mr. Walter Necker spoke on "The Unsystematic Systematist, and Other Random Observations on Bibliography in England and America". It was reported that preparations were actively going forward for the production of the first part of the third volume of the Society's *Journal*. The following officers of the Society were declared elected: *President*, Dr. J. Ramsbottom; *Honorary Secretary and Treasurer*, Mr. A. C. Townsend, British Museum (Natural History), Cromwell Road, London, S.W.7; *Committee*, A. G. Davis, W. N. Edwards, F. C. Fraser, F. J. Griffin, W. T. Stearn and C. Kirke Swann.

### Laboratory Animals Bureau Congress

THE sixth Laboratory Animals Bureau Congress was held at the Royal Veterinary College, London, during March 27–28. Some two hundred and fifty technicians from all parts of Great Britain attended. The Congress was opened by the secretary of the Medical Research Council, Sir Harold Himsworth. Six short papers were read by technicians, and one long one, on reproduction in mammals, by Dr. I. W. Rowlands, of the Agricultural Research Council Institute of Animal Physiology, Babraham. Visits were paid to the National Institute for Medical Research, Mill Hill, and to the Lister Institute at Elstree, and a programme of films of zoological interest was shown at the College. Chairmen at the four sessions were Prof. S. P. Bedson, Dr. L. Harrison Matthews, Dr. R. Lovell and Prof. R. E. Glover. As in previous years, the Animal Technicians Association held its annual general meeting at the time of the Congress. The proceedings of the Congress will be published in full in the *Journal of the Animal Technicians Association*.

### Applied Microbiology

MICROBIOLOGY is now well established as a scientific discipline, and the publication of the results of fundamental research is fairly well catered for in the journals of the scientific societies. In recent years the application of microbiology to the manufacturing and food industries, to agriculture, and to the many fields in which control of micro-organisms is demanded, has resulted in the presentation of many papers of undoubted value which would, however, be out of place in journals devoted to fundamental research. Many industries, and even branches of industries, now publish the results of applied research, including microbiology, in their own journals. The Society of American Bacteriologists, by sponsoring a new journal, *Applied Microbiology* (The Williams and Wilkins Co., Baltimore 2, Maryland, U.S.A., 6 numbers, bimonthly, per volume annually 63*s*.), evidently considers that there is a place for yet another journal designed, to judge from the general statement of aims and from the list of members of the editorial board, to embrace all fields except animal and plant disease. The project is ambitious, and to achieve the apparent object there will have to be careful selection of papers, to avoid wandering into territory already catered for. The first number (January 1953) contains a catholic collection of papers, of which some at least have that wide appeal necessary to justify the appearance of another journal which must be read.

### New York Zoological Society: Aid for Biological Research in Europe

THE New York Zoological Society has renewed for 1953 its 'Point Four' programme of aid to biological research in Europe. In 1952 the Society made grants for research to individuals and institutions in Austria, Belgium, Denmark, England, France, Germany, Holland, Italy, Spain, Sweden, Switzerland and Turkey. This year funds will again be made available to research departments or individual investigators in universities, natural history museums, zoological parks, aquariums and non-profit biological laboratories. The use of funds is limited to the purchase of specific items of research equipment, books and technical journals, and the costs involved in providing experimental material. It is not intended to provide assistance to personnel of medical institutions, commercial laboratories, government-sponsored programmes or any programme concerned primarily with applied or economic biology; however, individuals or groups in such organizations are eligible for aid in connexion with any fundamental studies of their own which are being carried out simultaneously but separately. Applications for grants should be addressed to Dr. Ross F. Nigrelli, chairman of the New York Zoological Society European Research Fund, Zoological Park, New York 60, N.Y.

### Insects of Micronesia

THE Bernice P. Bishop Museum, Honolulu, is now supporting the project known as "Insects of Micronesia" which was hitherto carried on by the Pacific Science Board of the United States National Research Council with funds from the Office of Naval Research of the United States Navy; the National Science Foundation, Washington, D.C., has made a grant of 15,200 dollars to the Bishop Museum to help in continuing the work for the next eighteen months. The project is under the direction of J. Linsley Gressitt, and the results will be published by the Museum as a special series. About four hundred thousand specimens have been assembled from Micronesia, and these are being studied by more than a hundred specialists representing some fifty institutions in a dozen countries. J. F. Gates Clarke, N. L. H. Krauss and Dr. Gressitt have been completing the field-work in the Caroline Islands during 1952–53 under a contract by the Office of Naval Research.

### Announcements

THE Stas Medal of the Société Chimique de Belgique was presented to Prof. F. A. Paneth, professor of chemistry in the University of Durham, on the occasion of the general meeting of the Society on March 22.

PROF. JEAN LERAY, of the Collège de France, Paris, has been elected a member of the Mechanics Section of the Paris Academy of Sciences in succession to the late Prof. E. Vessiot. Prof. Christian Champy, professor of histology in the University of Paris, has been elected a member of the Anatomy and Zoology Section of the Academy in succession to the late Prof. C. Pérez.

THE National Coal Board has appointed Mr. A. Whitaker to be director of extra-mural research. In addition to its own research establishments at Stoke Orchard and Isleworth, the Board has extensive research interests in several research associations and also sponsors projects at a number of universities and with commercial firms. This work will in future be directed by Mr. Whitaker, who will be responsible to the director-general of research at headquarters, Dr. W. Idris Jones. Mr. Whitaker is a physicist; during the War he was with the Parnall Group of companies and was awarded the O.B.E. for work in connexion with aircraft equipment.

THE Zoological Society of London is offering a limited number, not exceeding six, of research studentships to senior undergraduates reading zoology, tenable during the summer vacation for a minimum period of four weeks at the Society's Gardens, Regent's Park, or at Whipsnade Park, where laboratory and other facilities are provided. Work which includes observations on living animals will be given preference; experiments requiring licences are not allowed. Grants in aid of travelling expenses and a subsistence allowance for those living away from home may be awarded. Applications, giving particulars of the applicant's age and attainments and a brief outline of the work proposed, and supported by the head of the department in which he or she works, should be sent before April 30 to the Director, Zoological Society of London, Regent's Park, London, N.W.1.

IN a paragraph in *Nature* of February 21, p. 332, entitled "A Dominant Sex-linked Mutation in the House Mouse", summarizing a paper by E. D. Garber published in *Science*, 116, No. 3004 (1952), the gene 'bent-tail' and its morphological effects were described. Dr. D. S. Falconer points out that he had already recognized a sex-linked gene, 'tabby', with morphological effects in the mouse (see *Nature*, 169, 664; 1952).

# DISTRIBUTION OF ANIMALS AND PLANTS IN AFRICA

A WHOLE-DAY meeting of the Linnean Society of London was held in the Society's rooms at Burlington House on January 29. The subject for discussion was "Problems of Distribution of Animals and Plants in Africa". In opening the meeting, the president of the Society, Lieut.-Colonel R. B. Seymour Sewell, stressed the importance of a sound taxonomic background to studies on distribution. Only when one knew with what species one was dealing was it possible to answer questions regarding its place of origin, method of spread and eventual isolation. Other studies of importance to the biogeographer were palæontology and climatology, including the study of past climates.

The first paper was read by Mr. E. Milne-Redhead, of the Royal Botanic Gardens, Kew, who dealt with the distributional ranges of flowering plants in tropical Africa. Of the three arid regions, the Sudanese is by far the poorest and the south-western the richest floristically. The northern savannas exhibit drier (Sudanese) and wetter (Guinean) zones characterized by the presence, in the former, of numerous species of *Acacia* and, in the latter, of *Isoberlinia*. *Brachystegia*, which is abundant in the wetter part of the southern savanna, is absent from the corresponding zone of the northern. An additional feature of the southern savannas is the presence of a thicket vegetation in the dry areas of central Tanganyika. The Kakamega forest marks the extreme eastern limit of the Congo forest, which was at one time much more extensive in Uganda than it is to-day. The vegetation of Uganda is now largely secondary and very difficult to classify. The existence of a complete gap in the dry area of the Gold Coast and Togoland is to be noted, as is the constriction of the Congo forest in the neighbourhood of the 15th meridian, which may mark the site of a former route for migration between the northern and southern savannas. The extension of forest into the savannas in the form of fringing forests along the rivers should also be noted. The small relict areas of lowland forest along the east coast are floristically different from the Guinean and Congo forests. Mr. Milne-Redhead concluded by describing distributions of individual species illustrating points of special interest. He ended with an appeal to zoologists to restrict the term 'Ethiopian' to the territory formerly known as Abyssinia instead of applying it, as now, to tropical Africa as a whole.

Mr. R. E. Moreau, of the Edward Grey Institute, Oxford, followed with a paper on the distribution of African evergreen-forest birds. He began by stating that, contrary to general belief, birds are excellent zoogeographical material. Those of tropical Africa are very strictly confined to their habitats, so much so that where the latter form isolated ecological islands the avifauna frequently shows a high degree of subspecificity, an indication of the thorough reproductive isolation of populations even when these are in close geographical propinquity. Over most of tropical Africa the 5,000-ft. contour forms the lower limit of the montane forest birds; but in certain areas, as in the mountains near the Indian Ocean, the transition takes place at altitudes as low as 3,000 ft. Broadly speaking, it may be said to take place between the annual isotherms of 18° C. and 21° C. Owing to the present very great restriction of most of the African montane forests and their isolation from the lowland forests, due partly to a dry climatic cycle and partly to human exploitation, it can only be studied in unbroken series in some areas of the eastern Belgian Congo and, on a smaller scale, on hills near the Indian Ocean. It is a remarkable fact that even in such areas as these the avifauna of the montane forest is almost as different from that of the lowland forest as it is from that of the savanna. Despite this, however, many montane species have a wide distribution in isolated forests. (An extreme example is afforded by the resemblance of the Cameroon Mountain avifauna to that of East Africa.) As against this the Abyssinian mountain fauna is much poorer than might be expected, while the degree of subspeciation even on closely adjacent mountains in East Africa is high. In conclusion, Mr. Moreau suggested some possible features of the climatic history of the continent which might help to account for these facts. Viewed *in toto*, however, the problem of the origins of the present distribution of forest birds remains a most baffling one.

The last paper of the morning session was read by Dr. A. T. Hopwood, of the British Museum (Natural History), on the origin and history of the African mammalian fauna. He began by stressing the difficulty of dating the available fossil remains. This arises mainly from two causes, the virtual absence of marine deposits and the difficulty of distinguishing ecological differences from differences of age. Like the birds, the mammals tend to be closely restricted to their preferred habitats, and in consequence distinct savanna and forest forms may be found in close geographical proximity. Oligocene deposits are rich in Hyracoidea and Proboscidea, both of which are probably African in origin, although the Oligocene Proboscidea of Baluchistan have some very primitive features. The Oligocene of the Fayum and of Baluchistan is also very rich in anthracotheres. Large collections are available from the Lower Miocene of Central Africa. These have not yet been fully worked out; but the fauna is known to have contained primitive mastodons, very close to those of the Upper Oligocene of Baluchistan, well-developed chrysochlorids (an apparently autochthonous group) and many rodents and creodonts as well as the earliest known fossil aardvark. The latter may possibly have been a Lower Miocene or Oligocene invader. The Miocene fauna of Kenya shows a close resemblance to that of south-west Africa, except that the latter contains no primates. No Pliocene remains are yet known. The Pleistocene fauna shows a very close resemblance to that of the recent era, many forms being scarcely even specifically distinct. Hippopotamus and giraffe first appear in Africa in the Lower Pleistocene and were almost certainly invaders from Asia, perhaps from India.

In the afternoon the chair was taken by Dr. W. E. Swinton. Mr. P. F. Mattingly, of the British Museum (Natural History), opened the session with a paper on the distribution of African mosquitoes. He began by discussing the climatic limits of Chapin's faunal districts, speaking mainly with reference to the subgenus *Stegomyia*. Only two species of this subgenus are naturally distributed throughout the Upper and Lower Guinean Forest districts, an example of the exclusive nature of the evergreen forest. Both species extend into the surrounding savannas. To the north they are limited by the 40-in. isohyet which here seems to form the natural boundary of the West African subregion. To the east they extend into the Kakamega forest, and the limit here seems to be an altitudinal one, about 5,500 ft. in the case of one species and about 6,000 ft. in the case of the other. To the south this difference allows one species to spread up on to the Rhodesian plateau, while arresting the other at about 3,500 ft. and confining it to the western subregion. Evidence was brought to show that the effect of rainfall on distribution may be largely indirect, the operative factor being the subsoil water-level which determines the nature of the vegetation, and so of the microclimate. The existence of a West African savanna species with a discontinuous distribution in the coastal area of Natal and Zululand indicates a former much wider extension of the central African forests. The affinities and distribution of the East African Highland fauna were discussed, and attention was directed to the existence of a typical member of the African group of *Stegomyia* in a restricted area of eastern Asia. This was discussed in relation to the origins of the African fauna, and notes were given on geographical variation and the zoogeography of introduced species.

Prof. P. C. C. Garnham, of the London School of Hygiene and Tropical Medicine, then read a paper on the distribution of blood protozoa in Africa. He said that, with the exception of a few groups of special importance, this was practically a virgin field. In addition to the two factors discussed by previous speakers, the organism and its environment, it was necessary to take account of two more, the host and the vector. There could be no zoogeography of the blood protozoa *per se* but for the fact that there occur cases in which the host and the vector are present but the parasite is not. The factor of human interference was of special importance because man could act separately on parasite, host or vector, exterminating or reducing them or increasing their numbers by importation, domestication or transportation to more suitable environments. The best parasites to study would be those whose hosts are static or have a limited range. Unfortunately, data concerning these are scanty. Examples were then given from the malaria parasites, of which the human forms occur throughout Africa, except in deserts and above certain altitudes (about 9,000 ft. in equatorial latitudes), the related Hæmoproteidæ, the hæmogregarines, the trypanosomes and the piroplasms, all of which show interesting examples of discontinuous or restricted distributions.

Dr. W. E. Kershaw, of the Liverpool School of Tropical Medicine, followed with a short paper on the distribution of human filarial parasites in West Africa. He said that the distribution of these parasites could be related in varying degrees to the vegetational zones, though less clearly than in free-living animals. The human parasite *Loa loa* occurs, it is believed, also in monkeys. It is transmitted by biting flies (*Chrysops*), which feed on monkeys in the canopy and on man either on the ground or in houses built on ridges level with the canopy. The parasite is confined to the evergreen forest and disappears as soon as the forest fringe is crossed. *Acanthocheilonema perstans* is also ubiquitous in the forest and absent from the mountain grassland, despite the presence there of one of its vectors (*Culicoides* spp.). It is also abundant, however, in the arid, eroded grasslands of the Bauchi plateau. It seems, therefore, that, in this case, very different vegetational zones can provide suitable conditions for the maintenance of the parasite.

This session concluded with a paper by Dr. E. B. Worthington, of the Conseil Scientifique pour l'Afrique au Sud du Sahara, on the distribution of freshwater organisms. He said that the continent could be divided into ten aquatic regions, but confined his remarks mainly to the eastern and central area comprising six regions, the Nilotic, Victorian, Tanganyikan, Nyasan, Zambesian and East Riverain, pointing out that these were not all coincident with drainage basins because in some cases differences in ecological conditions formed more potent barriers than dry land. Small freshwater organisms and even fish may become airborne at times. Discussing the mode of origin of present-day distributions, he suggested a hypothesis, based on past tectonic and climatic changes, to account for the picture now presented by the great lakes of East Africa. This hypothesis, he said, had first been put forward twenty years ago, but it had stood the test of time and still seemed worth restating. Active work was in progress and details were continually being filled in. Finally, he directed attention to the great interest of studies on such phenomena as the *Haplochromis* species swarms of Lake Victoria for general evolutionary theory and for our understanding of the mechanism of speciation. He said that, despite criticism, he still adhered to his opinion regarding the importance, in this connexion, of the absence of predators. He concluded by referring to the factor of human interference. This had a long history but had recently been intensified by such developments as fish farming and the use of fish in the control of disease. In some cases it was irretrievably altering local conditions before sufficient had been learnt about them.

The whole of the evening session was devoted to an open discussion. Contributions of the principal speakers will be published in full, with a report on the discussion, in the *Proceedings of the Linnean Society*.

P. F. Mattingly

# THE BIRTH OF FLIGHT*

### By the Right Hon. LORD BRABAZON OF TARA, P.C.

ALTHOUGH from earliest times smoke must have been noticed to arise from fire, it was not until the eighteenth century that the brothers Montgolfier realized the principle of using hot air to make a balloon rise. Yet such a primitive people as the Australian aborigines invented the boomerang, which aerodynamically shows three remarkable characteristics: the lift obtained from a surface which is flat on the underneath but curved on the top; the recession of the axis of rotation due to a force on one side of the rotating body; and the auto-rotating effect of a boomerang due to the change of kinetic energy into rotational energy (at the end of its flight the boomerang rotates more violently than when launched).

Nature provides a varied selection of methods of flight. Thus there are the gliding seeds, of which a number among the conifers give remarkably long glides, and auto-gyration in Nature is illustrated by the fall of an ash seed which, with but one wing, rotates at a high speed and can be carried a long way by the wind. The flapping wing is the most obvious mechanism of flight observed in the animal world; but the position occupied by birds both in normal flight and in landing clearly shows the impossibility of designing a machine along these lines by an engineer.

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* Substance of a Friday Evening Discourse delivered at the Royal Institution on February 20.

Mr. R. T. Parham, of the Society of Model Aeronautical Engineers, has built two remarkable flying models (demonstrated during the Discourse): one a helicopter which remains almost stationary in mid-air, and another of the flapping wing type, weighing complete less than ¼ oz., which performs most creditably.

It is curious that nobody seems to have studied the gliding of birds with wings of high aspect ratio (that is, long and narrow), such as the gull or albatross, which can achieve a gliding angle of about 1 in 12 (though modern gliders can now exceed this, the limit being about 1 in 42); had this type of gliding in Nature been studied earlier, there is nothing that our ancestors could not have constructed along these lines, even with the materials available two thousand years ago.

Sir George Cayley (1774–1857) was a pioneer who should be remembered, for not only did he invent the hot-air engine and the tension-spoke wheel, but he also made very remarkable model gliders. Cayley had correspondence with Stringfellow regarding the building of a big machine with steam engines, and a quotation from one of his letters—"We must go slow, I assure you before flight is safe a hundred necks will be broken"—is a classical understatement in prophecy.

The Royal Aeronautical Society was born in 1866; but it was not until 1896 that Lilienthal, a very great man, started his series of glides which may be looked upon as the basic beginning of modern flying. Chanute biplanes with movable surfaces were the inspiration of the experiments in gliding made by the Wright brothers, and in 1902 they made more than a thousand glides, some as long as 600 ft. in winds up to 36 m.p.h.

Putting to one side the flights of Santos Dumont with powered airships early this century, the history of power flight is marked by the experiments in 1894 of Sir Hiram Maxim and by the machine which S. P. Langley built in the United States. After efforts had failed to launch the Langley machine from the air off a scaffolding instead of along the ground, the experiments were abandoned on December 8, 1903, and nine days later, on December 17, the Wright brothers made their first flight; whether Langley's machine would or would not have flown is problematical, but if it had been launched another way it certainly should have risen.

Remarkable developments in the construction of engines were made by the French with their rotary radial engine and the V-type *Antoinette*. The great *Antoinette* machine flown by Latham only just failed to cross the English Channel on two occasions, and this feat was achieved by the Blériot machine in 1909 with its three-cylinder air-cooled engine. Although the Americans and French would appear to have dominated the early stages of power flight, yet the British achievements with machines flown by Cody, Roe, Moore-Brabazon and others should not be overlooked, and remarkable work was done by Edward Busk at the Royal Aircraft Establishment well before the First World War.

# PARLIAMENTARY AND SCIENTIFIC COMMITTEE

## ANNUAL REPORT FOR 1952

THE annual report of the Parliamentary and Scientific Committee for 1952* lists addresses and discussions at meetings of the general committee during the year. Included among these addresses are that by Lord Woolton on government organizations concerned with research and technology, by Dr. J. B. Conant on Anglo-American scientific relations, by Mr. T. M. Herbert on "The Present Scope of the Railway Research Programme" and by Sir Andrew McCance on "Application of Research in the Steel Industry". Addresses were also given on "Management and the Better Use of Science and Technology in Industry", and, followed by discussions, on "Foot-and-Mouth Disease" and the "Shortage of Science Teachers and its Consequences".

The report records the motion tabled on December 5 by Mr. Austen Albu but not debated; this motion, after recording the necessity for a great expansion in exports—particularly of those goods which require for their design and manufacture a high degree of research, technological development and scientific organization of production—urged the Government to take all possible steps to accelerate the more intensive application of the results of research and scientific discovery. For that purpose, it recommended that particular attention should be paid to the importance of ensuring: (1) adequate and long-term arrangements for financing industrial and agricultural research, whether by individual firms, research associations, government establishments or other means, and all consequential action necessary to ensure the fullest appreciation and application of the results of that research; (2) the use of the capital investment programme to encourage more rapid and effective applications of the results of scientific research in the agricultural, industrial and Colonial fields, with adjustments of taxation to assist small businesses engaged on work of scientific development; (3) the provision of the best possible scientific advice at high levels in connexion with all policy decisions relating to capital investment, industrial re-organization and controls concerned with the use of man-power and materials; and (4) an increase both absolute and relative in the number of scientific workers and technologists in all industries and accordingly the most rapid possible expansion of the facilities for their education in the universities, technical colleges and other educational establishments by the provision of sufficient money and materials and by steps to improve the supply of science teachers for the schools.

As a result of further meetings of the Colonial Sub-Committee, a memorandum dealing with questions relating to education, agriculture and fisheries, health, forestry and the future of the Colonial Development and Welfare Fund was prepared, and approved by the General Committee on December 16. In connexion with the last-named Fund, the memorandum included the following statement.

"All plans for the effective application of science and technology in the Colonial territories depend to a large extent on the availability of funds from this source, and as most of these plans are inevitably of a long-term nature it appears desirable that the funds should not only be increased in volume but that arrangements should be made for sufficient monies from them to be available for several decades ahead. This is particularly important so far as assistance to Colonial education is concerned. Our review of the evidence which we have heard leads us to the conclusion that progress towards the better application of science and technology in Colonial territories depends primarily on opportunities for elementary education being widely extended. Until education is so broadly based that the vast majority of the indigenous population has become literate there will be no chance of obtaining technically trained field workers in sufficient numbers; nor will such field workers as do exist be able to obtain from villagers and peasantry that degree of intelligent co-operation without which theory, however sound, can never be translated into practice.

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* Annual Report of the Parliamentary and Scientific Committee. Pp. 24. (31 Palace Street, London, S.W.1.)

"It appears unquestionable that the successful development of the Colonial Empire depends chiefly on the more efficient application of modern scientific knowledge and methods in such fields as agriculture, forestry, medicine or veterinary science and in other activities connected with the development of natural resources. But such efficient application depends in its turn very largely upon the technical competence of the indigenous populations and their ability to take an active part in the process."

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# BUDGETS OF THE SCIENTIFIC DEPARTMENTS OF THE UNIVERSITY OF CAMBRIDGE

By Sir LAWRENCE BRAGG, O.B.E., F.R.S.

AN analysis has recently been made of the recurrent annual expenditure for seventeen scientific departments in the University of Cambridge. A brief summary of the figures is given below, as they may be of general interest. I am much indebted to the University treasurer, Dr. H. M. Taylor, for providing me with the material and assisting me in preparing this summary. The figures relate to the financial year 1950–51.

Some explanation of the basis of the analysis is necessary. For some years an analysis has been made of the expenditure in the Cavendish Laboratory, and a reasonable allocation of the budget between research and teaching shows that one research worker costs as much as ten full-time undergraduates. In arriving at this figure it is reckoned that the time of the staff is divided equally between teaching and research, and other items, such as assistants' wages, materials and apparatus, are allowed for. The 'cost per effective research worker' is arrived at by adding to the number of staff, holders of research fellowships and scholarships and Ph.D. students, one-tenth the number of full-time undergraduates (due allowance being made when undergraduates only get a part of their teaching in the Laboratory), and dividing the total itemized costs by the total number so obtained. In the Cavendish Laboratory, for example, an estimated cost of £755 per 'effective research worker' implies a cost of £75 a year for an undergraduate student. It must be remembered that the last figure only represents the University's contribution to his teaching, a very substantial part of which is provided by his College.

The expenditure includes the contributions to research made by outside bodies such as the Department of Scientific and Industrial Research and other government bodies, and by industry; in other words, the complete budget of each department. The capital cost of buildings and of large items of equipment such as the cyclotron is not included; but the recurrent expenditure of maintenance and of providing assistants to run apparatus has been taken into account. A proportionate share of the cost of the central administration and of the services of the Buildings Syndicate is added to the budget of each department.

For the scientific departments as a whole the staff and students are made up of: graduate staff, 340; research students, 561; undergraduates, 2,870; research assistants, 80; and assistant staff, 745. The volume of the buildings is 12·797 million cu. ft., the volume per 'effective research worker' being 15,000 cu. ft. The current expenditure during the financial year 1950–51 for the scientific departments is as follows:

| | Totals | Per effective research worker |
|---|---|---|
| Administration | £82,244 | £69 |
| Teaching and research salaries | 411,266 | 346 |
| Assistant staff wages | 156,095 | 131 |
| Supplies | 149,386 | 125 |
| Heat, light, water* | 32,185 | 27 |
| Repairs and maintenance* | 49,673 | 42 |
| Totals | £880,849 | £740 |

* The annual cost of heat, light and water per thousand cubic feet is £2·5, and that of repairs and maintenance £3·9

When a research student is admitted to one of the Cambridge laboratories, he is therefore in effect being given a research grant of £740 a year. This does not, of course, imply that, if an extra research worker is taken on, the budget is automatically increased by this amount, or vice versa if the number drops, since many of the charges are fixed charges which can only be altered by a general expansion or contraction of the department taking place over a long period. The figures do not include the fellowships, scholarships or maintenance allowances paid to research workers who are not on the staff. If we take these grants to be on the average £500 a year, the cost to the community of maintaining a scientific research worker at Cambridge is, in round figures, £1,250 a year.

The figures for individual departments vary considerably, but most lie in the range £600–900 a year. The costs of physics and chemistry, which are the largest scientific departments, are very close to the average value. For the Cavendish Laboratory the staff and students are made up of: graduate staff, 32; research students, 117; undergraduates, 544; and assistant staff, 88 (including research assistants). The expenditure for the Cavendish Laboratory is as follows:

| | Total cost | Cost per research worker |
|---|---|---|
| Administration: | | |
| Departmental £5,506 | | |
| Central £6,600 | £12,106 | £70 |
| Salaries | 44,752 | 257 |
| Wages | 25,694 | 148 |
| Supplies | 33,419 | 192 |
| Heat, light, water | 7,277 | 41 |
| Repairs and maintenance: | | |
| Departmental £4,496 | | |
| Central £3,723 | 8,219 | 47 |
| Totals | £131,467 | £755 |

As might be expected, costs for the literary faculties are considerably lower. When calculated on the same basis of one research worker being equivalent to ten undergraduates, the average figure is £416 a year as compared with £740 a year in the scientific faculties. Assistants' wages, supplies and services are expensive items in the scientific budgets.

# DEPOPULATION AND RURAL LIFE IN SCOTLAND

IN 1948, the Social Survey of the Central Office of Information was asked by the Department of Health for Scotland to carry out, in selected areas of Scotland, an investigation into rural living conditions and the causes of rural depopulation. The three areas were the Solway counties of south-west Scotland, the Tweed Basin, and north-east Scotland, within the counties of Aberdeen and Banff.

The Solway area was the subject of a detailed report. In the other two areas the results of the investigations showed that conditions there differed only slightly from those obtaining in the south-west. A cursory examination of the three sets of results revealed that, in the districts that were surveyed, the main problems of rural life remained the same, although sometimes presented with slightly different emphases. It seems possible, therefore, that the same kind of remedial measures would be applicable to all the survey areas. On the other hand, the analyses of the results from the Solway survey left in doubt the fundamental factors that had caused the decline of the population of the area. An attempt has therefore been made to isolate these factors with the aid of material from the Tweed and the Aberdeen inquiries, together with the results of a postal questionnaire sent to persons known to have migrated in the preceding twenty years[*].

A summary of the major findings showed that, in the rural areas studied, a tenth of the adult population said they would prefer to move away; but the proportion varied from county to county. Wigtownshire and Peeblesshire showed a rather higher proportion of potential migrants (those counties being more isolated and less well served with modern amenities than others), while in the better-served counties of Selkirk and Berwick the proportion was somewhat lower than the average. Only a small minority (17 per cent) of the potential migrants had actually made plans to move within a year of the date of interview, giving an average of 1·7 per cent of the adult population of the survey areas whose desire to move had reached the stage of action. People related to earlier migrants tended to become potential migrants themselves slightly more often than people who were not so related. They were also rather more conscious of the advantage of urban forms of life.

Analysis showed that national and local government, the building industry and the personal service industries produced a rather higher than average proportion of potential migrants. In contrast, there was a significantly smaller proportion of potential migrants from among those employed in agriculture, and from people who were retired or had no occupation. On the other hand, the desire to migrate was most frequently found among professional workers, clerical workers and the managerial and executive grades. The supervisory and skilled operative grades produced a smaller than average proportion of potential migrants. Within agriculture, farmers, bailiffs and foremen showed the smallest proportion of potential migrants of all occupations.

The desire to move was expressed rather more often by the young and the single people than by the old and the married. Thus, while of the general population of the survey areas 20 per cent were under thirty years of age, among the potentially migrant group 37 per cent were of this age.

The situation of the informant's dwelling had only a small degree of association with his desire to move or to remain. Thus, people living in an isolated house, or in a house situated in a small lonely group, were less likely to wish to move away than people living in the burghs. Similarly, people whose houses had no road access were less likely to wish to move than people living on main and other metalled roads. There was a greater degree of association, however, between the informant's subjective estimate of the convenience of the location of his home and the desire to move. Nearly three times as many people who said their homes were situated inconveniently as of those who thought them conveniently located said they wished to move to a town. The majority of houses thought 'inconveniently' placed, however, were in burghs or villages. An analysis of some of the actual conditions of housing and amenity in the survey areas showed that the households of potential migrants were, slightly more often than the average, enjoying a main water supply and main drainage, and were more often provided with gas, electricity, telephone and refuse collection services.

Visits to burghs were rather more frequent among potential migrants than among other people. The reasons for their visits laid a rather greater emphasis upon social calls and entertainments than upon business and marketing, compared with the rest of the rural population.

The reasons which potential migrants gave for their preference appeared to fall into the following major categories: the desire for a better job; the desire to escape rural loneliness and stagnation; the wish for change and new experience; and miscellaneous answers of which a considerable proportion referred to factors such as marriage, transfer by employer, and personal family reasons. Replies to a postal questionnaire showed that migrants had made a considerable advance in occupational skill and position after leaving rural areas. As many as 50 per cent of past migrants said they would not have moved away from the countryside had a better choice of jobs been available there.

From these findings it is difficult to point without hesitation to any single factor which has led to the process of depopulation. The explanations given by past and potential migrants for their wish to migrate offer the most solid indications as to the causes of rural depopulation. Both in the past and to-day the desire for occupational advance appears to have been the most frequent cause of migration, while evidence suggests that migration has, in fact, been accompanied by a rise in occupational status. Secondly, there was a desire to escape from the stagnation and solitude of rural life, a desire for new experience and the more vivid social life of the towns. Thirdly, there was the migration brought about by rural–urban intermarriage (probably accelerated by the War) resulting in homes being set up in the towns where the husband or wife was already living. Fourthly, some moved or wished to move for a number of circumstantial reasons, such as ill-health, family reasons, transfer by employer, and so on. Finally, there was a miscellaneous group of reasons such as bad climate in the rural areas, or children's education.

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[*] Depopulation and Rural Life in the Solway Counties. By Bertram Hutchinson. (N.S. 120.) Pp. iv+110+25 plates. Depopulation and Rural Life in the Tweed Valley. By Bertram Hutchinson. (N.S. 120b.) Pp. ii+60. Depopulation and Rural Life in Aberdeen. By Bertram Hutchinson. (N.S. 120c.) Pp. 63. Depopulation and Rural Life in Scotland. (N.S. 120d.) Pp. ii+36. (London: Social Survey, 1949.)

These answers make little reference to the general environmental conditions of rural life, such as housing, public services, entertainments, and transport. A careful analysis of the environmental conditions of informants showed that in many respects potential migrants were no worse off than the remainder of the population, and in some ways were actually better equipped on an average. There is, in fact, a suspicion that small improvements in housing and amenities in rural areas have served to whet the appetite of those who have profited by them rather than to satisfy it. It cannot be said that material factors at any time take the centre of the stage in the examination of the causes of depopulation.

The aim, therefore, must be to make possible a satisfactory mode of life for the rural people on a standard which can be compared favourably with urban conditions. In this way any sense of inferiority among rural dwellers can be avoided, while fulfilling their need for self-respect. Such an outcome can be achieved in part by the provision of a more varied field of rural employment; but it must probably be accompanied by fundamental improvements in rural amenities. Better jobs in the country, it seems, must have their counterpart in the possibility of a standard of living that the people have come to expect.

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# ABSORPTION OF POLYMYXIN BY BACTERIA

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THE five members of the polymyxin group of antibiotics, *A*, *B*, *C*, *D* and *E*, have been shown to possess similar antibacterial spectra and potency[1]. Considerable evidence has accumulated[2–4] indicating that the polymyxins are rapidly bactericidal and not bacteriostatic, although in one paper[5] it was suggested that polymyxins *A* and *B* are bactericidal for small inocula and bacteriostatic for large inocula. In assay experiments, the marked dependence of the minimum lethal concentration of polymyxin upon the size of the inoculum[3,4,6,7] suggests that bacterial absorption of the antibiotic is high.

This communication describes experiments on the absorption of polymyxin *E* by washed suspensions of several Gram-negative and -positive bacteria. The release of soluble cell constituents, initiated by the presence of the antibiotic, and possessing an absorption maximum in their ultra-violet spectra at 260 mμ, has been followed concurrently. Free purines and pyrimidines contribute to this maximum[8,9]. Since microbiological assay of polymyxin is both tedious and not capable of high precision, a simple and accurate method has been developed based upon the observation[10] that the polymyxins form stable unimolecular films at the air/water interface when spread upon 70 per cent (w/w) ammonium sulphate solution. Fig. 1 shows the force/area curves for polymyxin *A*, *B*, *D* and *E* obtained using a standard Langmuir–Adam surface balance. Full details of the properties of these films and estimations of the molecular weights of the antibiotics have been described elsewhere[10]. To determine the concentration of polymyxin in aqueous or buffered solution, an aliquot is spread upon the ammonium sulphate solution, and the area at a surface pressure of 16 dynes/cm. (where compressibility is at a minimum) is compared with that of the standard force/area curve of the particular polymyxin at the same surface pressure. The concentration of the polymyxin solution then follows by proportion. The method is rapid, requires less than 0·5 ml. of solution, and can detect the polymyxins at a concentration of less than 5 μgm./ml. to ± 10 per cent and at 100 μgm./ml. to ± 1 per cent.

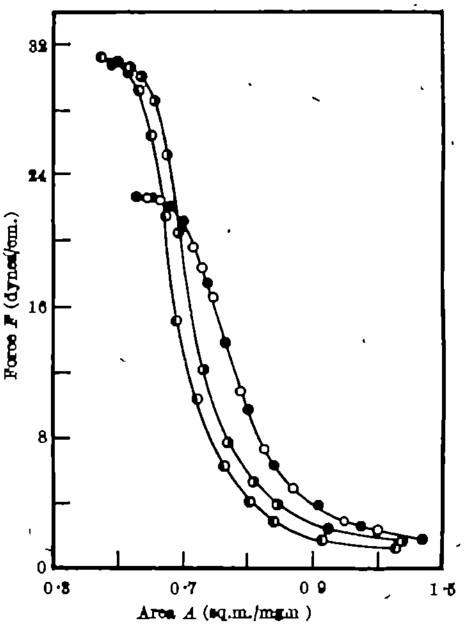

Fig. 1. Force/area curves for polymyxins *A*, ○—○—; *B*, —◐—; *D*, —●—; and *E*, —◒—, spread upon 70 per cent (w/w.) ammonium sulphate solution, *p*H 4·5, at 20° C.

For the absorption experiments the bacteria were harvested after 16 hr. growth at 37° C. and washed four times with 0·01 *M* phosphate buffer, *p*H 6·3,

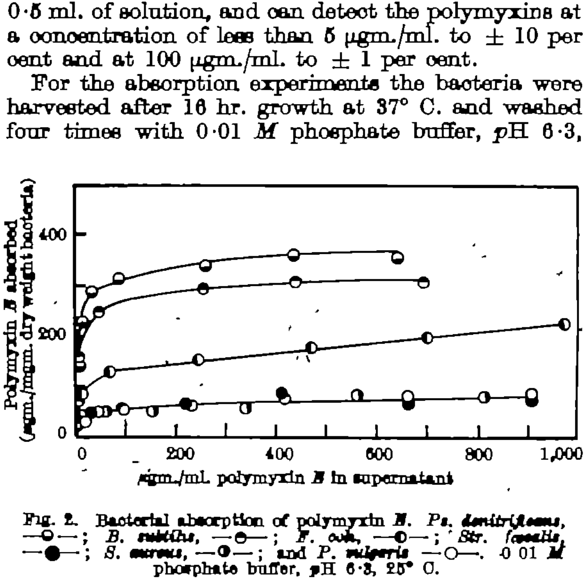

Fig. 2. Bacterial absorption of polymyxin *E*. *Ps. denitrificans*, —◒—; *B. subtilis*, —⊖—; *E. coli*, —◐—; *Str. faecalis*, —●—; *S. aureus*, —◑—; and *P. vulgaris* —○—. 0·01 *M* phosphate buffer, *p*H 6·3, 25° C.

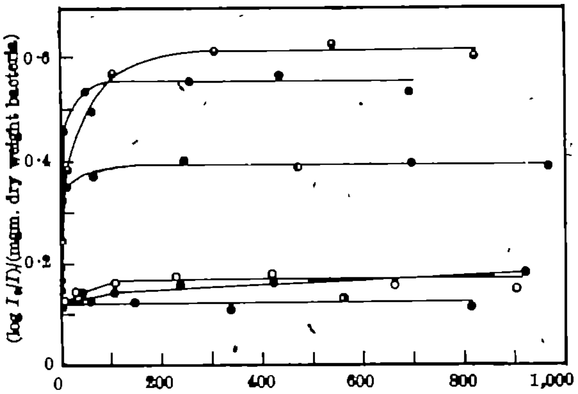

Fig. 3. Release of bacterial cellular material possessing an absorption maximum at 260 mμ. The curves are corrected for the 260-mμ absorption due to free polymyxin E. *Ps. denitrificans*, —◓—; *B. subtilis*, —○—; *E. coli*, —○—; *Str. faecalis*, —●—; *S. aureus*, —○—; and *P. vulgaris*, —○—. 0·01 *M* phosphate buffer, *p*H 6·3, 25° C.

using the centrifuge, care being taken to remove any autolysed organisms present. The bacteria were resuspended to 1 mgm./ml. dry wt. in 0·01 *M* phosphate buffer alone and buffered solutions of polymyxin *E* sulphate. 3-ml. samples were incubated for 20 min. at 25° C. The organisms were then removed by centrifugation and the supernatant solution finally cleared by recentrifuging. Aliquots of these solutions were then assayed for (*a*) residual polymyxin by the above method, and for (*b*) the presence of released cell constituents absorbing at 260 mμ, using a Unicam photoelectric spectrophotometer. The control experiments in the absence of polymyxin showed that the amount of cellular material released during the incubation period and forming an insoluble monolayer on the ammonium sulphate was very small, but where necessary was allowed for in the calculation of polymyxin absorbed. Also with certain organisms (*M. lysodeikticus* and *B. subtilis*) almost complete absorption of polymyxin was obtained at low antibiotic concentrations, giving rise to trough areas no greater than those of the control. This indicated that the cellular materials released did not form monolayers upon the salt solution and hence did not interfere in the assay method.

The polymyxin *E* absorption isotherms and released cellular material isotherms for six organisms are shown in Figs. 2 and 3. Determination of the sensitivities of the organisms by streaking 24-hr. broth cultures upon nutrient agar containing increasing quantities of polymyxin *E* showed that *Ps. denitrificans*, *B. subtilis* and *E. coli* were all inhibited by 5 μgm./ml., whereas *S. aureus*, *P. vulgaris* and *Str. faecalis* were not inhibited by 100 μgm./ml. The results indicate that more polymyxin is absorbed by the sensitive organisms than the highly resistant bacteria. The initial absorption process is complete at polymyxin concentration in the supernatant of 100–150 μgm./ml., after which further absorption is slight. Of four strains of *E. coli* investigated, three showed agglutination phenomena which were maximal at supernatant concentrations of 150 μgm./ml. Similarly, Latterade and Macheboeuf[11] have shown that the *R* form of *E. coli* is agglutinated, whereas the *S* form which contains the *O* antigen is not. Suspensions of *Ps. denitrificans* containing the antibiotic exhibit an increase in optical density also maximal at 150 μgm./ml., and may be due to formation of an insoluble complex between bacterial components and polymyxin similar to those demonstrated between polymyxin and yeast ribonucleic acid[11] and serum albumen[12,5]. Fig. 3 shows that, in the case of the highly resistant organisms, polymyxin causes no significant increase in the release of material showing absorption at 260 mμ when compared with untreated control cells. With sensitive bacteria, however, the presence of polymyxin causes a rapid release of cellular material which is complete at low concentrations of polymyxin in the supernatant. Experiments with *B. subtilis* showed that the absorption of polymyxin and release of material showing absorption at 260 mμ were rapid and unaffected by incubation times between 5 and 60 min.

It is evident that one of the effects occurring immediately after the exposure of sensitive bacteria to polymyxin is a disturbance of the osmotic properties of the organisms and consequent rapid release of cell materials. In this connexion, it has been shown that the injection of polymyxin *E* to a concentration of 0·5 μgm./ml. beneath certain oriented monolayers results in absorption and rapid penetration of the monolayer, although the depression of surface tension of a polymyxin *E* solution at this concentration would be less than 0·1 dyne/cm.

We wish to thank the Wellcome Research Laboratories for the polymyxins, Dr. E. F. Gale for certain bacteria, the Department of Pathology, Cambridge, for culture media and the Medical Research Council for a personal grant to one of us (A. V. F.).

[Dec. 11.

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# CHROMATOGRAPHY OF THE GROWTH SUBSTANCES IN PLANT EXTRACTS

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A METHOD for the chromatographic separation of plant growth substances was described by Bennet-Clark and Tambiah at the Society of Experimental Biology conference in January 1951. Later, they published details of this method[1], which Luckwill[2] has also employed.

For the successful routine chromatography on paper of plant extracts, the original technique has been modified. The plant tissues examined have usually been seedlings, which were chosen for their possible use in subsequent growth studies, and since

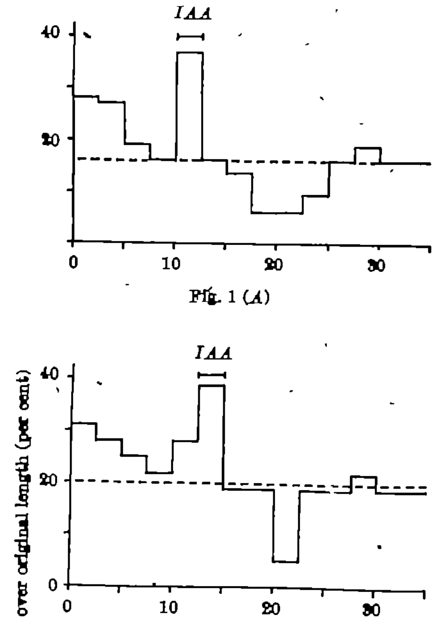

Fig. 1 (A)

Fig. 1 (B)

Activities in coleoptile extension, shown as histograms, of squares cut from chromatograms of etiolated broad bean shoot extract (1 A) and broad bean root extract (1 B). Broken lines represent the extension of controls, and the position of an indole-3-acetic acid guide-spot is marked *IAA*.

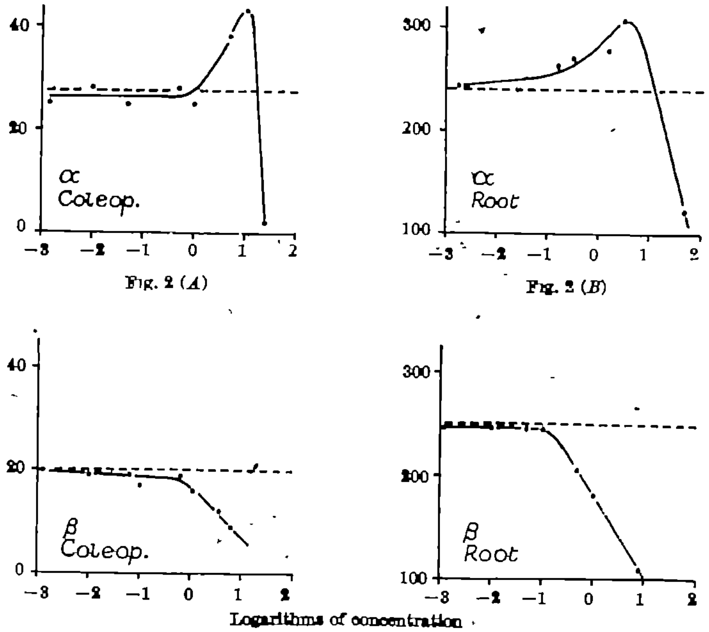

Fig. 2 (A)

Fig. 2 (B)

Fig. 2 (C)

Fig. 2 (D)

Activities in coleoptile extension (2 A) (2 C) and root extension (2 B) (2 D) of a series of concentrations of accelerator-α (2 A) (2 B) and inhibitor-β (2 C) (2 D). Unit concentration is roughly that of the hormone in the tissue (see text). Broken lines represent the extension of controls.

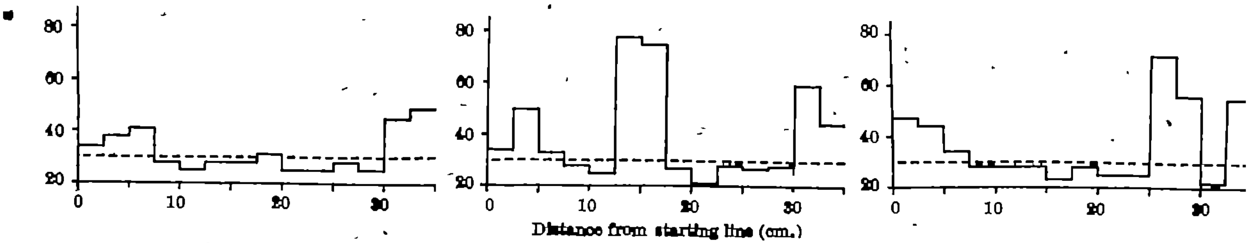

Fig. 3 (A)

Fig. 3 (B)

Fig. 3 (C)

Activities in coleoptile extension, shown as histograms, of squares cut from chromatograms of *Aegopodium podagraria* rhizome extract after rhizom had been treated with water (3 A), indole-3-acetic acid (3 B) and 2 : 4-dichlorophenoxyacetic acid (3 C). Broken lines represent the extens of controls. The 15-cm. band is due to indole-3-acetic acid, the 27·5-cm. band to 2 : 4-dichlorophenoxyacetic acid, and one 32·5-cm. band indole-3-acetonitrile

these were found to be relatively poor in growth substances (compared, for example, with many members of the Cruciferæ), considerable purification was found to be necessary before the extracts could be successfully chromatographed. In order to simplify purification, etiolated tissues were used, and then it was found that the extract fraction containing the acidic substances could be chromatographed without further purification; however, the fraction containing the neutral and alkaline substances usually would have required treatment to remove oils.

The methods used were as follows: macerated plant tissue was extracted with alcohol for twenty-four hours at − 5° C. The alcoholic extract was separated by centrifugation, concentrated under reduced pressure and the aqueous residue extracted with ether at $pH$ 3. The ether extract was treated with sodium bicarbonate solution, which was separated and then acidified and re-extracted with ether. The ether-soluble acidic substances from the plant extract, obtained in this final ether extract, were suitably concentrated and applied to the starting line of a chromatogram, as a spot or a strip, from a dropping pipette in a stream of nitrogen. The chromatograms were developed in isopropyl alcohol : water :: 10 : 1, with ammonia in the base of the tank and, parallel with the extract, guide spots of the known growth substances indole-3-acetic acid and indole-3-acetonitrile could be run and their positions detected at the conclusion of the development by spraying with a ferric chloride – perchloric acid mixture and nitrous acid – nitric acid mixture respectively.

The biological testing of developed chromatograms using subapical sections of *Avena* coleoptiles was described previously[1]. A second biological test has been used in which the section 1·5–3·0 mm. from the tip of pea (*Pisum sativum* var. The Pilot) radicles, grown in moist sawdust for four days at 22° C., were shaken at 25° C. for twenty-four hours with 2 ml. 1 per cent sucrose solution containing the growth substances, and their length extension growth measured. Since the presence of paper squares in the test liquid, as used in *Avena* coleoptile bioassay method, could interfere with the pea root bioassay method, the latter was mainly used for testing solutions of growth substances eluted from chromatograms. To obtain these eluted solutions a large amount of plant extract was applied to paper as a strip and was developed parallel with a spot of the same extract. The chromatogram developed from the spot was cut into 2·5-cm. × 2·5-cm. squares and bioassayed, thus locating the active areas; the parallel active areas were cut from the large chromatogram and eluted by boiling with alcohol and ether.

The results described below have been obtained with a variety of etiolated seedlings and roots, of which the following are examples: pea (*Pisum sativum*) shoots and roots, broad bean (*Vicia faba*) shoots and roots, sunflower (*Helianthus annuus*) shoots, maize (*Zea mays*) roots, potato tubers and shoots, and *Aegopodium* rhizomes.

On all the chromatograms of the acidic fractions of ether extracts of shoot and root material which have been bioassayed, three active areas have been clearly detected. Figs. 1 *A* and 1 *B* show the results, in the form of a histogram, of bioassays with *Avena* coleoptile sections of chromatograms of extracts of broad bean shoots and broad bean roots, respectively. The position of an indole-3-acetic acid guide spot is shown as *IAA*.

The central active area ($R_F$ = approx. 0·3) corresponds with indole-3-acetic acid, which can be detected in this position as a characteristic coloured spot when a chromatogram of an extract of plant material rich in this substance is sprayed with $Fe^{+++}$ – perchloric reagent. In addition, serial dilutions of eluates of this area, when tested for *Avena* coleoptile section extension and pea root section extension, give typical growth-concentration curves. Assuming that the active area with $R_F$ value less than that for indole-3-acetic acid, as shown in Figs. 1 *A* and 1 *B*, corresponds to one substance, the term accelerator-α is suggested for it, and if the same applies to the area with $R_F$ value greater than indole-3-acetic acid, then the term inhibitor-β is suggested for that substance. Accelerator-α and inhibitor-β have been eluted from chromatograms and serial dilutions of the eluates have been assayed for *Avena* coleoptile extension and pea root section extension; and in Fig. 2 the percentage extension of the sections over original length has been plotted against the logarithm of concentration. The concentration scale was arbitrary, normal or unity being the concentration obtained if all of the eluate were dissolved in the same number of ml. of solvent as grams of plant material were extracted to give the eluate. The shape and the position relative to the axes of the curves shown in Fig. 2 are typical of eluates obtained from several different sources. It may be noted that accelerator-α has a very considerable root-growth promoting effect in 'physiological concentrations'.

Two points of interest arose from an application of the chromatography of plant extracts to a growth study involving the rhizomes of *Aegopodium podagraria*, regarding which we possess special information[5]. Fig. 3 *A* expresses as a histogram the results of a bioassay of a chromatogram of the acidic fraction of an ether extract of these rhizomes. Accelerator-α was clearly detected together with an accelerator, not previously encountered except possibly in traces, which runs very close to the solvent front. This new accelerator has been shown by $R_F$ comparison, also by the characteristic colour reaction on spraying with nitrous – nitric acid and by similarity in growth effects of a series of dilutions, to be very probably indole-3-acetonitrile[4], which although not an acid is carried to some extent from an ether solution into sodium bicarbonate solution and back to ether on re-acidification. Although the chromatogram recorded in Fig. 3 *A* did not show it, chromatograms of larger quantities of rhizome extract indicate the presence of indole-3-acetic acid and inhibitor-β; however, from the evidence shown it is clear that the activity of the indole-3-acetonitrile in these rhizomes is greatly in excess of the activity of the indole-3-acetic acid.

The *Aegopodium* rhizomes can be fed artificially with indole-3-acetic acid or with 2 : 4-dichlorophenoxyacetic acid; each of these treatments causes a characteristic and very considerable modification of their growth-rates and geotropic response[5]. These feeding treatments caused a marked change in the chromatogram of the extract as shown in Fig. 3 *B*, which is of an extract of rhizomes grown in indole-3-acetic acid, and Fig. 3 *C*, which is of rhizomes grown in 2 : 4-dichlorophenoxyacetic acid. Indole-3-acetic acid clearly entered the rhizomes, considerably increasing their normal content, and 2 : 4-dichlorophenoxyacetic acid, which runs on the chromatogram at an $R_F$ value between those for inhibitor-β and indole-3-acetonitrile, also entered in quantity. Neither treatment produced any obvious change in the concentration of accelerator-α, inhibitor-β or indole-3-acetonitrile.

Of particular interest is the occurrence in *Aegopodium podagraria* rhizomes of indole-3-acetonitrile, which previously has been reported only in members of the Cruciferæ. Activity due almost certainly to the nitrile has also been found in chromatograms from potato tuber extracts and has been identified by spraying with nitrous – nitric acid and biological assay.

Since activity in the region 27·5–30 cm. due to indole-3-acetonitrile has been detected clearly in *Aegopodium* and potato, it now appears possible that the small humps shown in this region in Figs. 1 *A* and 1 *B* (bean) are also due to nitrile. Such activity has not always been noticed; but this may be due to its being obscured by impurities running near the solvent front and the fact that the biological testing of the region near the solvent front was often omitted in our earlier assays.

Obviously, investigations under conditions of chromatography favourable to the running of indole-3-acetonitrile should be carried out on the fraction of plant extracts containing the neutral substances where the bulk of the nitrile should be located. Of interest also is the detection and possibility of estimation of the synthetic growth substance 2 : 4-dichlorophenoxyacetic acid in a plant extract.

Without going into detail which will be published *in extenso* elsewhere, it may be stated that all shoot and root materials studied have contained hormones α and β and indole-3-acetic acid. We have no information at present on the nature of either α or β; however, one cannot dismiss the possibility that α is auxin-*a*, the real existence of which is often doubted. No active substance of $R_F$ similar to accelerator-α has yet been detected on chromatograms of extracts of urines of various origins. [Dec. 16.

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# LETTERS TO THE EDITORS

*The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications*

## Use of Tracers in Chemical Dosimetry

The action of X-rays and gamma-rays on a solution of ferrous sulphate in 0·8 *N* sulphuric acid has been studied by a number of investigators[1]. The iron is oxidized to the trivalent state, and the amount of trivalent iron is proportional to the radiation dosage. For this reason the ferrous sulphate solution has been used for radiation dosimetry. The amount of ferric ion is usually measured colorimetrically, photometrically or volumetrically. In the present investigation, some experiments have been carried out to measure the ferric ions radiometrically in order to increase the sensitivity of the dosimeter.

Ferrous ammonium sulphate was dissolved in redistilled water and acidified with sulphuric acid, and iron-59 was added to the solution as a tracer. This solution was irradiated with gamma-rays from a cobalt-60 source. After irradiation, the ferric ions formed were separated from ferrous ions by extraction of the ferric thiocyanate with *iso*amyl alcohol. The activity of the organic phase and of the water phase was then determined with a liquid Geiger–Müller counter tube. From these measurements one obtains the percentage of ferric ions in the irradiated solution.

The radioactive isotope iron-59 used as a tracer in this experiment was made with the Werner synchro-cyclotron by bombardment of copper with 185-MeV. protons. The iron formed was separated by extraction with *iso*propyl ether.

The measurements can easily be carried out with an accuracy of more than 2 per cent. By changing the concentration of the ferrous ammonium sulphate in the solution, one obtains different dosage ranges. It seems possible, for example, to measure the radiation dosage in the range 0–100 r. with an accuracy of ± 2 r. The sensitivity can probably be increased still more. The amount of tracer used must not be so large that it gives a radiation dosage which cannot be neglected in comparison with the dosage to be measured.

Experiments have also been carried out to investigate the suitability of an acid or neutral solution of potassium iodide for chemical dosimetry. The action of ionizing radiation on solutions of potassium iodide has been studied by Lefort[2]. In the present experiments the radioactive isotope iodine-131 was added as a tracer to a neutral, hydrochloric or sulphuric acid solution of potassium iodide, which was then irradiated with cobalt-60 gamma-rays. After the irradiation, the solution was extracted with carbon disulphide and the activity of the organic phase and of the water phase was determined as before.

At the beginning of the irradiation, the iodide is oxidized to iodine in an amount proportional to the radiation dosage. However, a state of equilibrium is soon reached because the radiation also reduces the iodine. This state of equilibrium is reached at 25 per cent iodine for a neutral solution, at 60–70 per cent iodine for a *N* hydrochloric acid solution and at about 35 per cent iodine for a sulphuric acid solution of *p*H 2. The number of iodide ions oxidized by a certain dosage of radiation is considerably lower than the corresponding number of ferrous ions in a ferrous sulphate solution. For this reason one has to use very dilute iodide solutions to get a dosimeter of high sensitivity. However, these dilute solutions do not seem to be stable enough to be useful as dosimeters.

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Jan. 14.

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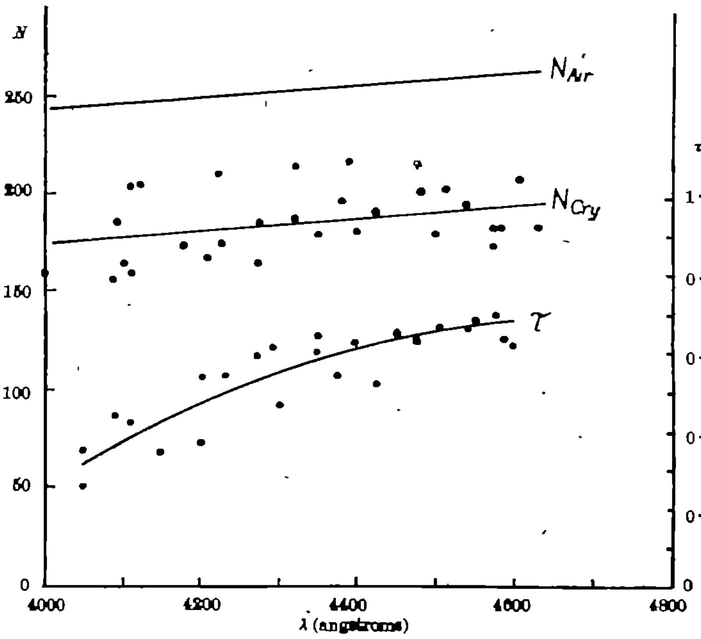
## Multi-layer Dielectric Reflecting Films at Wave-lengths between 4000 and 4600 A.

Recent correspondence[1,2] has directed attention to the lack of information about the efficiency of multi-layer dielectric reflecting coatings at wave-lengths shorter than 5200 A.; this prevents an assessment of the relative merits of dielectric and silver films as coatings for Fabry–Perot interferometer plates at these wave-lengths. To this end, multi-layer dielectric interference filters have been prepared, and their characteristics measured over the wave-length range 4000–4600 A.

Each filter was deposited on glass, and consisted of two reflecting films, both of seven λ/4 layers (four zinc sulphide and three cryolite), separated by a λ/2 spacing layer of cryolite, thus giving a first-order



pass-band at wave-length λ. By suitably orienting the glass support in the evaporation chamber, each layer was deposited in the form of a wedge such that λ varied over the filter between 4000 A. and 4600 A. In this way the pass-band at each point of the filter was made to centre on the wave-length for which the reflectivity of the seven-layer films was a maximum.

The half-intensity width and peak transmission of four such filters have been measured for several wave-lengths in the above range by scanning the pass-band, dispersed by a large glass spectrograph, using a multiplier photo-cell in conjunction with an amplifier and recorder. The results obtained are shown in the accompanying graph. *N* (middle curve) is the ratio of the wave-length of the pass-band to its half-width, and is the "effective number of interfering beams"[3], and $\tau$ is the fraction of the incident light transmitted at the peak of the pass-band. From these measurements the geometric mean values of the reflexion, transmission and absorption coefficients for the pair of films in each filter can be calculated, and values for three wave-lengths are shown in the accompanying table.

| λ | 4100 A. | 4300 A. | 4500 A. |
|---|---|---|---|
| Reflexion coefficient | 0·982 | 0·983 | 0·983 |
| Transmission coefficient | 0·011 | 0·012 | 0·014 |
| Absorption coefficient | 0·007 | 0·005 | 0·003 |

These values refer to the system cryolite/7-layer film/glass and would be altered if the spacing layer were air. Theory indicates that the reflexion coefficients would be increased by about 0·005 for the system air/7-layer film/glass, while the ratio of transmission to absorption remains constant. Values of *N* embodying this correction are shown in the upper curve of the graph.

A comparison of silver and dielectric films as Fabry–Perot interferometer coatings may now be made by comparing values of *N* for a given $\tau$, since *N* is directly proportional to the attainable resolution assuming perfectly flat plates. For $\tau = 0·45$ at λ 4200 A., new and aged silver films give $N = 16$ and 11, respectively[4], whereas for seven-layer dielectric films *N* is about 250. The theoretical resolution at this wave-length using dielectric films is thus fifteen to twenty times that obtained with silver films. In practice, of course, the resolution is limited by imperfections in the interferometer plates; but whereas silver films do not allow full advantage to be taken of good-quality flats, dielectric coatings are evidently more than adequate.

The performance of interference filters is not subject to this limitation, since irregularities of the glass support are of no account, and full use may be made of the superiority of dielectric coatings. For example, at λ 4600 A. a pair of seven-layer coatings separated by a first-order spacer gives a half-width of 22 A. and a peak transmission of 70 per cent, whereas a first-order silver interference filter might have a half-width of 150 A. and a transmission of 40 per cent[5]. Theoretically, a higher-order spacer would give an even narrower pass-band, but roughness in the spacing layer appears to limit what can be achieved by this means[6]. Improvement, however, is possible by increasing the number of dielectric layers, and a preliminary experiment with a pair of nine-layer coatings separated by a first-order spacer has resulted in a half-width of 15 A. and a peak transmission of 60 per cent at λ 4700 A.

We are grateful to Mr. J. E. Geake for the loan of the amplifier and recorder.

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W. L. Wilcock

Physical Laboratories,
The University,
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Dec. 30.

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## The Sunspot Number Series

Sunspot numbers form a quasi-periodic series (see Fig. 1, upper curve) going back for eighteen cycles to 1750. Very numerous attempts have been made to analyse the series, with little success. It does not appear to contain a truly periodic term, as do tides and weather records. The fundamental Fourier component, as determined over a particular section of the series, yields only a poor estimate of the next cycle, both in duration and in phase. Very little regularity of any kind has been found.

The objects of analysis have been twofold: to discover a process which would yield a time series resembling the sunspot series, and to predict the future of the series, which incidentally would be very valuable in relation to telecommunications. No suggested process has been substantiated and predictions are made on an empirical basis. The range and accuracy of forecasting would presumably be improved if some hypothesis could be found which would give rise to series resembling the sunspot series.

The present communication presents an idea which could lead to such a hypothesis. According to Hale's well-known discovery, based on observations of the magnetic polarities of sunspots, the sunspot cycle lasts twenty-two, not eleven, years. The upper curve of Fig. 1 does not include this information; but as there is no known difference in the terrestrial effects between successive eleven-year cycles, its

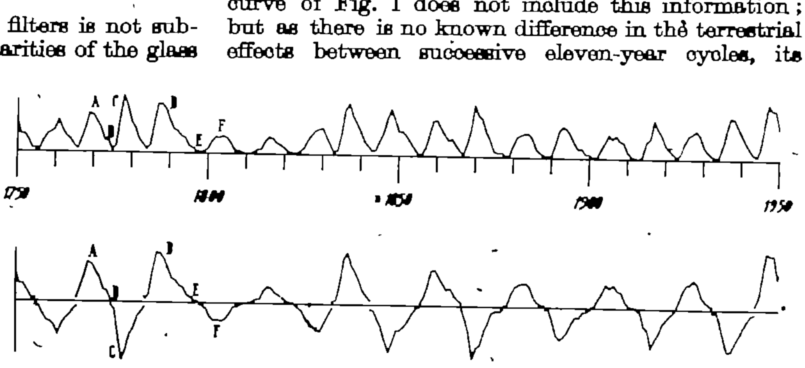

Fig. 1. (Above). Sunspot number series, 1750–1950
(Below). The same series, but showing alternate 11-year cycles reversed in sign

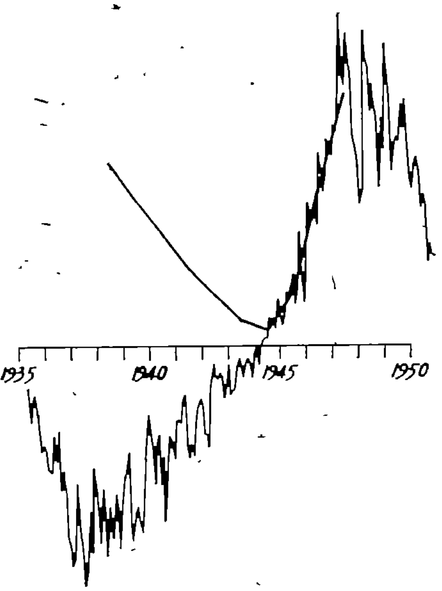

Fig. 2. Monthly means (—) and annual means (—) about the sunspot minimum of 1944

appropriateness has not hitherto been questioned. It is now proposed to plot alternate cycles, positive and negative, as in the lower curve of Fig. 1.

It may be objected that, in years of minimum spots, the sunspot number has not always been zero, whereas the alternating representation requires accurate zeros. In the years 1766, 1784, 1843 and 1944, the minima were very noticeably different from zero. This objection can be met with the aid of Fig. 2, in which the minimum of 1944 is shown in greater detail, by monthly means in addition to annual means. It is clear that the sunspot number actually passed through a very good zero in 1944, but that the taking of annual means obscured this fact. Any further difficulty vanishes when it is remembered that spots belonging to successive cycles are to be taken with opposite signs, and that it is possible to identify which cycle a spot belongs to by taking into account its latitude and magnetic polarity. In plotting Fig. 1 (lower), no attempt has been made to correct the minimum sunspot numbers.

The two curves of Fig. 1 look at least equally regular. In particular, the lower curve does not exhibit obvious discontinuities at the zeros, apart from the gaps due to the above-mentioned deviations of the minima from zero. It has attractive features, such as symmetry about its mean value, and a mean value which is practically zero (less than 1 per cent of mean maximum).

A hypothesis of Yule's[1] likens the sunspot series to the motion of a swinging pendulum which boys are pelting with peas, sometimes from one side and sometimes from the other. After lengthy analysis, Yule concluded that further work on this line seemed to be blocked. Yule, however, began by subtracting the mean value from the series. The series was thus asymmetrically distributed about its zero, and the maximum excursions in the negative direction were all practically equal. It is therefore perhaps not surprising that the stipulated mechanism failed. The present idea re-opens this promising line of investigation.

If the new presentation is significant, a correlation might be expected between the fall of one cycle to zero and the rise of the following cycle, that is, a steep rise might be expected to follow a steep fall to zero. It is found that the correlation coefficient between the average rate of fall from maximum to minimum and the average rate of rise from the minimum to the next maximum is 0·57. In comparison, if the rate of rise is correlated with the rate of fall of the following cycle and the preceding cycle but one, the values are − 0·03 and − 0·001 respectively. As particular examples of this correlation, the steep fall *AB* was followed by the steep beginning *BC*, and the gradual fall *DE* was followed by the gradual beginning *EF*.

The idea of representing the sunspot series as a twenty-two-year oscillation with zero mean value is offered to mathematicians, physicists and engineers sharing a common interest in sunspots. Some past attempts to analyse the sunspot number series may well have been near the truth, but may have foundered on the eleven-year version of the upper curve of Fig. 1.

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Australia. Jan. 9.

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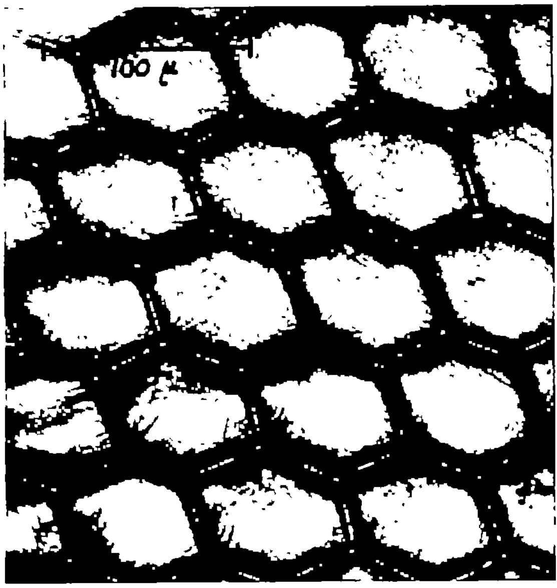
## A Special Kind of Growth Structure in Metal Single Crystals

The purpose of this communication is to describe and illustrate the growth of single zinc crystals, using a method in which the growth boundaries are examined, without etching, in their natural relief by means of a stereomicroscope.

The crystals are produced by a somewhat modified Czochralski–Gomperz method, in which the diameter of the single crystal wires is held at about 0·5 cm. If now the crystal wire is suddenly removed from the surface of the melt out of which it is growing, one gets as the termination of the wire a section which is more or less convex according to the temperature gradients prevailing in the region of growth, and which consists of small polygonal units, themselves individually convex.

In the case of zinc, under favourable conditions, remarkably regular hexagons are obtained, as may be seen in the accompanying photograph, which represents the appearance of part of such a termination grown under a steep temperature gradient. The zinc used had a purity of 99·99 per cent, the rate of withdrawal or growth was 30 cm./hr., and the hexagonal crystallographic axis was, in this case, inclined approximately 25° to the axis of the wire. Inside the hexagons there are small raised spots, sometimes only single, which are probably due to traces of dendrites growing out from the interface into the melt. Also there are, running across the whole section, parallel straight lines, traces of 0001 planes, not produced by later plastic deformation. Corresponding to the growth structure at the termination, there is also visible on the outer surface a structure which looks as if the wire had grown in parallel hexagonal strands, with their axes making a small angle (a few degrees) to the axis of the wire.



The growth structure obtained by the above method obviously bears a close relation to the structures which Buerger[1] has obtained by etching with strong hydrochloric acid the cleavage and outer surfaces of zinc single crystals grown by the Bridgman method. The method described here has been successfully extended to other metals; a fuller account of the results will be published elsewhere.

F. BLAHA

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Oct. 14.

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## Gloss of Papers

WE have completed a psycho-physical study of the gloss of several series of coated and uncoated papers differing widely in surface finish and in colour, ncluding a black, a green and a mauve, besides an assortment of shades of white, cream, yellow and brown.

Over such a wide range considerable disagreement s found between judgments of individual observers, and marked shifts in ranking occur when the conditions of illuminating and viewing the specimens are changed. Judgment appears to be based upon an appraisal of a physical situation taken as a whole. The factors of this physical situation are weighted differently by different observers under the same conditions and by the same observer under different conditions. Consequently it is possible only to devise a method of instrumental grading which shall satisfy the mean judgment of a large number of observers under certain average conditions of grading. Within these limitations, an extension of an empirical equation previously suggested[1] enables instrumental measurements to be fitted to visual gradings tolerably well. The general expression is:

$$G = AS(a+b \tanh 10/bL) - B \tanh [cS(P-1)/100]^2,$$

and is applied to papers illuminated by a nearly parallel beam incident at 45°, where $S$ is the intensity of light reflected at the specular angle (45°), $L$ the ntensity in the direction of the normal (0°) and $P$ is defined as the ratio of intensity at 45° to that at 40°. $A$, $a$, $B$, $b$ and $c$ are constants and $G$ is the numerical estimate of the visual gloss. All intensities are expressed as a percentage of the intensity reflected normally to a surface of magnesium oxide under the same incident beam.

It is seen that the equation represents a weighted mean of three factors. The first is $S$, the intensity at the specular angle. For papers of high luminance factor and moderate gloss, this factor predominates. The second is ($S \tanh 10/bL$) and provides a measure of the contrast observed when the eye is transferred from the specular angle to a direction remote from the specular angle: the hyperbolic tangent has no physical significance but is introduced in order to prevent $G$ from rising to abnormally high values for black and dark grey papers. The third term, $\tanh [cS(P-1)/100]^2$, is appreciable only for papers at the higher end of the gloss scale. For highly glossy papers having the same values of $S$ and $L$, the one having the more sharply peaked polar curve is adjudged the less glossy by most observers, and the third term of the equation makes allowance for this.

It appears that in order to get the best possible correlation between $G$ and visual observations, the weighting constants $A$, $a$, $B$, $b$ and $c$ must be adjusted to suit the individual observer and the prevailing conditions of observation. This is generally impracticable and undesirable, and for most purposes we find that the equation reduced to the form:

$$G = S(0{\cdot}390+0{\cdot}325 \tanh 20/L) - 100 \tanh [0{\cdot}115\ S(P-1)/100]^2$$

gives with visual observations product-moment and rank correlation coefficients of the order of +0·94 for all types of paper, and it is suggested that it may be made the basis of a practical method of gloss specification. For comparative work with similar papers where $P$ is small and $L$ nearly constant, the equation can, of course, be simplified. The incident and reflected beams used in this work were in the form of truncated wedges of vertical angle 0° 30′.

Our thanks are due to Prof. B. Steenberg of Svenska Träforskningsinstitutet, Stockholm, for supplying some of the papers, together with the visual gradings of 476 Swedish observers. A detailed account of this work is being prepared for publication elsewhere.

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S. R. C. POULTER

Printing, Packaging and Allied Trades
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Oct. 10.

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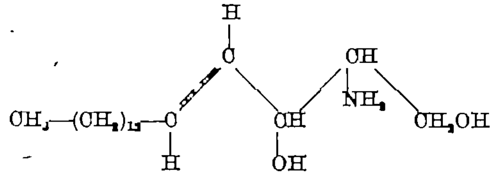
[1] Harrison, V. G. W., and Poulter, S. R. C., *Brit. J. App. Phys.*, **2**, 92 (1951).

## Trans-Ethylenic Structure of Sphingosin

THE molecular structure of sphingosin (I) has been established with reasonable certainty by degradation[1] and by the synthesis of the dihydro derivative[2]. Concerning the spatial structure, however, no more can be inferred at present from the available data of optical rotations than that the compound would seem to belong to the D-(−)amino carboxylic acid series[3].

An attempt was made by Ono[4] to decide on the steric disposition of the substituents of the ethylenic double bond by conversion of the compound with lead tetra-acetate into hexadecenal, and hence to the corresponding hexadecenoic acid to which the author assigns the *trans* structure. Unfortunately, no experimental details of the selective oxidation of (I) are given, or the melting point of the 2-hexadecenal obtained and of the other geometrical isomer of hexadecenoic acid, or the principle used for establishing the configurations.

The investigation of the configurational correlation[5] of (I) to the four theoretically possible threoninol isomers is expected to disclose the configuration of both asymmetric centres in (I). The work being in progress at our laboratory, at present we offer the evidence on the spatial structure of the olefinic chain in (I).



(I)

Carter[6] has stated without further comment that triacetyl dihydrosphingosin melts at almost the same temperature as does triacetyl sphingosin, and the mixture of the two substances shows very little melting point depression. Now, according to the syncrystallization rule of Bruni[7], only the more stable of a pair of geometrically isomeric ethylenes would form mixed crystals with the corresponding dihydro derivative. Since the skeleton of the long aliphatic chain of dihydrosphingosin can have only the staggered orientation, sphingosin cannot be expected to enter the crystal lattice of the former unless it represents the *trans* form of the ethylene bond. Actually, we find that neither the triacetyl nor the tribenzoyl derivative gives a depression of melting point with the corresponding triacyl dihydrosphingosin, the observed values taken with mixtures of various proportions indicating strongly the formation of solid solutions ('mixed crystals') as evidenced by the accompanying photographs and graph. This suggests with a very high degree of probability that sphingosin has the *trans* ethylenic structure, which would seem to be well in line with the known stability of the compound toward heating and toward alkalis[8].

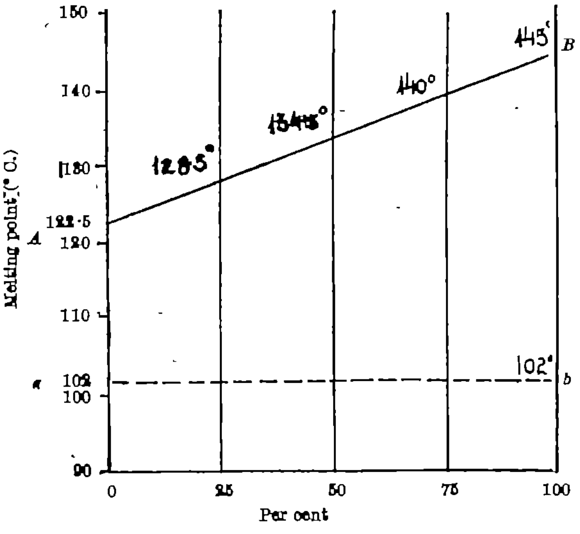


Fig. 1. *A*, Tribenzoyl-sphingosin ; *B*, tribenzoyl-dihydro-sphingosin ; *a*, triacetyl-sphingosin ; *b*, triacetyl-dihydro-sphingosin

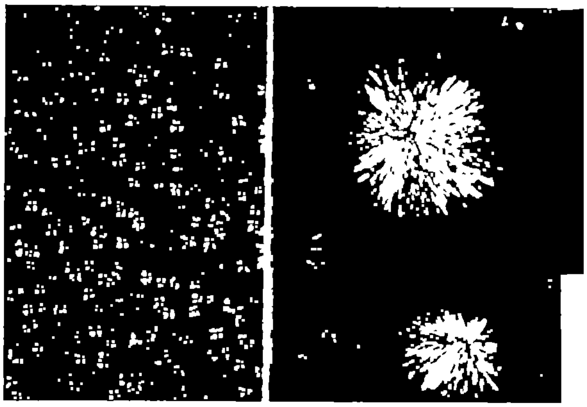


Fig. 2. (Left) : Triacetyl-sphingosin + triacetyl-dihydro-sphingosin (equal parts). (Right) . Tribenzoyl-sphingosin + tribenzoyl-dihydro-sphingosin (equal parts). (Nicol prism ; × 75)

Further synthetic and physical investigations on the subject will be published in detail in the *Acta Chimica Hungarica*. We are indebted to Prof. S. Koch for crystallographic evaluations, and to Dr J. Mezősi for the photomicrographs.

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Oct. 7.

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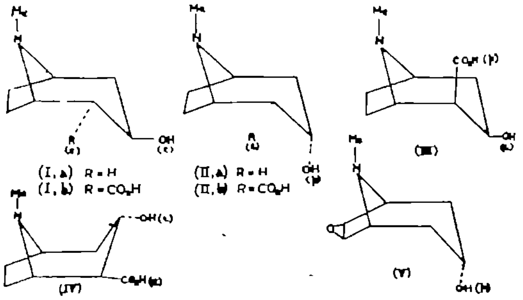
## Conformation of Tropane Alkaloids

It has become generally accepted that *cyclo*hexane compounds[1] and pyranosides[2] possess the chair conformation. By analogy we may assume that piperidine and its derivatives also exist in the chair conformation. Starting from this assumption, it is possible to determine the conformation of tropane alkaloids.

The sodium and alcohol reduction of tropinone leads mainly to ψ-tropine. This method of reduction of a ketone is known to afford an equatorial hydroxy substituent[3]. The hydroxy group in ψ-tropine should, therefore, be in the equatorial position and (I)*a* and (II)*a* should represent the conformation of ψ-tropine and tropine, respectively. The fact that tropine can be epimerized to ψ-tropine by the action of sodium amylate supports this view. Similar reasoning indicates an equatorial position for the hydroxy group in ψ-ecgonine. This conformation is in keeping with the observation that ecgonine, which should have the hydroxy group in the polar position, is more readily dehydrated than ψ-ecgonine.

The reduction of methyl tropinone-2-carboxylate leads to the methyl ester of *dl*-ψ-ecgonine, *dl*-ecgonine and a 'third racemate'—the first-named reduction product being obtained in a preponderant amount. Thus, ψ-ecgonine is the most stable of the four epimers possible for 2-carboxy-3-hydroxy-tropane. Both the hydroxy and the carboxy groups in the unknown epimer should therefore be assigned polar positions, whereas in ψ-ecgonine both these substituents should be equatorial. The conformation of ψ-ecgonine, ecgonine and the 'third racemate' can now be represented by (I*b*), (II*b*) and (III), respectively.



Fodor[4] has deduced the configuration of tropane alkaloids by an elegant investigation and shown that in ψ-ecgonine the hydroxy group is *syn* with respect to the nitrogen and *trans* with respect to the carboxyl group. The conformation (I*b*) is in accord with this configuration. If, however, instead of the chair conformation we assign the boat conformation to the piperidine ring, ψ-ecgonine will be represented by (IV) and the hydroxy will be *anti*-placed with respect to the nitrogen and will therefore be at variance with Fodor's findings.

In view of the ready conversion of scopine to scopolamine—a tetrahydrofuran derivative—the only reasonable conformation for scopine is (V), in which the piperidine ring is in the chair form[4]. This may be counted as indirect evidence in favour of the chair conformation of the piperidine ring in (I) and (II). The conformation of atropine, cocaine and other related alkaloids follows from (I) and (II). It is interesting to note that all the tropane alkaloids possessing mydriatic or anæsthetic properties have the ester group (in position 3) in the polar position.

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## Organic Anion Binding by Denatured Bovine Serum Albumin

IN the course of investigations in progress in this laboratory on the binding of acidic phosphatides by bovine serum albumin, certain deviations from the commonly accepted properties of denatured bovine albumin prompted a closer study of the binding of an organic anion (methyl orange) by bovine albumin denatured with urea and guanidine hydrochloride. The view that bovine albumin loses its high affinity for methyl orange after denaturation seems to have arisen mainly from experiments employing heat as the denaturing agent[1]. Yet the persistence of high affinity for the dye has been used as evidence for the maintenance of the native state of bovine albumin[2].

It is to be expected that heat denaturation, especially if allowed to result in coagulation of the protein, would tend to decrease the binding power because of the formation of new intermolecular salt bridges and hydrogen bonds between adjacent uncoiled peptide chains. If, however, denaturation is restricted to changes in the spatial relationships of individual molecules with minimal secondary intermolecular associations, as in partial or complete uncoiling of a globular protein, the binding power should increase, since previously 'buried' binding sites would become available in the process. This appears to be true for the heat denaturation of egg-albumin[3]. If one considers the empirically derived binding index of Klotz[4], denaturation *per se*, without secondary aggregation, association and salt-bridge formation between molecules, should produce either no change or an increased binding affinity, as $\Sigma(\equiv NH^+)/\,|\,\Sigma(-OH)-\Sigma(-COO^-)\,|$ already probably represents a minimum value in the native state.

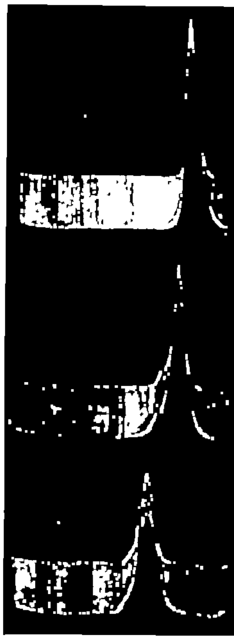
The binding properties of denatured bovine serum albumin have been investigated by comparing the effects of urea and guanidine hydrochloride denaturation on the binding of methyl orange after removal of the denaturing agents. Parallel experiments on bovine albumin denatured with urea and with guanidine hydrochloride were carried out.

The protein preparations used in these experiments consisted of purified bovine plasma albumin (given by Dr. Walter L. Hughes, jun., Laboratory of Physical Chemistry Related to Medicine and Public Health, Harvard University) and Armour crystalline bovine serum albumin. The latter proved to be electrophoretically pure and also homogeneous by sedimentation analysis in the Spinco analytical ultracentrifuge. The methyl orange was a reagent-grade product of the Allied Chemical and Dye Corporation (National Aniline Division).

The bovine serum albumin was mixed with appropriate amounts of powdered urea and guanidine hydrochloride in the dry state and denatured by the addition of water to produce a 40 per cent solution with respect to urea and an 8-*M* solution with respect to guanidine hydrochloride. The denaturing agents were rapidly removed by exhaustive dialysis in the cold, first against water and then against 0·1 *M* phosphate buffer at *p*H 6·5, using a modification of the system described by Wentzel and Sterne[5]. Maintenance of the original total nitrogen to tyrosine ratio of the aliquots at the end of dialysis was taken to indicate complete removal of the urea and guanidine hydrochloride, respectively.

Bovine serum albumin samples treated in the foregoing manner showed increases in relative viscosity, increased digestibility on incubation with trypsin and pepsin, and an increase in the intensity of the colour produced with Folin's reagent[6], as compared with the native albumin. Urea-denatured samples showed an increase in the available guanidinium groups detectable by the modified Sakaguchi reaction[7].

Electrophoretic patterns obtained in runs conducted at *p*H 6·5 (0·1 *M* phosphate buffer) and *p*H 8·6 (0·1 *M* diethylbarbiturate buffer) showed definite changes in the electrophoretic behaviour of denatured bovine albumin solutions, varying in extent



Patterns obtained from the descending limb showing the changes in the electrophoretic behaviour of urea-denatured bovine serum albumin. Perkin-Elmer Tiselius apparatus, 2·0 ml. cell, 165 V.-10 m.amp. current. Time of run in all cases, 86 min.
(a) 1·0 per cent native bovine serum albumin in 0·1 *M* diethyl barbiturate buffer, *p*H 8 6.
(b) 0·86 per cent urea-denatured bovine serum albumin in 0·1 *M* diethyl barbiturate buffer, *p*H 8 6.
(c) 0·86 per cent urea-denatured bovine serum albumin in 0·1 *M* phosphate buffer, *p*H 6 5

with different denatured aliquots, but characterized by decreased mobility and broadening of boundaries with double- and triple-notched peaks (see figure).

Aliquots which showed unequivocal denaturation effects, as determined by the foregoing criteria, were used in binding studies. Dialysis equilibrium experiments were carried out according to the method of Klotz and his associates[8] at 2° C., using a 24-hr. equilibration period. The outside dye concentration was varied in different experiments to bring $2 \cdot 45 \times 10^{-6}$ to $9 \cdot 8 \times 10^{-6}$ mole of dye per millilitre in contact with the protein molecules. The results uniformly showed a greater number of dye molecules bound by the denatured albumin as compared with the native. This is illustrated by the results in the accompanying table.

DATA FROM TYPICAL DIALYSIS EQUILIBRIUM EXPERIMENT
10 ml. 0·2 per cent protein solution inside bags except for control
Buffer: 0·1 *M* phosphate, *p*H 6 5, equilibration at 2° C. for 24 hr.

| | Residual free dye concentration (*M* × $10^{-6}$/ml.) | Moles dye bound per mole protein* |
|---|---|---|
| Buffer control | 6 72 | |
| Native bovine albumin | 5·76 | 24 |
| Guanidine hydrochloride denatured albumin | 5·22 | 32 |
| Urea-denatured albumin | 4·38 | 61 |

* Assuming a mol. wt. of 69,000 for bovine serum albumin.

It may be noteworthy that this effect appears to be much more marked when denaturation is effected by urea than when it is produced with guanidine hydrochloride. Different samples of bovine albumin denatured with guanidine hydrochloride also showed greater variation in the number of dye molecules (25–38 per mole albumin) bound in the presence of identical initial dye concentration than was observe with urea-denatured albumin (53–62 per mo albumin).

Assuming that partial reversal of denaturation the albumin takes place in spite of the rapid remov of the denaturing agents by dialysis, it appea significant that denaturation with urea and guanidin hydrochloride causes no decrease in the amount organic anion bound to the albumin; rather, i agreement with theory, it causes an increase in th number of bound dye molecules depending on th statistical distribution of uncoiled, partially coiled and 'native' molecules in a denatured protein solution. The loss of binding affinity for organic anion observed with heat-denatured albumin probabl represents a special case and not a general propert of 'denatured' bovine serum albumin.

The assistance of Mrs. Marilyn C. Harris an Mrs. Marian Spiro in these experiments is gratefull acknowledged. This investigation was supported i part by a grant of the U.S. Public Health Service National Institutes of Health.

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## Decarboxylation of Collagen

INVESTIGATIONS in this department into the nature of the chrome tanning process have involved the preparation of various modified forms of collagen. Among possible modifications, the decarboxylation of collagen appeared to be of interest, although it has received scant attention from previous workers. Fox[1] reported that Grignard reagents had been used for decarboxylating an esterified polypeptide with the formation of a tertiary alcohol; more recently, Fromageot *et al.*[2] have used lithium aluminium hydride to reduce the terminal carboxyl groups of insulin to primary alcohols.

Collagen in the form of finely divided 'hide powder' was therefore treated with these reagents, and the dicarboxylic amino-acid content estimated by the method of Consden, Gordon and Martin[3]. Methylated collagen (0·86 m.mole OMe/gm. collagen) was treated with the Grignard reagent, methyl magnesium iodide, for 18 hr. Lithium aluminium hydride was dissolved in *n*-dibutyl ether and allowed to react with the hide powder for 12 hr. at 40° C. The metallo-protein complex formed in each case was decomposed by the addition of dilute mineral acid. The modified collagens produced were then washed with distilled water until free of salts. Analysis

| Treatment | Total side-chain carboxyl | Glutamic acid | Aspartic acid | Amide-nitrogen |
|---|---|---|---|---|
| None | 1·24 | 0·75 | 0·47 | 0·26 |
| Methyl magnesium iodide | 1·05 | 0·62 | 0·40 | 0·25 |
| Lithium aluminium hydride | 0·43 | 0·18 | 0·20 | 0·14 |

yielded the results shown in the accompanying table (expressed as m.mole/gm. dry protein).

It is seen that treatment of the methylated collagen with methyl magnesium iodide brings about a small reduction in the number of side-chain carboxyl groups. Lithium aluminium hydride, on the other hand, appears to effect more extensive reduction of the carboxyl group. In accordance with the work of Morrison *et al.*[4], some reduction of the amide groups was also observed.

It is hoped to publish full details of this work in the *Journal of the Society of Leather Trades Chemists*.

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# Determination of Glycerol in Fermentation Solutions: a Rapid Chromatographic Procedure

A RAPID and simple chromatographic procedure has been developed in this laboratory for the determination of glycerol in solutions obtained by the sulphite-fermentation process of Cuban blackstrap molasses, and it is considered that the method may have wider applications. Neish[1] has described a chromatographic procedure for the determination of glycerol present in amounts up to about 5 mgm. in small samples of fermentation solutions. The present method is suitable for the determination of glycerol which may be present in amounts of the order of 500 mgm., thus permitting the use of a volumetric procedure for the final determination of glycerol.

It has been shown that glycerol is readily separated from sugars by partition chromatography on paper strips, and a number of solvents may be employed[2]. This was confirmed with acetone—a solvent easily separated from glycerol by distillation. It was found, however, that when the same solvent was employed in conjunction with large samples and columns of cellulose, glycerol could not be easily separated from sugars or the fermentable constituents of molasses; but excellent separation was obtained when alumina was used as adsorbent under the conditions described below, and the glycerol could be determined in the eluate by oxidation with sodium metaperiodate and direct titration of the formic acid produced[3].

The preliminary experimental work was carried out employing samples of molasses to which known amounts of glycerol were added. In addition to the unfermentable constituents and residual unfermentable organic impurities which are present in fermented liquors, molasses also contain large concentrations of fermentable sugars which cause serious interference with the 'periodate' procedure for glycerol. This imposed more rigorous conditions on the chromatographic procedure. In order to avoid strong retention of glycerol by the other constituents of fermentation solutions, it was found necessary to add a small amount of acetic acid to the solution of the sample and to the solvent employed for extraction.

The chromatographic method involves the preparation of a column of coarse-grade cellulose powder (2·5 gm.) (Whatman), which acts as a support for chromatographic alumina (5 gm.)[4]. Sufficient of the sample is taken to give up to about 0·5 gm. glycerol. It should contain about 3 ml. water, its volume being 5 ml. (approximately). Sulphite fermentation solutions analysed in this laboratory contained glycerol in concentrations up to 12 per cent. After addition of sodium sulphite (0·5 gm.), sodium acetate (1 gm.) (these compounds assist in the retention of sugars and impurities by the adsorbent) and acetic acid (0·1 ml.) to the sample, the resulting solution is mixed with alumina (15 gm.) and the mixture then transferred to the prepared column. The glycerol is eluted with 250 ml. of solvent (acetone containing 5 per cent v/v water and 0·05 per cent v/v glacial acetic acid).

It was found that there is a small but constant retention of glycerol by the alumina adsorbent; but this difficulty was easily overcome by standardizing the caustic soda solution for the procedure, using 1 gm. molasses to which a known amount of glycerol had been added.

Employing the procedures described, typical results for the recovery of glycerol from mixtures with Cuban blackstrap molasses are given in the accompanying table. Similar results were obtained for fermentation liquors to which known amounts of glycerol had been added.

| Weight of molasses (gm.) | Weight of glycerol added (gm.) | Titration (ml. 0·1 *N* NaOH) | Factor* (gm. glycerol ≡ 1 ml. 0·1 *N* NaOH) |
|---|---|---|---|
| 1 | Nil | 0·4 | — |
| 1 | 0·7500 | 80·4 | 0·0094 |
| 1 | 0·3333 | 35·8 | 0·0094 |
| 1 | 0·2499 | 27·0 | 0·0094 |
| 1 | 0·0833 | 9·1 | 0·0096 |

* Theoretical value = 0·0092 (value which would be obtained in the complete absence of glycerol hold-up).

A mixture of 0·1 gm. each of sucrose, glucose and mannitol gave a titration of only 0·3 ml. 0·1 *N* sodium hydroxide. The total amount of material extracted from a mixture of 0·3 gm. each of these compounds was less than 1 mgm., whereas when cellulose alone was used 80 mgm. was extracted.

The method has been applied to the analysis of solutions from the alkaline fermentation process of Eoff, Linder and Beyer[5].

Full details of this work will be published at a later date.

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## An Occurrence of Aluminium Succinate in *Cardwellia sublimis* F. Muell.

ALUMINIUM succinate has been found as a massive deposit in a cavity in the heartwood of *Cardwellia sublimis* F. Muell. (Proteaceæ), commonly known as northern silky oak or bull oak. This is a commercial timber tree restricted to the rain forests of tropical Queensland. The deposit occurred in a so-called 'wind shake' in a log from Jarra Creek near Tully, North Queensland. Inquiries from foresters and saw-millers indicate that such occurrences are rare. The log was about 10 ft. in girth, and the deposit apparently extended from the base to at least 25 ft. up the stem of the tree. A similar occurrence of aluminium succinate has been previously recorded[1] in *Orites excelsa* R. Br. (Proteaceæ), popularly known as silky oak or prickly ash, a timber tree of the subtropical rain forests of New South Wales. Basic aluminium succinate was also identified as a white deposit in the galleries of a longhorn beetle in timber of *Qualea* sp. (Vochysiaceæ) from South America[2].

The present deposit was a loosely aggregated greyish-white powder, which lost 41·2 per cent by weight when dried at 100° C. The alumina content of the dried material was 40·9 per cent, and of the ash 99·9 per cent. The formula for basic aluminium succinate calculated by Smith (*loc. cit.*), which would agree with this result, is $Al_2(C_4H_4O_4)_3.Al_2O_3$, but Campbell *et al.* (*loc. cit.*) doubt its validity. Qualitative analysis, confirmed by Dr. F. N. Lahey of the Chemistry Department, University of Queensland, failed to reveal the presence of metals other than aluminium, or organic acids other than succinic acid. The succinic acid, purified by sublimation, was identified by melting point and mixed melting point with an authentic sample. Purification of the original sample by crystallization was impracticable, owing to its complete insolubility in a wide range of solvents; consequently the exact composition was not determined.

Samples of bark and wood from another log of *Cardwellia sublimis* from Tully contained approximately 1·09 and 0·86 per cent alumina and 2·8 and 9·7 per cent ash respectively on a dry-weight basis. The ash of bark and wood contained approximately 40·0 and 82·6 per cent alumina respectively.

The physiological significance of the accumulation of aluminium in large quantities by certain plants is obscure. Chenery[3] has suggested that this accumulation may have some value in taxonomy; and a survey was made of aluminium-accumulating species in the Queensland–New Guinea flora, using the aluminon test[3]. The occurrence of aluminium (>1,000 p.p.m.) in these plants exhibits a remarkable degree of specificity. Its taxonomic and ecological implications for the local flora will be discussed elsewhere.

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## Alkaloids of *Datura innoxia*

THE brief reference in *Nature* of December 13, p. 1002, to a paper by James and Thewlis[1] on the separation and identification of solanaceous alkaloids in normal and grafted plants of *Atropa belladonna* and *Datura innoxia* prompts us to place on record certain results we have obtained in a similar study. So far as we are aware, the alkaloids of *D. innoxia* have not hitherto been fully characterized[2]. James and Thewlis state that they found hyoscine and hyoscyamine to be present and, from evidence of the hyoscine : hyoscyamine ratios in the two plants and in their reciprocal grafts, have deduced that alkaloid synthesis occurs mainly in the roots.

Three samples of *D. innoxia* Miller (see Timmerman[3]), one from the 1950 crop and the others from the 1952 crop, were analysed by the method described previously[4,5], and the presence of hyoscine (0·24, 0·30 and 0·37 per cent) was confirmed. The fraction at first considered to be hyoscyamine (0·035, 0·062 and 0·073 per cent) afforded a picrate of melting point considerably below that of hyoscyamine picrate. This material, on fractional crystallization from water, gave two picrates, one of melting point 162–164° C., undepressed on admixture with authentic hyoscyamine picrate, and the other, melting point 175–176° C., undepressed on admixture with authentic meteloidine picrate. It is therefore apparent that, in addition to hyoscine and hyoscyamine, *D. innoxia* contains meteloidine. There is indirect support for this conclusion in certain discrepancies between the acidimetric and colorimetric values for hyoscyamine[1]; meteloidine does not give a colour in the Vitali–Morin test. In *ad hoc* experiments, it has been confirmed that hyoscyamine and meteloidine are not separated by the chromatographic method employed both by us and by James and Thewlis.

From an extension[5] of our earlier experiments[6] on grafts within the same genus, the simplest conclusions with respect to *D. innoxia* are that the main site of alkaloidal syntheses are the roots for hyoscine and the aerial parts for hyoscyamine; the site of synthesis of meteloidine has not been located.

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## Resistance of Hop Stems to Invasion by *Verticillium albo-atrum*

MOST fungi causing vascular wilts of plants enter through the roots and then invade systemically the xylem tissue of the root and stem. Their effects are usually judged by the severity of leaf symptoms, and on this criterion is based an assessment both of host resistance and of fungal pathogenicity. The extent and intensity of fungal growth in the xylem (particularly of the stem) parallels the severity of leaf symptoms, and is also used as an indication of host resistance and fungal pathogenicity[1–4].

If a host species or variety has high resistance to a particular strain of wilt pathogen, fungal invasion is slight. The xylem of the root is slightly invaded, and if the fungus enters the stem, its growth there is slight and attenuated. Conversely, the xylem of a plant of low resistance becomes extensively invaded, in both root and stem.

The hop varieties *OR55* and Fuggle possess respectively high and low resistance to the virulent race of *Verticillium albo-atrum* and demonstrate the phenomena described[1]. Similar effects are seen when plants of Fuggle are infected with one or other of the two races of *V. albo-atrum* of differing pathogenicity (one mild and the other virulent)[2]. The tomato varieties Pan America and Bonny Best have respectively high and low resistance to *Fusarium oxysporum lycopersici* and also display the phenomenon of differential fungal growth within them[4,5].

Roots of wilted plants are rarely studied, the assessments of disease usually being made on the stems. Since it is well known, however, that slight fungal growth in the stems is associated with slight fungal growth in the roots, and vice versa, the natural assumption appears to have been made that the whole plant (root and stem alike) provides a medium of uniformly high or low resistance to invasion. From this assumption arises a further one, namely, that the normal stems of plants of high and low resistance are intrinsically different in their reaction to the pathogen. This appears so axiomatic that it has been used as a basis for the study of the causes of resistance to wilt pathogens. Several workers have thus investigated the action of fungal toxins on healthy stems[6,7] or attempted to isolate compounds from stems of plants of high resistance which should not (theoretically) be present in stems of plants of low resistance[8]. Such studies have, in general, revealed no differences between the stems.

The present work on hops, at the East Malling Research Station, has attempted to differentiate between stem and root reaction, and to study the reactions of stems from varieties of differing resistance when grown under uniform conditions. If stems of such varieties are invaded from their own roots, their reactions are not being tested under identical conditions, since (*a*) they are growing on roots of differing varietal status and (*b*) these roots are differentially invaded. Two methods of studying the reaction of hop stems free from the effects of these factors have been used: (1) infection through rootstocks of another variety, and (2) direct stem inoculation of one variety with strains of *V. albo-atrum* to which plants of this variety show a differential response when root-inoculated.

*Grafting experiments*. Reciprocal rootstock–stem grafts were made of the varieties *OR55* and Fuggle (controls being grown on their own (grafted) roots). The plants were infected through these new roots by infesting the soil with a virulent strain of *V. albo-atrum*. When infected through Fuggle roots, both *OR55* and Fuggle stems became heavily invaded and died. When infected through *OR55* roots, both became lightly invaded and showed only mild symptoms. Thus under equal root-invasion conditions, the stems of both varieties showed an equal reaction. They were thus equally resistant.

*Stem inoculation experiments*. Stems of the Fuggle variety, growing on their own (healthy) roots, were directly inoculated with the two races of *V. albo-atrum* (mild and virulent). Two inoculation methods were used. When a small drop of spore suspension of either race of the fungus was introduced directly into the stem xylem, both races caused only mild wilt, and grew in an attenuated fashion in the stem above the point of inoculation. When a large amount of spore suspension of either race was put into a pith cavity, both races caused severe wilt, accompanied by extensive xylem invasion. The roots on all plants remained uninvaded. These results indicate that the reaction of the Fuggle stems was not determined by the race of fungus but by the conditions of invasion. When invaded from a small inoculum in the xylem, resistance of the stems was high; when invaded from a large inoculum in the pith cavity, this resistance was either reduced or overcome. The fact that stem reaction could thus be changed shows that, although not affected by fungal strain, the stems were not functioning as purely inert growth media for the pathogens.

Somewhat similar tests of inoculum dose have been made with the two races on Fuggle roots. In this case the size of the inoculum did not affect the severity of wilt or the growth of the fungus in the plant. The mild race invariably caused mild wilt and the virulent race caused severe wilt. Roots thus seem to differ fundamentally from stems in that their resistance is related to fungal virulence and not to dose of inoculum.

The results suggest the following conclusions on the mechanism of invasion of varieties of differing resistance. The site of differential resistance is in the roots. The stems of varieties of high or low resistance show equal resistance to both strains of the pathogen. Under conditions of mild root-invasion, this resistance is high; but in a variety of low resistance the host–parasite association in the roots causes stem resistance to be reduced or overcome. The following possible reasons for this are suggested as a basis for further study: (1) A reduction of stem resistance by: (*a*) diffusion of toxins from the invaded roots; (*b*) impairment of normal root-function. (2) Increase in the invasive power of the fungus by: (*a*) establishment of a suitable 'inoculum potential'; (*b*) diffusion of fungal accelerators.

The main conclusions may be widely applicable to vascular wilts. The results of Heinze and Andrus[5] suggest a similar relationship in the case of tomato wilt (although Scheffer and Walker[9] have recently disputed this). Wardlaw's observations[10] that the pseudostem of banana could only be infected through roots are also in agreement. If, in fact, the present conclusions are of general application, they may necessitate a re-orientation of previous views on the mechanism of parasitism by vascular pathogens and suggest a new approach to the study of host resistance. The experiments are to be reported in detail elsewhere.

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[1] Dimond, A. E., Davis, D., Chapman, R. A., and Stoddard, E. M., *Conn. Agric. Exp. Sta. Bull.*, **557** (1952).

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[9] Scheffer, R. P., and Walker, J. C., *Phytopathology*, **42**, 474 (1952).

[10] Wardlaw, C. W., "Diseases of the Banana" (Macmillan, 1935).

## Use of Repellents to simplify Insecticide Field Trials

A DIFFICULTY frequently met in insecticide field trials is that although the insecticide application may kill the insects on the treated plots at the time, these plots may be re-invaded very quickly by insects from the control plots and surrounding untreated areas. This is particularly marked in the case of trials on the control of cotton *Lygus* (*Lygus vosseleri*, Popp.), where the greater part of the damage is done by an immigration of highly mobile adults into the crop. One method of avoiding this difficulty is to use large plots of several acres in extent; but the very size of the plots seriously reduces the precision of an experimental comparison, besides being very expensive in time, materials and labour. Recent work has shown that where the principal purpose of the experiments is to study the effect of *Lygus* upon the yield of cotton, the result may be obtained very much more simply by using the repellent effect of certain insecticides.

During 1951 it was noticed that where small units of cotton, two rows of twenty plants each, scattered at random throughout a largely unsprayed field, were sprayed to 'run-off' level each week with 0·1 per cent DDT, they were quite free from signs of *Lygus* damage, while untreated plants, even in adjacent rows, showed signs of very heavy damage. Since a DDT deposit of this type takes up to twenty-four hours to kill adult *Lygus*, it was felt that this protection must have been due to a repellent effect of the insecticide.

Following this indication, laboratory experiments were carried out to investigate possible repellent effects of DDT and 'Toxaphene' deposits. Adult *Lygus* of both sexes were placed in small cages and offered a choice of treated and untreated sorghum heads as food. Approximately every ten minutes the numbers of *Lygus* on treated and untreated heads were counted. After each count the cages were shaken to dislodge feeding *Lygus* and the cages rotated through 180°.

Table 1. TOTAL NUMBERS OF VISITS MADE BY ADULT *Lygus* TO TREATED AND UNTREATED *Sorghum* HEADS

| | Treated | Untreated | |
|---|---|---|---|
| Trial 1 | 50 | 165 | Treated *Sorghum* dipped in 0·1 per cent DDT and dried. Ten *Lygus*/cage. Two cages per trial |
| Trial 2 | 34 | 71 | |
| Trial 3 | 20 | 62 | |
| Trial 4 | 20 | 51 | |
| Means | 31 | 87 | |
| Trial 5 | 24 | 180 | Treated *Sorghum* dipped in 0·2 per cent 'Toxaphene' and dried. Ten *Lygus* per cage. Two cages per trial |
| Trial 6 | 11 | 38 | |
| Trial 7 | 46 | 162 | |
| Means | 27 | 127 | |

Assuming that in the absence of repellent effects the numbers of visits to treated and untreated heads would have been similar, the $\chi^2$ test shows that DDT and 'Toxaphene' deposits are highly significantly repellent to adult *Lygus* of both sexes ($P < 0{\cdot}001$).

This effect was confirmed in the field during the 1952 cotton season. Ten single rows of twenty plants each were marked out at random in a two-acre cotton strip. Five of these were sprayed to 'run-off' level with 0·2 per cent 'Toxaphene' and five with 0·1 per cent '*C.R.* 686', a systemic phosphorous insecticide. Insecticide applications were made at weekly intervals during the period of *Lygus* immigration. For the purpose of comparing damage on sprayed and unsprayed plants, the tenth row to the right of each sprayed row was taken as a control.

Towards the end of the *Lygus* attack the third, fourth, fifth and sixth leaves from the top of the plant were graded on an arbitrary scale of damage ranging from 0, for no signs of damage, to 4 for a leaf completely shredded and tattered. Counts were made on fifteen plants on each treated and control row. The results are shown in Table 2.

Table 2. MEAN GRADE OF DAMAGE PER LEAF

| | |
|---|---|
| Rows sprayed with 'Toxaphene' | 0·79 |
| Rows sprayed with '*C.R.* 686' | 0·33 |
| Untreated control rows | 1·91 |

Analysis of the detailed records showed that differences between treated rows and untreated controls were highly significant ($P < 0{\cdot}001$).

A detailed examination of 15 plants in each row was also made, and the percentage of fruiting points formed up to that date which had been shed was calculated (see Table 3).

Table 3. MEAN PERCENTAGE OF FRUITING POINTS SHED

| | |
|---|---|
| 'Toxaphene' sprayed rows | 7 per cent |
| '*C.R.* 686' sprayed rows | 7 per cent |
| Control rows | 13 per cent |

For the analysis of the shedding records an angular transformation was used and the differences between treated and control rows shown to be highly significant ($P < 0{\cdot}001$).

Thus it has been shown that in a cotton field where large numbers of more attractive unsprayed plants are readily and closely available the deterrent effects of certain insecticide deposits are sufficiently strong to keep the treated plants free from *Lygus* damage. Conversely, the yield loss due to *Lygus* in unsprayed cotton may be readily estimated by using this method to protect a small proportion of the plants in the field.

This relatively simple and economical method of studying the effects of *Lygus* upon cotton yield is now being developed, and a detailed paper will be published elsewhere at a later date.

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East African Agriculture and
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Empire Cotton Growing Corporation,
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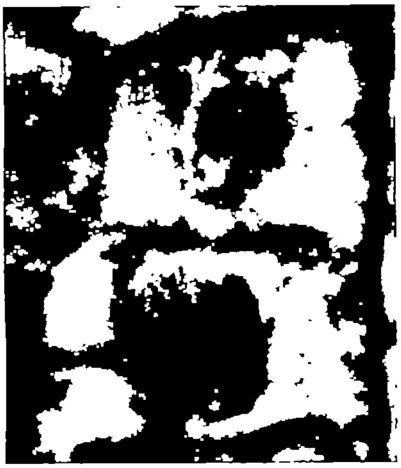
## Virus-induced Nucleolar Abnormalities in Tomato

IN view of current opinions on the nature of virus particles[1], recent work carried out in this department on the effect of the 'aspermy' virus upon nuclear, and especially nucleolar, behaviour in plant cells may have a special significance. Caldwell[2] reported prophase collapse in diseased pollen- and embryo-sac mother cells in tomato, accompanied by peculiarities of nucleolar behaviour, and Wilkinson[3] has observed similar meiotic abnormalities in *Nicotiana glutinosa*. Recent examination of somatic divisions in diseased tomato and tobacco plants has revealed the occurrence of widespread nucleolar and other abnormalities, some of which recall the aberrations regarded as typical of the cell-divisions found in malignant animal tissue; for example, arrested metaphase, collapse at metaphase, spindle malformation and breakdown, tendency to form giant nuclei, etc. In particular, abnormal persistence of the nucleolar material, and sometimes an apparent multiplication of nucleolar bodies during the mitotic cycle, have been very striking. Thus, in dividing cells of root tips obtained from tomato shoots heavily infected with the 'aspermy' virus, the nucleolar material,



Cells from root tissue of diseased tomato showing collapsed metaphase and (lower) nucleolar vesicle and one-sided spindle at early anaphase. × 1,000

instead of dispersing during prophase, persists through anaphase in the form of one or more prominent and somewhat elongated vesicles. The accompanying photograph shows a typical dividing nucleus at early anaphase, with the nucleolar vesicle in a central position upon the somewhat distorted spindle; incidentally, in the cell above can be seen an example of metaphase collapse. Similar results have been obtained in tobacco species infected with the same virus.

This postponement of the utilization of nucleolar material by the contracting chromosomes, normally completed by early metaphase (when the pellicles which invest the chromosomes are fully formed), provides further support for the view that there is competition between the virus particles and chromonematal material for nucleoprotein contained in the nucleolus. This view was formulated by me at a meeting last year of the Society for the Study of Fertility and mentioned in *Nature* (August 9, 1952). A detailed account of the work is being prepared for publication.

JOHN WILKINSON

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Exeter. Jan. 14.

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## Polyploidy in *Primula farinosa* L.

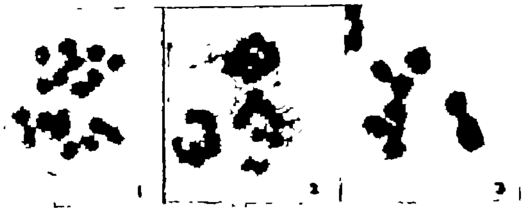
THE discovery of a tetraploid form of *Primula farinosa* on the Baltic island of Gotland during the summer of 1950 was somewhat unexpected, as hitherto this plant has seemed a well-defined diploid species ($n = 9$), at least in Central and Northern Europe. This tetraploid form revealed $n = 18$ at meiosis (Fig. 1), and the plant appeared morphologically distinct from the British *Primula*, with more elongated spatulate leaves (Fig. 4).

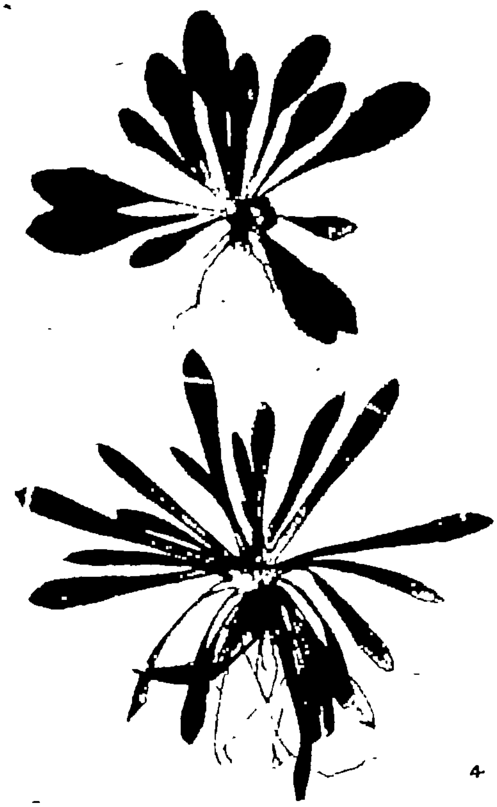
This led to a more comprehensive study of *P. farinosa* in Great Britain. However, all specimens collected on Widdybank Fell, Teesdale, in May 1952 proved to be diploid with $n = 9$ (Fig. 2); and a further survey of the *Primula* from other limestone areas in Yorkshire, Durham and Westmorland has so far revealed the same result; but in every case the chromosomes seemed smaller than those of the tetraploid form.

However, the intricacies of this species are considerable, and indicate a cytological complexity that was not visualized in the first instance, for plants of *P. farinosa* var. *acaulis* collected on Gotland, and kindly sent to me by Dr. Bengt Pettersson, have also proved to be diploid with $n = 9$ (Fig. 3). However, the chromosomes of this plant are considerably larger than those of the British diploid and the Swedish tetraploid (Figs. 1, 2 and 3), and a gene difference for chromosome size is therefore suspected. Thus the diploid and tetraploid forms of this species are both represented on the Baltic island of Gotland, which has for many years been renowned for its peculiar and interesting flora, rich in endemics.

These preliminary results indicate the complexity of the problem, and the tetraploid plants produce an interesting connecting link between the original diploid form of *P. farinosa* and the other members of the sub-section Farinosae, which give rise to a very long polyploid series: *Primula farinosa*, $n = 9$; *P. farinosa*, $n = 18$; *P. scotica*, $n = 27$; *P. scandinavica*, $n = 36$; *P. stricta*, $n = 63$.

However, it is now clear that a more detailed cytological survey of this group, from all over its geographical range, is desirable. I should be most





(Above) Meiotic metaphases in acetocarmine of forms of *Primula farinosa*. × 1,200. (1) Tetraploid from Gotland; (2) diploid from Teesdale; (3) diploid from Gotland.
(Below) (4) *Primula farinosa*, above from Teesdale, below from Gotland

grateful for any living plants or seeds of *P. farinosa*, *P. scotica*, *P. scandinavica*, *P. stricta* and *P. finmarchica* from Great Britain, Europe and North and South America.

E. W. DAVIES

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## Habitat of *Polycelis felina* (= *cornuta*) and *Crenobia alpina* in the British Isles

THE few text-books on freshwater biology which refer particularly to the British Isles regard *Polycelis felina* and *Crenobia alpina* as stenothermous, stream-dwelling species. Beauchamp[1], however, showed that *C. alpina* inhabited suitable shores of some Cumberland lakes during the winter; but he considered that summer temperatures were too high for their occurrence in lakes at this season. The generally accepted view is that in the British Isles these two species cannot establish themselves where the temperature exceeds 13°–15° C. in the case of *C. alpina*[1,3] and 16°–17° C. for *P. felina*[3]. On the Continent, Theinemann[4] considered that the widest range of *C. alpina* and *P. felina* was 0·7°–15° C. and 0·5°–15·75° C. respectively. It has been reported several times from the Continent that *Crenobia alpina* is a permanent member of the fauna of Alpine and other mountain lakes where a suitable substratum occurs (for references see Beauchamp[1]).

During a survey of the freshwater triclads of the lochs on Islay (Argyll), *Polycelis felina* was found in six of them in July 1952 during a spell of warm weather when the average maximum air temperature, as recorded on Colonsay, was 20° C. and the average 16° C., following a June of average warmth. Its abundance varied from a small to an exceedingly large population (see table). Twenty-three lochs in all were examined, and of these eleven were judged to provide a stony, wave-washed shore suitable for *P. felina*. These lochs are listed in order of concentration of calcium ions in the accompanying table—the number of *P. felina* and the total triclad population (*P. nigra* and/or *P. tenuis*) taken per unit hour of collecting is also recorded. It is clear that this supposedly typical stream species occurred in some lochs in great abundance, and in four was numerically the dominant species. There can be no question that here it formed a typical component of the lake fauna and was not restricted to areas near streams; there is no reason for supposing that it is not a permanent member. It is also interesting to note that *P. felina* reached its greatest abundance in the more calcareous lakes. According to Carpenter[2], this is contrary to the view expressed by Bornhauser, who observed that this species was markedly absent from streams with a high lime content. The explanation, however, may lie in the interpretation of the term 'high'. Loch Finlaggin, and to a lesser extent Loch Gorm also, are exceptions to the calcium ion – *P. felina* trend. The former had a relatively high population of *P. tenuis*, and competition may explain the absence of *P. felina*; while Loch Gorm had a shore of stones lying on sand which would be disturbed during wind action and become most harmful to soft-bodied triclads.

| Loch | Calcium (mgm./l.) | *P. felina* (1 hr. collecting) | Total triclads | Loch type | Height above sea-level (ft.) |
|---|---|---|---|---|---|
| nam Ban | 1·6 | Nil | Nil | Hill loch | 350 |
| Cam | 2·8 | Nil | 20 | Hill loch | 300 |
| Ardnahoe | 2·8 | 81 | 162 | Hill loch | 200 |
| nan Gillean | 4·4 | Nil | 248 | Hill loch | 300 |
| Gearach | 4·8 | Nil | Nil | Peaty hill loch | 250 |
| Gorm | 8·8 | 8 | 16 | Coastal loch—sandy | 50 |
| Skerrols | 9·6 | 140 | 216 | Lowland loch | 75 |
| Finlaggin | 15·6 | Nil | 210 | — | 170 |
| Lossit | 16·4 | 324 | 324 | Hill loch | 300 |
| Cadharn | 19·2 | 346 | 442 | Hill loch | 230 |
| Ballygrant | 23·2 | 228 | 264 | Hill loch | 230 |

Considering now *Crenobia alpina*, this species was not recorded from the Islay lochs, but was collected from Loch Baile à Ghobhain and Loch Fiart on Lismore Island, and from Loch Restil (Argyll) in July 1951. The former two are low-lying, calcareous lochs (calcium, 50 mgm./l.) and the triclads were taken from exposed, stony shores. In more sheltered bays, *C. alpina* was absent and *Polycelis nigra* occurred. Loch Restil is a small, lime-poor (calcium, 2·4 mgm./l.) hill loch at approximately 800 ft. above sea-level. At the time, the records were considered as examples of aberrant behaviour, perhaps due to the drying-up of streams. However, on the clear-cut evidence of the Islay records for *P. felina*, they may be better regarded as examples of the lake-dwelling habit of *C. alpina* in the British Isles.

It is generally considered that these two triclads are limited in their distribution by their stenothermy, or associated oxygen tension[5]. Examination of average maximum July air temperatures for the British Isles (1901–30) shows that Islay, by virtue of its maritime position, lies north of the 62° F. (16·7° C.) isotherm; Lismore is 1°–2° F. warmer. Allowing for the lower temperature of lake water and the certainty of periods of average temperature greater than 16·7° C. (average annual maximum temperature for Islay, 1901–30, was approximately 22·5° C.), the habit may still fit with the physiological explanation, particularly in the case of *P. felina*. (It is hoped to arrange for water temperatures to be recorded in one of the Islay lochs during the summer.) Thus *P. felina* and perhaps *C. alpina* may be permanent lake-dwellers in the northern part of the British Isles, but confined to streams farther south. *P. felina* was recorded from a stony beach in Windermere during August 1950, but during a period of heavy rainfall and near the entry of a stream.

Different varieties of *P. felina* have been described by Theinemann, and it will be interesting to compare the Islay loch specimens with stream-dwelling forms. Living collections of Islay material have been submitted to Mr. Anders G. Dahm, University of Lund, Sweden, who is working on the taxonomy and ecology of this species.

I am grateful to the Nature Conservancy for defraying expenses for the field-work, and to the Meteorological Office for supplying data of temperatures for Colonsay.

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[1] Beauchamp, R. S. A., *J. Anim. Ecol.*, 1, 175 (1932).

[2] Carpenter, K., *J. Ecol.*, 16, 105 (1928).

[3] Macan, T. T., and Worthington, E. B., "Life in Lakes and Rivers", 126 (Collins, London, 1951).

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[5] de Beaufort, L. F., "Zoogeography of the Land and Inland Waters" (Sidgwick and Jackson, London, 1951).

# FORTHCOMING EVENTS

*(Meeting marked with an asterisk * is open to the public)*

## Monday, April 13

Institution of Electrical Engineers, Radio Section (at Savoy Place, Victoria Embankment, London, W.C.2), at 5.30 p.m.—Discussion on "The Relative Merits of Broad-Band Transmission by Beam, Cable and Waveguide" (to be opened by Mr. E. C. H. Organ).

Society for General Microbiology (at the Royal Institution, 21 Albemarle Street, London, W.1), at 6 p.m.—Dr. D. D. Woods: "The Integration of Research on the Nutrition and Metabolism of Micro-organisms" (First Marjory Stephenson Memorial Lecture).*

## Monday, April 13—Thursday, April 16

Ergonomics Research Society (in the Department of Human Anatomy, The University, Oxford).—Symposium on "Human Performance—its Measurement and Limitations".

## Monday, April 13—Friday, April 17

Physical Society (at the Imperial College of Science and Technology, Imperial Institute Road, London, S.W.7).—37th Exhibition of Scientific Instruments and Apparatus

Tuesday, April 14

At 6.45 p.m.—Dr. E. C. Bullard, F.R.S.: "Seismic Study of the Ocean Basins".

Wednesday, April 15

At 6.45 p.m.—Dr. L. A. Jordan: "Particles, Pellicles; Pigments, Paints and Physics".

Thursday, April 16

At 6.45 p.m.—Prof. W. V. Mayneord: "Scintillation Counting and its Medical Applications".

## Tuesday, April 14

Zoological Society of London (at the Zoological Gardens, Regent's Park, London, N.W.1), at 5 p.m.—Scientific Papers

Institution of Chemical Engineers (at the Geological Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Mr. G. G. Haselden: "The Fractionation of Liquid Air".

Institution of Electrical Engineers, Measurements Section (at Savoy Place, Victoria Embankment, London, W.C.2), at 5.30 p.m.—Dr. T. Kilburn, Mr. G. C. Tootill, Mr. D. B. G. Edwards and Mr. B. W. Pollard: "Digital Computers at Manchester University"; Mr. B. W. Pollard and Mr. K. Lonsdale: "The Construction and Operation of the Manchester University Computer"; Dr. T. Kilburn and Mr. G. Ord: "Universal High-Speed Digital Computers—a Decimal Storage System"; Prof. F. C. Williams, F.R.S., Dr. T. Kilburn, Mr. G. N. W. Litting, Mr. D. B. G. Edwards and Mr. G. R. Hoffman: "Recent Advances in Cathode Ray Tube Storage".

Institution of the Rubber Industry (at the Royal Society of Tropical Medicine and Hygiene, Manson House, 26 Portland Place, London, W.1), at 6.30 p.m.—Annual General Meeting; at 7 p.m.—Films: "Basic Principles of Lubrication", "Krilium".

Society of Public Analysts and Other Analytical Chemists, Polarographic Discussion Panel of the Physical Methods Group (at the Chemical Society, Burlington House, Piccadilly, London, W.1), at 6.30 p.m.—Papers on "Polarography".

## Wednesday, April 15

Royal Society of Arts (at John Adam Street, Adelphi, London, W.C.2), at 2.30 p.m.—Mr. L. Landon Goodman: "Materials Handling and Processing".

Geological Society of London (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Mr. Maurice Black: "The Constitution of Chalk".

Royal Meteorological Society (at 49 Cromwell Road, London, S.W.7), at 5 p.m.—Annual General Meeting; Sir Charles Normand: "Monsoon Forecasting" (Presidential Address).

Royal Microscopical Society (at Tavistock House South, Tavistock Square, London, W.C.1), at 5.30 p.m.—Prof. B. K. Johnson: "Microscopy in the Region of Wave-length $\lambda = 2000$ A. to 1000 A."; Mr. R. J. King and Dr. E. M. F. Roe: "Optical Conditions for Quantitative Ultra-Violet Microspectroscopy".

Society of Chemical Industry, Corrosion Group (at the Chemical Society, Burlington House, Piccadilly, London, W.1), at 6.30 p.m.—Mr. F. C. Porter: "The Corrosion of Aluminium and its Alloys in Supply Waters".

## Thursday, April 16

Royal Society (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Mr. K. A. Kermack: "A Biometrical Study of *Micraster coranguinum* and *Isomicraster senonensis*"; Mr. B. Nicolai and Mr. R. D. Preston: "Cell Wall Studies in the Chlorophyceae".

Institution of Mining and Metallurgy (at the Geological Society, Burlington House, Piccadilly, London, W.1), at 5 p.m.—Prof. Shiou-Chuan Sun: "Frothing Characteristics of Cresylic Acids in Flotation"; Dr. J. S. Webb: "A Review of American Progress in Geochemical Prospecting and Recommendations for Future British Work in this Field".

London Mathematical Society (at University College, Cardiff), at 5 p.m.—Dr. G. Higman: "p-soluble Groups".

Society of Chemical Industry, Road and Building Materials Group (at the Building Centre, Store Street, London, W.C.1), at 6 p.m.—Annual General Meeting; Mr. A. W. Christie: "Road Surfaces as Reflectors of Light, from the Point of View of Street Lighting".

Society of Chemical Industry, Microbiology Group (at the Medical Society of London, 11 Chandos Street, Cavendish Square, London, W.1), at 6.15 p.m.—Dr. Lois Dickinson: "The Use of the Bacteriophage in the Study of Viruses"; Mr. L. J. Meanwell: "Bacteriophages of the Lactic Streptococci".

British Institute of Radiology (in the Reid-Knox Hall, 32 Welbeck Street, London, W.1), at 8 p.m.—Dr. A. E. Jones and Dr. A. Gluckmann: A Discussion on "The Carcinogenic Effects of Radiation".

## Thursday, April 16—Saturday, April 18

Faraday Society (at the Royal Institution, 21 Albemarle Street, London, W.1).—Fiftieth Anniversary Celebrations, and General Discussion on "Equilibrium Properties on Solutions of Non-Electrolytes".

## Friday, April 17

Institution of Chemical Engineers, Graduates' and Students' Section (in the Large Chemistry Theatre, University College, Gower Street, London, W.C.1), at 10 a.m.—Symposium on "Effluent Disposal".

Association of Applied Biologists (in the Surveying Lecture Theatre, Imperial College of Science and Technology, Prince Consort Road, London, S.W.7), at 11 a.m.—Annual General Meeting; at 2.30 p.m.—Mr. R. W. Marsh: "The Past and Future of the *Annals of Applied Biology*" (Presidential Address)

Royal Astronomical Society (at Burlington House, Piccadilly, London, W.1), at 4.15 p.m.—Discussion of Geophysical Papers received during the Session.

Society of Chemical Industry, Fine Chemicals Group (in the Chemistry Lecture Theatre, King's College, Strand, London, W.C.2), at 7 p.m.—Annual General Meeting; at 7.30 p.m.—Dr. Wm. Mitchell: "Isolation of Fine Chemicals from Natural Sources"

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# APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Lecturer or Assistant Lecturer in the Department of Pharmaceutics, University of Malaya, Singapore—The Secretary, Inter-University Council for Higher Education in the Colonies, 1 Gordon Square, London, W.C.1 (April 18).

Speech Therapist (part-time) to the Godalming Clinic—The County Medical Officer, County Hall, Kingston-upon-Thames, Surrey (April 18).

Lecturers in Anatomy, Physiology and Pathology, and Lecturers or Assistant Lecturers in Civil Engineering and Mechanical Engineering, at University College of Khartoum, Sudan—The Secretary, Inter-University Council for Higher Education in the Colonies, 1 Gordon Square, London, W.C.1 (April 20).

Research Assistant in the Department of Chemistry, for work on ionic melts—The Professor of Chemistry, Queen's University, Belfast (April 20).

Light Current Electrical Engineer at the Royal Aircraft Establishment, Farnborough, for development of variety of precision electrical equipment and its application to research problems in aircraft flight control—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting D.114/53A (April 25).

Physical Chemist or Physicist (Scientist, Grade I) to take charge of investigations on the structure of coke—The National Coal Board, Central Research Establishment, Stoke Orchard, Cheltenham, Glos, quoting TT/611 (April 25).

Assistant Lecturer in the Department of Chemistry—The Secretary and Registrar, University College of North Wales, Bangor (April 27).

Director of the Tasmanian Museum and Art Gallery—The Agent-General for Tasmania, 457 Strand, London, W.C.2 (April 30).

Research Officers (Scientific Officer grade) to work on sugar beet breeding and cereal breeding—The Secretary, Plant Breeding Institute, School of Agriculture, Cambridge (April 30).

Research Studentships to senior undergraduates reading zoology—The Director, Zoological Society of London, Regent's Park, London, N.W.1 (April 30).

Senior Lecturer in the Department of Veterinary Pathology—The Secretary of University Court, The University, Glasgow (April 30).

University Lecturer and one or more University Assistant Lecturers in Mathematics—The Secretary of the Faculty of Mathematics, Arts School, Bene't Street, Cambridge (April 30).

Assistant in Physical Chemistry at University College, Dundee—The Secretary, The University, St. Andrews (May 1).

Lecturer or Assistant Lecturer in Chemistry at University College, Ibadan, Nigeria—The Secretary, Inter-University Council for Higher Education in the Colonies, 1 Gordon Square, London, W.C.1 (May 1).

Senior Lecturer in Inorganic Chemistry, and Lecturers or Assistant Lecturers in Botany, Chemistry, Mathematics, Parasitology, and Zoology, at University College of Khartoum, Sudan—The Secretary, Inter-University Council for Higher Education in the Colonies, 1 Gordon Square, London, W.C.1 (May 1).

Lecturer in Public Health Engineering—The Head of the Department of Civil Engineering, Imperial College of Science and Technology, South Kensington, London, S.W.7 (May 2).

RESEARCH ASSISTANT TO WORK IN BEEKEEPING RESEARCH DEPARTMENT on problems relating to honey bees and their management—The Secretary, North of Scotland College of Agriculture, 41½ Union Street, Aberdeen (May 5).

ASSISTANT LECTURER IN CHEMISTRY, and an ASSISTANT LECTURER IN ZOOLOGY—The Registrar, University College, Cathays Park, Cardiff (May 9).

LECTURER IN THE HISTORY OF SCIENCE—The Secretary of Faculties, University Registry, Oxford (May 9).

ENGLISH ELECTRIC CO. STUDENTSHIP IN AERONAUTICS—The Deputy Registrar, City and Guilds College, Exhibition Road, London, S.W.7 (May 15).

ENTOMOLOGIST, and a RESEARCH OFFICER—The Director, Tobacco Research Board of Southern Rhodesia, P.O. Box 1909, Salisbury, Southern Rhodesia (May 15).

MAHENDRALAL SIRCAR PROFESSOR OF PHYSICS—The Registrar, Indian Association for the Cultivation of Science, Jadavpur, Calcutta 32, India (May 15).

ORGANIC CHEMIST (Senior Research Officer grade)—The Director, Laboratory of Human Nutrition, Oxford (May 16).

SCIENTIFIC OFFICER IN THE ENTOMOLOGY DEPARTMENT, to work probably on problems of soil arthropods or other invertebrates—The Secretary, Rothamsted Experimental Station, Harpenden, Herts (May 16).

SENIOR RESEARCH OFFICER to undertake research on the kinetics of the gasification reactions of coal under high pressure, a RESEARCH OFFICER to undertake research on the influence of ash catalysis on the reactions which occur during the complete gasification of coal, a RESEARCH OFFICER to undertake research directed at the improvement of methods for the analysis and testing of brown coal, and gas mixtures which result from its gasification, a TECHNICAL OFFICER to undertake the analysis and testing of coal, ash, fuel gases, and other materials associated with the pilot plant investigation of the gasification of brown coal, a TECHNICAL OFFICER to assist in pilot plant research on the gasification of coal under high pressure, and a TECHNICAL OFFICER to develop techniques for the investigation of the sintering and fusion of coal ash; in the Chemical Engineering Section of the Division of Industrial Chemistry, Commonwealth Scientific and Industrial Research Organization—The Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting Ref. 590/439 (May 16).

UNIVERSITY DEMONSTRATOR IN BOTANY—Dr. A. S. Watt, Department of Botany, Downing Street, Cambridge (May 16).

ASSISTANT LECTURER IN ARCHÆOLOGY—The Registrar, University College, Cathays Park, Cardiff (May 30).

COATS FELLOWSHIP IN CHEMISTRY or PHYSICS—The Clerk of the Senate, The University, Glasgow, W.2 (May 31).

ORNITHOLOGIST (Professional Officer grade), an ENTOMOLOGIST (Assistant Professional Officer grade) and a HERPETOLOGIST (Assistant Professional Officer grade)—The Director, Transvaal Museum, P.O. Box 413, Pretoria, South Africa (May 31).

ASSISTANT LECTURER IN BOTANY—The Registrar, University College, Exeter.

ASSISTANT TECHNICAL SECRETARY (with a degree in metallurgy) TO THE METALLURGY (General) DIVISION—The Personnel Officer, British Iron and Steel Research Association, 11 Park Lane, London, W.1, quoting 'Technical Secretary'.

ENTOMOLOGIST to develop a field technique to control biting midges, and a TECHNICAL ASSISTANT graduate or technician to assist in investigating the larval ecology of midges—Dr. D. S. Kettle, Department of Zoology, West Mains Road, Edinburgh 9.

EXPERIMENTAL OFFICERS (preferably biologists, but chemists or physicists with interest in biological research acceptable) at a Ministry of Supply Research Establishment near Salisbury—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting G.90/53A.

EXPERIMENTAL OFFICERS in R.A.F. Signals Establishments at (a) Ruislip, for general experimental work and tests in connexion with design of radio communications and radar systems, (b) Medmenham, for work on installation design of airfield communications and landing aid systems, equipment, investigations and siting problems, (c) Henlow (Assistant Experimental Officers only) for experimental work on calibration of transfer standards, involving bridge, frequency, and pulse measurements—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting D.90/53A.

LECTURER (Grade B) IN THE HYGIENE AND PUBLIC HEALTH DEPARTMENT—The Clerk to the Governing Body, Battersea Polytechnic, Battersea, London, S.W 11.

MECHANICAL ENGINEER or PHYSICIST (with first- or second-class honours degree or equivalent in mechanical engineering or physics) to undertake experimental and theoretical work with light mechanisms, at the Royal Aircraft Establishment, Farnborough—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting C.169/53A.

METALLURGIST or PHYSICAL CHEMIST (with university degree or equivalent qualification) to carry out research involving particular emphasis on vacuum melting of pure iron and special alloys (location of work: Sheffield)—The Personnel Officer, British Iron and Steel Research Association, 11 Park Lane, London, W.1, quoting 'Vacuum Melting'.

RESEARCH ASSISTANT (with experience in algology, preferably with unicellular algæ) for work in biophysics IN THE DEPARTMENT OF BOTANY—Dr. R. D. Preston, Department of Botany, The University, Leeds 2.

RESEARCH ASSISTANT (with honours degree in engineering) for measurements for the elastic and plastic states for a metal-working process—Prof. Ford, Mechanical Engineering Department, City and Guilds College, Exhibition Road, London, S.W.7.

RESEARCH ASSISTANT (Inter.B.Sc. standard) for chemical investigations on the interaction of ink and paper—The Printing, Packaging and Allied Trades Research Association, Randalls Road, Leatherhead, quoting C.2.

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Royal Institute of Chemistry. Lectures, Monographs and Reports, 1952, No. 4: The Scientific Examination of Paintings. By Dr. A. E. A. Werner. Pp. 16. (London: Royal Institute of Chemistry, 1952.) 5s. net. [52

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British Hydromechanics Research Association. Fifth Annual Report, October 1951 to September 1952. Pp. 28. (Harlow: British Hydromechanics Research Association, 1952.) [92

Transactions of the Royal Society of Edinburgh. Vol. 62, Part 2, No. 9: Geology of Central Vestspitsbergen. Part 1: Review of the Geology of Spitsbergen, with special reference to Central Vestspitsbergen; Part 2: Carboniferous to Lower Permian of Billefjorden. By E. R. Gee, W. B. Harland and J. R. H. McWhae. Pp. 299–356+7 plates. (Edinburgh and London: Oliver and Boyd, Ltd., 1952.) 18s. 6d. [92

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Dominion of Canada: Department of Agriculture, Science Service. Guide to the Chemicals used in Crop Protection. By H. Martin and J. R. W. Miles. Pp. 236. (London, Ont.: University of Western Ontario, 1952.) [52

Meddelanden från Lunds Astronomiska Observatorium. Ser. 1, Nr. 179: A Radar Investigation of the Delta Aquarid Meteor Shower of 1950. By Bertil-Anders Lindblad. Pp. 27. Ser. 1, Nr. 180: On the Masses and Luminosities of Extragalactic Nebulae. By Erik Holmberg. Pp. 13. (Göteborg: Elanders Boktryckeri A.-B., 1952.) [52

Research Bulletin of the East Punjab University. No. 16: Sperm Formation in certain Coleoptera with particular reference to Chromosome Numbers, Acrosome and Mitochondrial Nebenkern. By Vishwa Nath, Rajkrishnan Bhardwaj and Manohar Lal Gupta. Pp. 39–50. 3 rupees. No. 17: Potassium Meta-Periodate as Volumetric Agent, Part 2, Indirect Determinations. By Balwant Singh and Apper Singh. Pp. 51–56. 13 annas. No. 18: Studies on the Hariana Breed of Cattle. By G. P. Sharma, K. N. Vali and K. R. Suri. Pp. 57–68. 1.8 rupees. No. 19: Preparation of Active Carbon from a few Indigenous Sources and Comparative Efficiency of Different Activation Treatments. By Balwant Rai Puri, M. L. Lakhanpal and Balvir Varma. Pp. 12. 1.8 rupees. (Hoshiarpur: East Punjab University, 1951–1952.) [52

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Indian Central Cotton Committee. Technological Bulletin, Series A, No. 79: Technological Reports on Standard Indian Cottons, 1951. By Dr. C. Nanjundayya. Pp. iv+88. (Bombay: Indian Central Cotton Committee, 1952.) 2 rupees. [52

Guide to the Botanic Gardens, Entebbe, Uganda. Pp. ii+8+15 plates. (Entebbe: Botanic Gardens, 1952.) 2s. [52

Education in a Technological Society: a Preliminary International Survey of the Nature and Efficacy of Technical Education. (Tensions and Technology Series.) Pp. 76. (Paris: Unesco; London: H.M. Stationery Office, 1952.) 200 francs; 4s.; 75 cents. [92

Smithsonian Institution: United States National Museum. Bulletin 200: The Generic Names of the Beetle Family Staphylinidae; with an Essay on Genotypy. By Richard E. Blackwelder. Pp. iv+483. (Washington, D.C.: Government Printing Office, 1952.) 1.50 dollars. [92

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# ACADEMIC FREEDOM AND THE UNORTHODOX

PROF. A. MACBEATH, of the Queen's University, Belfast, delivered an evening discourse to the British Association last September, putting forward a plea for 'heretics' as he termed them; and his thoughtful diagnosis of the contemporary situation has been published in *The Advancement of Science* (vol. 9, No. 35; December 1952) almost simultaneously with the delivery of Dr. J. B. Conant's last report as president of Harvard University, on his appointment as United States High Commissioner to Germany. In that report Dr. Conant likewise stoutly champions the right to dissent, and threw the full weight of his authority against any large inquiry in the McCarthy spirit into teaching systems and courses of instruction in colleges and universities. Dr. Conant himself believes that Communists should be banned from appointments in any school, college or university, and supports the discovery and prosecution of any subversives. He is not opposed to security investigations even in the academic world, provided it is conducted with "due process of law"—and Prof. W. Gellhorn and Mr. Alan Barth's books have provided sufficient evidence that many investigations have failed to observe this condition or to be conducted with the restraint that is necessary to avoid doing more harm than good. Nevertheless, said Dr. Conant, "It would be a sad day for the United States if the tradition of dissent were driven out of the universities. For it is the freedom to disagree, to quarrel with authority on intellectual matters, to think otherwise, that has made this nation what it is. . . . An industrial society was pioneered by men who were dissenters . . . the global struggle with communism turns on this very point. . . . The independence of each college and university would be threatened if Government agencies of any sort started inquiries into the nature of the instruction that was given. The colleges of the United States have nothing to hide, but their independence as corporate scholarly organizations is of supreme importance".

Dr. Conant thus stands with his fellow countrymen, Prof. G. Boas, of Johns Hopkins University, and Prof. H. S. Commager, of Columbia, whose warnings against the growth of authoritarianism and championship of the claims of criticism and dissent and non-conformity are quoted by Prof. Macbeath as evidence that the friends of freedom in the United States are alert and active. Indeed, the appointment of Dr. Conant himself as High Commissioner for Germany, in spite of his outspoken defence of academic freedom, suggests that his actions are not unwelcome to the American Government. The attack on nonconformity may continue in the United States and elsewhere; but it is at least clear that a widespread body of responsible men and women will not tolerate in silence and without resistance the development of the kind of society in which freedom of inquiry, criticism and originality do not flourish.

Prof. Macbeath began his discourse by reminding his audience that by the beginning of this century the freedom, which Milton with his sure insight recognized as the foundation of all other liberties and which is an essential condition of the advancement of science, seemed to be so thoroughly established that people tended to take it for granted as part of the natural order of things. To-day it is perhaps in greater danger than at any time since Milton wrote; and that dissent should be regarded as disloyalty, criticism as an unfriendly act, and difference of opinion as disaffection, show how far we have drifted towards authoritarianism and away from the free, frank and critical discussion of all questions which is the essence of democracy. Moreover, there are tendencies in the society which science has helped to produce which may slowly but surely destroy the spirit of free inquiry and produce a state of affairs in which science can no longer flourish.

The plea for 'heretics' was therefore essentially concerned with these factors in our contemporary society and with the causes which have produced them. Prof. Macbeath sees no evidence that the moral or intellectual qualities of our people have deteriorated. The conditions in which we live make greater demands on the intelligence, the imagination and the sympathy of our people, and as a result the people are bewildered, perplexed and unhappy. Although science has helped to produce it, this state of affairs is not an inevitable consequence of science or even of its application. Science has developed in the context of a society which provides its stimulus and inspiration and which provides the men who engage in it; and, rather than blame science, we should, if we wish to use wisely the power which science has placed at our disposal, seek to regain and retain our hold on the disintegrating factors in the situation.

This position must not be attributed merely to the wilfulness or wickedness of any group of men, and we cannot solve our problem by neglecting one half of life when we find reconciliation with the other difficult. Indeed, Prof. Macbeath laid his main stress on the need for sincerity—for acting on principles to which we are apt to render merely lip service. Much of the frustration and malaise in modern life are due to this discrepancy between our profession and our practice. If a principle is sound, the proper way is to act on it; to revitalize our society we need to reformulate the platitudes, to which we assent but in which we do not believe, and embody them in our institutions and way of life in such a manner that they would be true in theory and apply in practice.

The two most characteristic movements of the modern age, said Prof. Macbeath, are science and democracy. Both spring from respect for the dignity of man as an intelligent being. Both stand for what Plato called the victory of persuasion over force, of discussion over dictation, and both are tentative and experimental, rejecting all claims to dogmatic authority or certainty.

For three centuries men have been trying to embody their faith in this new attitude in institutions and a way of life. During the present century the presuppositions of both science and democracy have been challenged and they are called upon to defend themselves; this has been due mainly to technology and industrialism. It is these features of the modern age, he believes, which have produced the state of affairs threatening to destroy the scientific spirit to which they owe their origin.

In the modern world, science owes its prestige mainly to the power over his environment which i places at man's disposal. That power can be used for good or for evil, and when men found by bitte experience that it was not always wisely used, they reacted not only against freedom to misuse it but also against freedom in general. Such reaction is due at least in part to a confusion between science and the results of its application, and a consequent failure to distinguish between the freedom which is a necessary condition of scientific discovery and progress, and the control which has to be exercised over the use made of the results of applied science if they are to contribute to the welfare of man, and not to his undoing. It was also a confusion between what science does and what it does not profess to do which has led men to expect of science not only knowledge and power but also the wisdom to use it aright.

To these results must be added a natural resistance on the part of the ordinary man to the scientific attitude. It requires a long training and a hard discipline to eradicate the expectation that there exists a body of fixed and certain truth to be accepted as final, and to secure acceptance of the scientific viewpoint according to which all conclusions are on trial and the function of the mind is to be for ever reaching-out and for ever learning and testing Moreover, the scientific attitude is opposed to some of the settled tendencies of human nature, involving the co-operation of men of different classes and countries, in contrast to the relatively small groups to which many of our traditional, emotional and social habits and institutions have become adapted This resistance has also been greatly intensified by the changes which scientific techniques have introduced into the modern world. While science and democracy promise him a greater mastery and control over his environment, the individual man finds himself dependent and powerless. If he is to do anything, even to survive, he must join with others, and often on terms which are not of his choosing, while in large-scale organizations (industrial and political) fewer men than ever have the opportunity of exercising initiative, making responsible decisions, and guiding and controlling much even of their own behaviour.

Prof. Macbeath did not deny the need for such large-scale organization or for the planning inherent in it; but they constitute, he urged, a main threat to freedom to-day. They tend to ignore the distinction between persons and things; and a main problem of our time is to guard against this inherent tendency to tyranny on the part of administrators. They are liable to identify the plan which they wish to impose with the good of the community; then all dissent is regarded as disloyalty, all criticism as unreasonable and all objectors as traitors. Not only is the only safeguard against major mistakes then gone, but, equally important, there is the danger of inflexibility at a time when openmindedness and responsiveness to new ideas are more necessary than ver. Fixed ideas and habits to-day can be a public anger, and at best the time-lag between the technological changes and our habits and institutions auses a sense of tension and frustration in our ociety.

Such tension and frustration cause much unhappiness and division of loyalties in modern life. By ndermining its cohesion, they encourage also the endency to authoritarianism and the revolt against eason, and in such circumstances those who prefer ase to liberty are apt to be impatient and resentful of the dissenter or nonconformist who demands easons.

It is in such circumstances that Prof. Macbeath champions the right to dissent and the vital function of the heretic. Toleration, he maintains, is to be encouraged, not as an indulgence to error, but as a method of arriving at truth and as a safeguard against mistakes. Failure in tolerance is indeed evidence of an ultimate lack of faith in the soundness of our beliefs, in the value of our way of life and in the intelligence of our people; it is evidence of fear that they cannot withstand criticism. The function of the heretic and critic is to force us to keep examining and testing, revising and perfecting our beliefs and ideals. When that function is no longer permitted, stagnation will set in and freedom and science and all they stand for will decay and die.

In the last analysis, points out Prof. Macbeath, there are only two ways of dealing with human beings—the way of persuasion and the way of force. Science stands for the former and can only flourish n an atmosphere of freedom, an atmosphere in which dissent and nonconformity and difference of opinion are tolerated. That freedom is one and indivisible: if t is threatened anywhere, it is everywhere in danger.

To science the chief danger is probably, as Prof. Macbeath suggests, not so much from positive restrictions consciously imposed, as that the atmosphere of a society which rewards conformity and penalizes dissent may cease to produce scientists, men imbued with the spirit of free inquiry. Nevertheless, those positive restrictions are serious enough and Prof. Macbeath's noble plea should rouse scientists everywhere to action against whatever restrictions cannot be thoroughly justified on impartial inquiry. His diagnosis shows clearly the real danger that science may be crushed by its own creations, and that scientists cannot afford to remain silent.

Prof. Macbeath, in this address, has very forcibly put the argument for freedom as one factor in national security, and he does not deny the necessity for striking a balance between individual freedom and national security. That issue, however, he does not discuss, and it is complicated by the further conflict of loyalties to which he scarcely refers—and then more by the implication that our concern should be to foster the loyalties which so much in our modern world tends to erode.

There can be no question that the defence of freedom has been made more difficult in the past few years by the question of loyalty, and in particular by the claims of some scientists to determine such issues entirely for themselves. Here Prof. Macbeath gave much less guidance than Prof. A. V. Hill in his presidential address, nor can it be said that the Present Question Conference on Conflicts of Loyalties? held at Oxford during August 2–9, so far as reported in *Question**, touches the vital issues. Mr. H. Westmann's address on "Conflicts of Loyalties?" and Prof. M. Polanyi's on "Science and Faith" present some of the features of Prof. Macbeath's diagnosis and of the danger of an anti-scientific attitude being engendered. While indicating the need for clear thinking, they give little clue as to how on one hand the roots of loyalty—whether to science, to society or to mankind—are to be re-established or how, on the other, confidence can be engendered in the society in which the scientist works so that his work will not endanger its security and welfare.

Where that confidence has been undermined, however, it has been at least in part because the scientist or technologist has first betrayed his loyalty to his own particular scientific discipline or professional tradition. That is primarily a matter for professional or scientific associations, and if they are neglectful the harm can scarcely be corrected from outside, while the attempt to do so endangers the whole condition of creative scientific activity. On such issues Prof. Macbeath's address is first and foremost a challenge to professional bodies of scientific men, and unless they meet the challenge with courage and imagination the danger to scientific advance to which he points may well become even more acute; without courage there is no liberty. Scientific men must safeguard the highest standards of professional conduct, integrity and loyalty; but they must also ensure that due place is found for the dissenters and nonconformists, whose vision and independence contribute so much to the flexibility of mind and receptivity towards new ideas necessary for the advance of science.

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* *Question: a Journal.* Edited by H. Westmann. Vol. 5, No. 1: Conflicts of Loyalties? By Prof. M. Polanyi, J. H. Oldham, Prof. W. R. Niblett, H. Westmann and Herbert Read. (Published for the Present Question Conference, Ltd.). Pp. 112. (London: Hammond, Hammond and Co., Ltd., 1952.) 8s. 6d.

## ECONOMICS OF THE PROTECTION OF PLANTS

Untaken Harvest

Man's Loss of Crops from Pest, Weed and Disease; an Introductory Study. By George Ordish. Pp. xii+171. (London: Constable and Co., Ltd., 1952.) 15s. net.

LOSSES caused by pests and diseases of plants have been expressed by many people in many ways. In this book, Mr. George Ordish maintains that such losses should not be calculated in terms of money or in terms of loss of yield but rather as a waste of land and labour. For example, if in the United Kingdom viruses are responsible for a loss of 10 per cent of the potato crop, the 7½ million ton yield represents only 90 per cent of the potential yield and the real loss is not the difference between 7·5 and 8·3 million tons "but the land, the labour and the resources used to grow these ungathered tons". The question that immediately arises is whether this method of representing losses can be successfully defended on biological grounds ? "Untaken Harvest" is a good selling title and rightly suggests some element of waste ; but is it good biology or indeed good natural philosophy to regard as an 'untaken harvest' the land, labour and resources used for growing 'ungathered tons' that exist only in the imagination ? Insects and fungi are part of the very complex community of living things ; were they to be removed, what would be the result ? Nobody knows, and nobody has yet grown an agricultural crop in the absence of insects and fungi. Though many biologists will not agree with Mr. Ordish's method of calculating losses, if they read this book they must agree that his case is very well argued and presented.

The book opens with a chapter on the pests and diseases themselves, in which there is also a brief résumé of control methods. Mr. Ordish then goes on to develop the main part of his thesis in Chapters 2 and 3 ; the losses caused by pests and diseases in many parts of the world are given, and their economic effects are described. The dangers and pitfalls awaiting the estimator of losses are discussed, and attention is directed to the lack of precise information and the need for more accurate figures and for better methods of assessing the losses. In spite of this, Mr. Ordish has in one table attempted to assess the losses by all the pests and all the diseases of all the crops in the United Kingdom. Let it be said at once that, *faute de mieux*, it is a brave attempt but lacking accurate figures ; one is inclined to pause and say with Pope, "Tis with our judgements as our watches, none go just alike, yet each believes his own". Unfortunately, when once figures of this nature have appeared in print, they are apt to be quoted *ad nauseam*, and other useful and more reliable figures in this book may lie neglected and forgotten.

In Chapter 3, which deals with the economic effects of the losses, Mr. Ordish is thoroughly at home, and the book is worth reading for this chapter alone. In estimating the relative efficiency of control measures, a ratio is established between the cost of the control and the potential benefit derived ; this is termed the cost/potential benefit ratio. The examples of such ratios given are worthy of careful study by the plant pathologist.

Chapter 4 deals with methods of combating the losses and the economics of the methods. These are well and fully discussed except that the credit for modern development in spray machinery appears to be very unevenly allocated. For example, no credit is assigned to the American forerunner of the auto-blast type of machine, and no mention is made of the excellent work of the Long Ashton Research Station in this field. On this subject Mr. Ordish has dealt only with a fragment of the literature, and, if a new edition is called for, opportunity ought to be taken to restore the balance. In this chapter, too, he says : "It seems to be generally agreed among a large number of entomologists that treatment from the air is not as effective as from the ground". Though many entomologists may agree, more than a few will disagree, and further careful comparisons of the two methods are badly needed.

The social effects of the losses are discussed in Chapter 5, and considerations on present and future crop protection in Chapter 6, wherein the economic of the various methods of plant protection are also discussed. The book concludes with a chapter on the trade in insecticides, fungicides and related products and there is an extremely useful table giving figure for world production and consumption of them.

Mr. Ordish, who is agricultural economist to Plant Protection, Ltd., has taken very great pains to read and collate an enormous amount of information which will be of great value to his colleagues in industry and to those who work in other spheres of applied biology. The emphasis could perhaps have been improved ; but as an economist Mr. Ordish has been able to see the problem in perspective. As an economist, however, he seems to have missed an opportunity of bringing other important factors into the picture—cultivations, fertilizers, breeding for increased yields, climatic factors, etc. Although reference is made to the fact that wheat yields have, during the past hundred years, risen from 26 to 36 bushels per acre, it is not made clear that some of this increase is due to better varieties, some to seed treatment, some to mechanization, but most is undoubtedly due to the increased use of fertilizers. How do losses from pests and diseases fit into this picture ? The answer to this question probably lies in closer co-operation between the soil chemist, nutrition chemist, plant pathologist, botanist, physiologist and all the rest of the scientific world that agriculture nowadays commands. I. THOMAS

## IDENTIFICATION OF COMMON WEEDS

### Common Farm Weeds Illustrated

By Plant Protection, Ltd. Pp. vii+172. (London: Butterworths Scientific Publications, Ltd., 1952.) 15s. net.

FARMERS and gardeners must eradicate weeds, and in order to do so with the maximum of efficiency it is desirable that the weeds should be speedily identified, especially if the use of weed-killers is contemplated. But a weed is only a plant which is growing where it either is not wanted or is doing actual harm, so to the pure botanist it is just another member of the plant kingdom (unless it has invaded his own garden).

Any good book on plants (including weeds), therefore, is of value to farmer and gardener as well as to botanist ; but the method of approach varies because the agriculturist and gardener seek to destroy, the botanist to study. So it is not surprising that the point of view also varies in that the farmer and the gardener fundamentally wish only to recognize the weed, no matter how, whereas the botanist treats the weed as a subject for scientific study. Perhaps, therefore, the botanist, especially the taxonomist, can be forgiven if he protests against the grouping of plants, no matter what they are, artificially according to colour of flower. This method is adopted here ; but, in view of the book's objective, the method is justified since quick recognition is all-important.

The book is divided into two sections : (1) arable weeds ; (2) grassland weeds. Following (1) is a list of grassland weeds also to be found on arable land ; following (2) is a list of weeds common to both arable land and grassland. Two facing pages are devoted to each plant. On the left-hand page is a large photograph of the plant in the juvenile stage; on the right, an adult plant is depicted. This is an ingenious method, for it will assist farmers and gardeners to catch their weeds in time. Below the two photographs are very simple descriptions using no technical terms. Here are described the plant itself, other popular names, general habit, shape of 'seed' and 'true' leaves, habitat, height, general appearance of flowers, habit of stems, and other points of recognition. Approximately eighty weeds are beautifully illustrated and well described.

The fact that the reviewer was able to go through the entire book in a matter of a few minutes, and, looking first at the right-hand pages, immediately recognized every adult plant, and, looking at the left-hand pages, recognized most of the juvenile plants, convinces him that the book will serve a very useful and important purpose for farmers and gardeners. Students of elementary botany will also find the book of considerable assistance in the identification of common plants.

L. J. F. Brimble

## THE PLACE OF DANCING IN RELIGION

### Religious Dances in the Christian Church and in Popular Medicine

By Prof. E. Louis Backman. Translated by E. Classen. Pp. xii+364. (London: George Allen and Unwin, Ltd., 1952.) 35s. net.

At all periods mankind has danced to get rid of surplus nervous emotion—to obtain release. During the First World War a United States hospital unit took over a British general hospital soon after the Germans had launched mustard-gas attacks. The sights and sounds were particularly distressing, and the nurses, new to war conditions, in many cases became hysterical, though doing their duties magnificently. When the matron organized dances, the nervous tension was released and the troubles ceased. It is only to be expected that, as dancing has this tension-relieving effect on a large number of people, it should appear in various forms in religious rites.

Even in prehistoric times, it would seem that dancing had a place in the various cults. Both in ancient Egypt and in Greece dancers are shown in the pictures of religious festivals; again, we read in the Old Testament how David danced before the Lord. Many other examples could be given. Naturally, then, when Europe became Christian, dancing was absorbed into the new cultus, though the Church naturally looked on it with disfavour, and from time to time attempts to exclude it were made. Nevertheless, it was not only the populace who frequently expressed their religious emotions by dancing; the clergy and choir, too, sometimes danced during the services. The Easter dances before the high altar in the cathedral at Seville are well known and still take place, and many less famous though equally ancient ones still happen in churches or churchyards at certain times of the year in many parts of the world, including England. It is true that nowadays these old rites are tending to disappear, but that is owing to the dull uniformity which is being imposed on mankind by modern conditions.

Prof. E. L. Backman, of the Royal University of Uppsala, has brought together a wealth of information on this subject, and the resulting volume is of great interest. The Church authorities in England were on the whole very averse to dancing becoming part of the cultus, and England has perhaps fewer examples to show than is the case on the Continent. Nevertheless, during Queen Elizabeth's reign men and women danced to the music of pipes and drums both inside churches and in the churchyards. I rather feel, too, that Prof. Backman might have mentioned the queer ritual dance which takes place yearly at Abbots Bromley in Staffordshire, where the participants carry reindeer antlers in front of their faces. It is true the dance is in all probability older than Christianity; but it has been so much Christianized that the antlers are kept in the church in the charge of the parson. Altogether, the book makes very good reading, and the translation would seem to be excellent.

M. C. Burkitt

## THE NEUROTIC IN SOCIETY

### Social Psychiatry

A Study of Therapeutic Communities. By Dr. Maxwell Jones, and A. Baker, Dr. Thomas Freeman, Julius Merry, B. A. Pomryn, Dr. Joseph Sandler, Joy Tuxford. Pp. xix+186. (London: Tavistock Publications, Ltd., in collaboration with Routledge and Kegan Paul, Ltd., 1952.) 18s. net.

Neurotic maladjustment is so prevalent and individual psychotherapy so prolonged that the psychiatrist has always sought more rapid methods of cure. During the Second World War, for example, physical treatments were pushed forward and patients subjected to insulin, prolonged narcosis and electrical convulsions. The 'cures' by these means have proved disappointing. Now the accent is on social psychiatry. This is the production of a special environment where the patient can adjust and find ways by which he can later take his place in society.

Dr. Maxwell Jones and his associates have written this book describing experiences in such communities: at Mill Hill, where an effort syndrome unit was established, at Dartford ex-prisoner of war hospital, and at Belmont Hospital for chronic neurotic unemployed. In these it was found impossible, owing to the numbers, to give individual psychotherapy, and lectures were discovered to be less useful than discussion groups where the patients were able to release their emotion. "Psycho-dramas" which are little plays, describing his own life, written by a patient were also found beneficial. Inmates do a four-hour day in industrial work, and are placed in industry by a resettlement officer when they are discharged. The results are claimed to be good; and six months after leaving hospital two-thirds of the patients have made a fair adjustment, or better, and one-third a poor or very poor adjustment. This is an interesting experiment, but one should reserve judgment until follow-up results for a longer period are published.

It is a pity when they have such interesting material that the authors have used such a repetitious and even slovenly style: for example, on p. 178 the old mistake of thinking that 'protagonist' means the opposite of 'antagonist' is made. The book records valuable facts on community life, and one looks forward to the publication of the final results later on.

Clifford Allen

# EXPERIMENTING AT HIGH PRESSURES*

By Prof. D. M. NEWITT, F.R.S., and K. E. BETT

Department of Chemical Engineering, Imperial College of Science and Technology, London

INVESTIGATIONS into the influence of pressure on the properties of matter are at present confined to limits prescribed by the mechanical properties of materials of construction. In plant designed to develop and sustain high internal pressures, two separate stress-systems have to be incorporated. The pressure is developed by an element of plant, usually a piston, in which there is under load an evenly distributed uniaxial compressive stress the magnitude of which is proportional to the pressure; and a portion of this element must be unsupported. Eventually the pressure has to be sustained by an enclosure, the walls of which are subjected to three principal stresses acting at right-angles to one another; two of these are tensile and one compressive. The important feature of this system is that the compressive stress and one of the tensile stresses are not uniformly distributed through the thickness of the walls, but have maximum values at the interior and diminish rapidly as the outer surface is approached.

A more uniform distribution of stresses under load can be achieved by making use of the property of work-hardening, as in the autofrettage process of cylinder construction; or by building a compound cylinder by the shrinkage process. In both cases it is necessary to know the distribution of the residual stresses and to develop means of stabilizing the residual system, so that no appreciable plastic flow will occur under working conditions. By making use of these processes and by providing external support for the vessel in such a way that the support increases proportionally to the internal pressure, it has been possible to construct plant in which pressures up to fifty thousand bars (a bar is approximately an atmosphere) can be maintained for considerable periods of time and pressures of the order of a hundred thousand bars for shorter periods. The energy stored in a material subjected to these stresses is made up of a work or potential energy component and a heat or kinetic component. Energy release may take place through either component separately or through a combination of the two, leading eventually to brittle fracture or plastic deformation.

It seems unlikely that these limits of pressure will be much exceeded with the materials and methods of construction at present available; and they are indeed sufficiently extensive to enable a comprehensive study to be made of those properties of matter which are associated with work done against the repulsive force fields of atoms and molecules.

There is, however, a second pressure domain of great interest to physicists, in which discontinuous transitions may be expected to take place by, for example, an overlap in the electron-phase space field of an atomic system. Calculations based upon quantum mechanical models place the lower limit of this domain at about one million bars; that is, far beyond any pressures at present attainable in the laboratory.

If attention is confined to the lower pressure domain, nearly every manifestation of pressure, whether chemical or physical, will require for its interpretation an accurate knowledge of at least three of the principal thermodynamic functions of the system, one of which, for obvious reasons, must be the pressure. A great deal of attention ought, therefore, to be paid to the accurate measurement of high pressure and to an assessment of the errors involved when the limits of practical working are approached.

Primary pressure gauges, of which the mercury column and the balanced free-piston gauge are examples, measure pressure in terms of fundamental units. They are, however, subject to restrictions imposed by the properties of the materials from which they are constructed and of the working fluid. Thus, in the case of the mercury column, the compressibility of mercury over the full range of the gauge has to be known; in the case of the free-piston gauge, the elastic and plastic deformation of the piston and cylinder assembly under the influence of pressure must be found, either by calculation or by direct measurement.

Suitably designed free-piston gauges will operate to about twelve thousand bars, but at this pressure they are relatively insensitive, due to the large frictional forces resulting from the increase in viscosity of the pressure-transmitting fluid. The area of the piston in such a gauge must of necessity be small, and direct measurement of the diameters of the piston and cylinder cannot be made with an accuracy sufficient to reduce the error of readings to less than 0·1 per cent. It is therefore necessary to obtain the effective piston area at low pressures by calibration against a mercury column or another free-piston gauge in which the diameter of the piston is large enough to be measured directly. At higher pressures, the piston and cylinder undergo deformation and the effective area, which is a function of pressure, has to be calculated from theories of elasticity. The error involved is uncertain, since the stresses arising from the efflux of liquid between the piston and cylinder cannot be measured directly.

In a free-piston gauge designed by P. W. Bridgman, the correction for elastic deformation was calculated to be 0·2 ± 0·05 per cent at 10,000 bars. Such a gauge will have an absolute accuracy of about 0·15 per cent, provided that its sensitivity is large compared with this figure.

A great deal of work at high pressures and, indeed, most of the work above ten thousand bars has been carried out with the aid of secondary gauges, of which the manganin gauge is the best known. Calibration of this gauge against a free-piston gauge shows that the response is a linear function of pressure to within the absolute accuracy of the primary gauge.

In order to extend the range of the manganin gauge to thirty thousand bars without the uncertainty of linear extrapolation, it is desirable to calibrate it against at least two fixed-pressure points. The lower point may be taken as the freezing pressure of mercury at 0° C., which is given by a free-piston gauge as 7,490 bars. The most suitable upper point is the I–II transition for pure bismuth, which at 30° C. takes place at 24,930 bars. This point has been measured directly by Bridgman using the method of volume discontinuity. In his apparatus, the pressure was transmitted to a specimen of the pure metal in direct contact with the piston, the distortion of the cylinder containing the specimen being determined experimentally. From measurements of the force transmitted to the piston and the area over which the piston acted, the pressure could be calculated. It is difficult to estimate the accuracy of the pressure measurement; but the total frictional effect obtained by measuring the transition point for both increasing and decreasing pressure was about 6 per cent.

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* Summary of three lectures given by Prof. D. M. Newitt at the Royal Institution on January 27 and February 3 and 10.

By using the fixed pressure points, the change in resistance with pressure of manganin wire can be expressed as an equation of the second degree. Although the departure from linearity depends upon the history of the wire, experience shows that, in general, the deviation is only about 2 per cent at 25,000 bars. The gauge can be made very sensitive to small pressure-changes when used in conjunction with suitable electrical measuring apparatus; but it will be obvious that its accuracy depends almost entirely upon the absolute accuracy with which the fixed pressure points are known.

At pressures much above thirty thousand bars, all available pressure-transmitting liquids either become very viscous or freeze, and the manganin gauge can no longer be used. Pressures in this range have, therefore, to be measured directly, it being assumed that, in a thin specimen of material under pressure, stresses sufficiently close to hydrostatic conditions can be realized. Corrections for distortion of the apparatus have to be computed; and, since the material is often stressed beyond its normal elastic limit, no great accuracy can be claimed for the result. At pressures of 100,000 bars, the error is probably of the order of ± 10 per cent.

Thus it can be seen that the error involved in the measurement of pressure is a function of the pressure-range under consideration. Below twelve thousand bars, it is possible to increase the precision of a free-piston gauge by reducing the distortion of the piston and cylinder assembly; this can be accomplished by using the stronger materials of construction now available and by providing more effective external support for the cylinder. It is doubtful if the range of the gauge can be greatly extended, because the large increase in viscosity of pressure-transmitting fluid results in a serious loss of sensitivity. At pressures above thirty thousand bars, when all liquids have frozen, true hydrostatic conditions no longer exist and stress differences within the compressed solid of the order of its plastic shearing stress are to be expected. In this range, the error in the pressure measurement resulting from the variable frictional forces opposing the motion of a piston is greater than that due to the uncertainty in the distortion of the cylinder. Thus, any attempt to increase the accuracy of the measurements must be directed towards reducing the frictional forces. One method of doing this is to decrease the cross-sectional area of the material under compression; such a procedure, however, makes the accurate assessment of volume changes during compression very difficult, especially if the apparatus undergoes appreciable creep.

Although Bridgman measured the freezing pressure of mercury more than forty years ago, no accurate redetermination has been made since then. Indeed, the value has been accepted and used to calibrate various primary and secondary gauges, some of which have a greater sensitivity than the accuracy claimed by Bridgman for his original measurements. In view of the difficulties involved in the direct measurement of pressure, it would therefore seem desirable for the present to base all work upon an arbitrary standard scale of fixed pressure points which can be corrected from time to time as more accurate data become available.

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# THE SOUTH ATLANTIC: LAND BRIDGES OR CONTINENTAL DRIFT?

THE proceedings of the symposium on "The Role of the South Atlantic Basin in Biogeography and Evolution", held by the Society for the Study of Evolution in New York during December 28–29, 1949, have now been handsomely published under the title of "The Problem of Land Connections across the South Atlantic, with Special Reference to the Mesozoic"*. Most of the contributions are remarkable—considering the speculative possibilities and heady enthusiasms inherent in the subject—for their scientific rigour, and several of them are of fundamental importance to everyone who is interested in the tangled complex of problems which come under discussion. These problems are essentially twofold: whether the southern continents received all their faunas and floras from the north or have been at times in direct contact with each other; and whether, if such contact existed, it was effected by land bridges or by contiguity, afterwards broken by continental drift. The chairman and editor, Dr. Ernst Mayr, points out that the symposium was organized, not to defend or disprove any particular hypothesis, but for the presentation and discussion of current evidence in one restricted but critical field of a much broader subject. In his conclusion he cheerfully admits that we are still confronted by many unsolved problems; but he claims with ample justification that the symposium has resulted in a much-needed correction of fact and clarification of concept. Dr. Mayr himself recalls the methodological principle that biological conclusions must be based on biological evidence, and geological conclusions on geological evidence. In particular, he directs the geologists' attention to the many pitfalls that lurk in biological interpretations—for example, in conclusions drawn from faulty classifications or from under-estimates of the dispersal powers of organisms over long periods of geological time.

Dr. G. G. Simpson's illuminating discussion of "Probabilities of Dispersal in Geologic Time" (pp. 163–176) is one of the high points of this invaluable publication. Simpson deflates many a speculative balloon by stressing the impossibility of inferring two simultaneous conclusions from what is actually known of the geographical distribution of a given group of organisms—namely, the land connexions of the time, and the probabilities of dispersal for the organisms concerned. To obtain a solution for either unknown,

* Bulletin of the American Museum of Natural History, Vol. 99, Article 3: The Problem of Land Connections across the South Atlantic, with Special Reference to the Mesozoic. (Proceedings of the Symposium on "The Role of the South Atlantic Basin in Biogeography and Evolution", held at the Fourth Annual Meeting of the Society for the Study of Evolution, New York City, December 28 and 29, 1949.) By E. Mayr (editor), M. Ewing, W. H. Bucher, K. E. Caster, C. O. Dunbar, M. Kay, G. G. Simpson, D. I. Axelrod, T. Just, W. H. Camp, P. J. Darlington, jun., A. E. Emerson, B. Schaeffer, D. H. Dunkle, E. H. Colbert and A. S. Romer. Pp. 79–258+2 plates. (New York: Amer. Mus. Nat. Hist., 1952.) 3 dollars

it is necessary to postulate either the existence (or absence) of land connexions or the probabilities of dispersal. Usually the latter postulate is made, the implication commonly being that $p$ is either 0 or 1. Simpson illustrates the very serious errors that may arise from confusing 'very low' with 'zero' and points out that estimates of probabilities, even when least subjective, may be wholly invalidated by the effect of geological time. Just as probability of dispersal is affected by the size of the population, so the passage of time multiplies the opportunities for dispersal. "If the probability that some member of a population will cross a barrier is ·000001 in any one year . . ., during the course of a million years the event would be probable, $p = \cdot 63$", and "in the course of 10 million years the event would become so extremely probable as to be, for most practical purposes, certain, $p = \cdot 99995$". Simpson concludes that evidences of random dispersals at scattered times indicate that probabilities of dispersal were so exceedingly low as to suggest the intervention of a major barrier. Ten years ago Simpson[1] directed attention to the relevant fact that, of the known Triassic reptiles of South America, only 43 per cent of the families and 8 per cent. of the genera are known in Africa, with no species in common. "These figures," he concluded, "are decidedly inconsistent with any direct union of corresponding parts of South America and Africa."

Among other general contributions, Dr. M. Ewing presents a useful summary (pp. 87–91) of geophysical evidence (up to 1950) and concludes that both seismic and gravity data show the great similarity of the Atlantic crustal structure to that of the Pacific, and their great dissimilarity to the continental crust. So far as such evidence goes, it is consistent with the hypothesis of the permanence of continents and ocean basins. But the Atlantic data are still too sparse to justify regional conclusions. Moreover, the discovery near the surface of crustal layers having the elastic properties of simatic rocks raises the question of what has happened to the many kilometres of sediment that must have accumulated over the original ocean floor, if the latter has existed for $\sim 3 \times 10^9$ years. Have they been deeply buried by repeated coverings of basic lavas and sills, and metamorphosed beyond seismic recognition ? If so, their radioactive contents might account for the unexpectedly high heat flow encountered through recently tested parts of the ocean floor. If not, then the seismic evidence recorded by Ewing could be interpreted as against the 'permanence' and 'land bridge' hypotheses and in favour of 'drift'.

Prof. W. H. Bucher sets out to deal with the general problems of "Continental Drift versus Land Bridges" (pp. 93–103), but his treatment is largely confined to the thesis that the topography, depressions, mountain ranges and structural relations of the ocean floor cannot be harmonized with Wegener's assumption that the simatic crust is or has been so weak that sialic bodies could drift through it. The criteria are not strictly so decisive as Bucher claims, since he fails to consider fully the effects of metamorphism and altogether ignores the hypothesis of sub-crustal convection currents ; nor does he even mention any of the evidence which favours the 'drift' hypothesis. Both Ewing and Bucher admit that vertical movements of considerable amplitude have demonstrably taken place, but Ewing limits the amplitude by the requirements of isostasy, while Bucher limits the area involved to that of a land bridge. Neither considers the possibility that the sub-crustal silicate mantle may not necessarily be as homogeneous in either space or time as theorists postulate. Localized changes of composition or phase, or of both, at depths below the so-called 'level of compensation' would adequately account for the vertical movements which seem so puzzling to geophysicists.

Turning to more specific evidence on South America and Africa, Prof. K. E. Caster gives an admirable and well-documented review (pp. 105–152) of the stratigraphical and palæontological data up to the end of the Mesozoic. Like others before him, he is so impressed by the Devonian–Triassic parallelism between the opposing lands that he favours a broad continental linkage up to the end of the Triassic. Nevertheless, he inadvertently raises a serious doubt as to the validity of what Dr. A. S. Romer (p. 253) calls "the strongest single piece of evidence for South American transatlantic connections". This is the occurrence of the supposedly freshwater reptile *Mesosaurus* in similar formations in South Africa and Brazil. Caster, however, records that *Mesosaurus* occurs in a fœtid limestone containing marine invertebrates, from which he infers that it was a nektonic animal inhabiting a seaway with a stagnant bottom. In a most stimulating discussion of Caster's paper, Prof. C. O. Dunbar makes the suggestion that, if *Mesosaurus* was thus adapted to a 'pelagic' life, it may well, like modern seals, have made long journeys to sea. In any event, it is improbable that migration could have been easy, since of the three African genera only one—and that of a different species—has been found in Brazil.

Another important point made by Dunbar is that, in the light of our present knowledge, the pre-Devonian record has no bearing whatsoever on the problem in hand. This is amply confirmed by recent work in dating the Pre-Cambrian. Caster states that the presence of *Collenia* "affords the best evidence to date for correlating strata in the oldest terranes on the two sides of the Atlantic basin". Unfortunately, the African occurrences to which he refers are in rocks which range in age from about six hundred million years to more than two thousand million years[2]. Dunbar also expresses the opinion that, until more is known about the reproduction of *Glossopteris* and its associates, it is scarcely necessary to drift continents or raise broad land-bridges to account for the distribution of this flora.

Prof. Marshall Kay also discusses stratigraphical evidence bearing on continental drift (pp. 159–162). His main point is to demonstrate from the distribution of Cambrian trilobites—on which weighty arguments have been based—that similarity of faunas does not in itself require close association later broken by 'drift'.

Dr. Mayr is satisfied (pp. 85 and 256) that there is no need to postulate former land connexions between South America and Africa to explain the distribution of mammals or birds, the available facts being "diametrically opposed to the possibility of such a connection". However, this clear-cut conclusion refers only to the late Mesozoic and Tertiary. For testing earlier connexions, fishes and reptiles are more suitable. Dr. E. H. Colbert reports fully on the Mesozoic reptiles (pp. 237–249). He thinks there may have been "a connection of sorts" during the mid-Triassic, but admits that no southern connexion would be essential if other evidence were forthcoming to prove that North and South America were then connected. The Jurassic evidence is inconclusive, while for the Cretaceous it is "rather unequivocally in favour of an active faunal interchange between South and North America". Discussing Colbert's paper, Dr. A. S. Romer (pp. 250–254) agrees about the Cretaceous and Jurassic but, although fully conscious that most hypothetical land bridges are not merely delusions but also snares to the unwary, he mildly disagrees about the Triassic. He writes: "I find myself here, after consideration of the evidence [which he carefully analyses] rather strongly inclined towards belief in the existence of a southern intercontinental connection between South America and South Africa in the Triassic. To my embarrassment; for in such a 'leftish' position I am disturbed . . . by the company (of bridge builders, radical continent shifters and Gondwanaland collectivists) which this may entail". Dr. B. Schaeffer reports on the fresh-water fishes (pp. 227–234), his conclusion—from what is admittedly a scanty record—being that there is no evidence of direct interchange between South America and Africa during any part of the Mesozoic.

In a most valuable paper on "Variables affecting the Probabilities of Dispersal in Geologic Time" (pp. 177–188), Prof. D. I. Axelrod illustrates his views with special reference to the effects of climatic and water barriers on angiosperm distribution. He claims that the continents have been in their present positions since the Middle Cretaceous and probably earlier: "The floras and the faunas, not the continents, have been moving during the past ages". Angiosperms, however, are not decisive for pre-Cretaceous times, and Dr. W. H. Camp's discussion of their phytophyletic patterns (pp. 205–212), though stimulating and suggestive, carries us no farther back. Dr. T. Just deals with the older and more critical fossil floras (pp. 189–204), but he finds the evidence insufficient for the drawing of firm conclusions.

In a brief survey (pp. 213–216) of living invertebrates in relation to Mesozoic South America, Dr. P. J. Darlington, jun., demolishes the idea that they provide any relevant evidence. In particular, he denies that paussids, which have been used as evidence of former land connexions, tell us anything significant about the history of South America. Prof. A. E. Emerson presents a highly original paper on "The Biogeography of Termites" (pp. 217–225) and reaches several tentative conclusions, the first being that "it is unnecessary to postulate any great change in continental masses and their connections since early Mesozoic times".

To end on a personal note: I should confess that, despite appearances to the contrary, I have never succeeded in freeing myself from a nagging prejudice against continental drift; in my geological bones, so to speak, I feel the hypothesis to be a fantastic one. But this is not science, and in reaction I have been deliberately careful not to ignore the very formidable body of evidence that has seemed to make continental drift an inescapable inference. In recent years the weight of evidence has become less oppressive, and this symposium has left me with the general impression that a few land bridges or linkages by island stepping-stones would probably suffice for the biogeographical problems. Matching of orogenic belts on opposing sides of the Atlantic is an exercise that has not been indulged in by the participants of this symposium. I have been collecting evidence from the Pre-Cambrian of South America, Africa[3] and India[4] for several years, and I think it is now safe to say that India cannot have been where Wegener placed it relative to Africa. The evidence on the other side, however, is still ambiguous. A remarkably good 'tectonic fit' between parts of South America and Africa can be recognized, but so far no correlation by age is possible, because the South American age determinations[5] have not been correlated with the tectonics and have not been checked by isotopic analyses. No doubt this temporary frustration will be overcome, and the matter will be decided one way or the other. At least we know how the problem can be settled.

Meanwhile, there remains the most serious enigma of all: the Permo-Carboniferous glaciations. Dunbar points out that the late Palæozoic glaciations in low latitudes present "a problem still unsolved, unless we accept continental drift". But if we accept continental drift only to explain these and other still older glaciations, it becomes no more than an *ad hoc* hypothesis. As such, it may still be justified as a stimulant to research, but it may also stand in the way of progress by distracting attention from the real problem. Can the meteorologists not come to our assistance and tell us whether or not widespread equatorial and low-latitude glaciation is possible while high latitudes for the most part enjoy a genial climate? The curious feature is that the evidence, so far as it goes, suggests that it was the distribution of ice in the Pleistocene that was exceptional, not the Permo-Carboniferous distribution. Southern Africa, in particular, was repeatedly glaciated during Pre-Cambrian times. While so many contradictory voices confuse judgment, one cannot do better than commend Dunbar's wise dictum that "it is unsafe to reject, *a priori*, either continental drift or foundering of broad land bridges". ARTHUR HOLMES

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[4] Holmes, A., Leland, W. T., and Nier, A. O., *Amer. Min.*, **35**, 20 (1950).

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# THE FARADAY SOCIETY, 1903–53

## By DR. F. C. TOMPKINS

On February 14, 1903, a small meeting took place in the rooms of the now defunct Faraday Club at St. Ermin's Hotel, Westminster, and a new scientific society was inaugurated. A little later "The Faraday Society" was formally founded, having as its objects the promotion of "Electrochemistry, Electrometallurgy, Chemical Physics, and Kindred Subjects". The Society celebrated its fiftieth anniversary this year on April 16 at the Royal Institution, which houses the famous laboratories where Faraday's researches were carried out.

In 1903, as to-day, there were dangers, both financial and otherwise, in creating yet one more society and one more journal. Indeed, Sir William Ramsay viewed the prospects with marked disfavour, for he could not find sufficient time to read the stream of scientific literature already appearing. Despite this, the project made a good start under the presidency of Sir Joseph Swan, ably supported by such eminent men as Prof. Crum Brown, Prof. F. G. Donnan, Lord Kelvin, Sir Oliver Lodge, Dr. Ludwig Mond, Lord Rayleigh, Sir James Swinburne and others. Within a year there were 254 members, with

F. S. Spiers as honorary secretary and editor of the *Transactions*. To these men we must attribute the coining of the phrase 'chemical physics' to describe the borderline field between chemistry and physics. It is no contradiction that in April 1951 the objects of the Society were re-defined as follows: "to promote the Study of Sciences lying between Chemistry, Physics and Biology", for the founders had wisely included that indefinite phrase "and Kindred Subjects". The Society could, therefore, adjust itself as a living organism to its environment. At its inception, the *Transactions* fulfilled the need of a publication catering for developments in the study of metals, both in the more academic and in its technical aspects, as well as one for reporting those studies recognized to-day as the province of physical chemistry.

The first volume of the *Transactions* appeared in 1905; in its 366 pages there are thirty papers, and the path along which the Society was to travel was, even then, clearly defined. The contributions were grouped, usually in pairs, covering different aspects of a common topic. The reading of the papers was followed by a discussion, and the importance of having a permanent record of the comments and criticisms of other scientists was appreciated. The earlier volumes of the *Transactions* contain such a record and it remains a constant source of historical interest and value. The second object which has been carefully nurtured through the subsequent years was the encouragement given to scientists from overseas to present papers; thus we find that, of the thirty papers in the first volume, one originated in the United States and another in France.

The Faraday Society, unlike many other scientific societies, has never held regular meetings devoted to the reading of papers on unrelated topics; rather it has sought to find a new approach to the technique of scientific discussion. The Society can point to the success of its endeavours by reference to its own General Discussions, the hundredth of which is being held in this, its jubilee year. The first, on "Osmotic Pressure", was held in January 1907 in London, and since that time two or more have been held yearly. The purpose of such Discussions was clearly defined—to secure a survey of the topic under discussion from the varied points of view of scientists working along different lines of attack; to focus general interest in a subject with the object of extending its development or applications; to afford an opportunity of bringing forward new facts and theories for criticism and appreciation; and finally to map out possible new lines of investigation. The Society is justly proud of its General Discussions, for even in this era of conferences they still retain a unique character. It had been accepted that the important aspect was critical appraisal of a large proportion of the papers, and practically the whole time of the meeting is therefore devoted to this. All the papers are published in full in the form of preprints two or three weeks before the meeting, so that they may be studied at leisure. A high standard of criticism is consequently attained, and the recognition of the value and quality of the verbal discussion has resulted in authors setting themselves a high standard for their contributions.

The success of these meetings and the achievement of their objects depends primarily on the choice of subject and the timing of the Discussion. In the main, faith has been placed in the national characteristic of compromise—the programme, though limited and well defined in scope, is so arranged that it is of value and interest to the physicist, chemist, biologist, geologist, etc.—that is, to scientists of different disciplines and experiences who bring different points of view to the common theme, and so effect a cross-fertilization of ideas, a synthesis and a stimulus to originality. Moreover, overseas contributions are particularly invited in order to obtain a representative cross-section of authoritative scientists, irrespective of nationality. The Society has, indeed, been fortunate in obtaining their constant support in its endeavour to make these meetings truly international in character.

Looking back, say, twenty-five years, to the time when the theory of strong electrolytes represented a new powerful approach to replace the classical theory of dissociation, we need only turn the pages of the 1921 Discussion volume to illustrate this point. Britain was represented by papers from Bell, Hartley, Wolfenden and Wynne-Jones, while from overseas came such distinguished men as Bjerrum, Brønsted, Fajans, Harned, Huckel, Onsager and Scatchard, and written contributions were received from Debye, McInnes and Randall. Scarcely a name which would spring naturally to one's mind when considering this topic is absent; and how aptly was the time selected. The Debye–Hückel theory appeared in 1923 and Onsager's extension three years later, but their work was still hotly debated. It is no exaggeration to attribute the general acceptance of these theories and the opening up of the modern attack on the problem of short-range forces in solution to this meeting. Again, two years later, in 1929, the overseas members and guests who attended and contributed to the Bristol meeting on "Spectra in Relation to Molecular Structure" included Raman of India, Badger, Birge, Mulliken, Taylor, Wood and others from the United States, Bonnino from Italy, Victor Henri from Switzerland, Grimm, Herzberg, Hund, Schaefer from Germany, Errera from Belgium, and representatives of the best work from Canada, France, Poland and the U.S.S.R.—a veritable galaxy of stars. The Society has done much for the consolidation of theory, the co-ordination of different lines of approach and the stimulus to further work, by timing these Discussions to coincide with the upward surge of interest and of development.

It is dangerous—and often invidious—to pin-point any one contribution as being that from which a marked advance in knowledge and development of the many varied aspects of physical chemistry has evolved. But one may sometimes reflect that, had not a contribution appeared at that particular time, then the road of advance would indeed have been more arduous and the progress along it slower. It is of interest, therefore, to browse through the pages of old Discussion numbers to find whether they record such papers of especial significance.

In 1921, on the subject of chemical kinetics, there was the first suggestion by Lindemann (now Lord Cherwell) of the modern concept of the nature of unimolecular reactions; this led to the well-known Hinshelwood–Lindemann theory and sounded the approaching doom of the old radiation theory. But, almost as if it were in compensation, after the destructive criticism of an application of radiation theory in one Discussion, there appears in a later one a concept of major importance in guiding the spectroscopist and the photochemist in a memorable contribution by J. Franck containing the first enunciation of that broad generalization, the Franck–Condon

Principle. Again, although the Society cannot claim to have published the original concept of chain reactions, its first application to hydrocarbon reactions is given in the 1926 Discussion volume, on "Photochemical Reactions", in a contribution by this year's president, Prof. H. S. Taylor, of Princeton. At another meeting seven years later, Rice proposed his chain mechanism of the thermal cracking of hydrocarbons. Although this concept has now been modified and extended, it is difficult to assess the immense value of this one contribution to many industrial developments. As is always true of any outstanding advance in fundamental theory, its value grows when quantitative deductions are made possible. The recognition of the guiding principle—that of the stationary state—is clearly stated in a paper by the outstanding German chemist, Bodenstein, in the 1931 Discussion. Two years later, Paneth described the synthesis of the antimony analogue of Bunsen's cacodyl radical at a meeting of the Society, and in the same year there were the enunciation of the Franck–Rabinowitch effect and the detailed applications by Hückel and Lennard-Jones of quantum mechanical theories and the birth of the modern language of molecular orbitals and the like.

In quite different fields, the Discussion volumes record equally significant and important discoveries, each of which has largely affected our modern outlook; thus in 1930 Donnan applied to organisms his ionic membrane equilibria; a 1932 Discussion reports H. S. Taylor's concept of activated adsorption and the theoretical contributions of Lennard-Jones on the application of potential energy relationships to adsorption—and there are many more.

Although its publications contain the record of many such important advances in particular branches, yet the Society has never attempted to contract its wide field of interest. The whole of the region lying between physics, chemistry and biology is deemed its province, so that the range covered is possibly unsurpassed in scope and breadth in any similar series of publications. At first there was a bias towards the more technical and applied aspects, with Discussions on fluxes, slags, igneous rock formation, soils, refractories, cements, corrosion, electroplating, passivity and hardening of metals, to list only a few. The later publications are concerned with the more fundamental problems as exemplified by meetings devoted to kinetics, photochemistry, radiation chemistry, electrode processes, spectroscopy, molecular structure, adsorption, chromatography, solid reactions, dielectrics, luminescence, crystal growth, etc. In addition, the growth of colloid science has always been one of especial concern to the Faraday Society. More than any other single body it has been responsible for the development of, and interest in, this subject in Great Britain. Inspired by the enthusiasm of Sir William Hardy, this interest has been constantly maintained, particularly by the efforts of Sir Eric Rideal.

In 1934, the Colloid Committee of the Faraday Society was formed. Broadly conceived, with representation from other interested societies, it received generous help and guidance from the Council of the Society, and one General Discussion every two years was devoted to a subject of interest to colloid chemists. Using the organizing facilities of the Society and with its financial backing, the Colloid Committee went forward, and it is possible to trace the emergence and growth of colloid science in the publications of the Society. Again an initial trend towards aspects having technical value gave place to more fundamental problems; for Discussions on soils, textile materials and the like were followed by others on colloidal electrolytes, the electrical double layer, and the size and shape factor in colloidal systems. More recently, the Society has again taken a lead, this time in fostering the growing interest in biophysics. So long ago as 1930, a Discussion was held on "Colloid Science applied to Biology"; "The Properties and Functions of Membranes, Natural and Artificial" was one of the topics in 1937, and "Modes of Drug Action" in 1943. A pattern was slowly emerging and was thrown into relief in 1948 when the Society, always responsive to modern developments, decided to enlarge the scope and activity of the original Committee by reconstituting it as the Colloid and Biophysics Committee of the Faraday Society, and also to devote one Discussion yearly to topics of interest to that Committee. Such Discussions held over the past few years include "The Physical Chemistry of Proteins", "Lipo-proteins" and "The Optical Methods of Investigating Cell Structure". The Committee also initiates informal meetings on similar subjects of importance to biophysicists and colloid scientists, summaries of which are published in the *Transactions*.

Nevertheless, although the aims and objects of the Society can be well appreciated by a study of its Discussions volumes, the *Transactions* published monthly contribute no less vigorously to the life of the Society. It has been termed the foremost journal in Europe devoted solely to physical chemistry. Although only a hundred and fifty or so papers appear yearly, the lack of size is in part a measure of the high standard required of the contributions.

If the international character of the Discussion meetings is emphasized by the fact that 50 per cent of the papers may be contributed from overseas and that, of the audience of two to three hundred, eighty–ninety are resident outside Great Britain, then, although contributions to the *Transactions* are predominantly from the United Kingdom, yet some six hundred members out of the total of more than 2,200 are from outside the British Isles—some from the Dominions and Colonies, others from all the countries of Western, and some from Eastern, Europe, and many from the United States and the South American continent. On its fiftieth birthday, it is appropriate, therefore, that the president should be Dean H. S. Taylor, who for the past twenty years or more has done so much to enhance the reputation of Princeton University as one of the foremost schools of physical chemistry.

The Society has seen many changes: the original objects with their bias towards electrochemistry, metallography and metallurgy in its more technical aspects have changed, but its efforts in this field have not been unrewarded, because this interest has been taken over by what may be affectionately termed its daughter society, the Institute of Metal Finishing, formerly the Electrodepositors' Technical Society. There is no doubt that other similar changes and broadening of interests will be initiated in the future; perhaps the formation of further daughter societies encouraged by the expanding interests of science may be anticipated.

The Faraday Society has been well served by its members. Because of its generous benefactors, particularly Colonel J. J. Bourke, its financial problems, although not absent, are often less serious than are those of many other scientific bodies, and because of the enthusiasm of its first secretary, F. S. Spiers, whose name is perpetuated by the Spiers Memorial Lectures (the seventh of which will be delivered this year by Prof. J. H. Hildebrand), and of his successor, G. S. W. Marlow, the Society has never lost its initial impetus.

Its purpose remains to serve the changing needs of those interested in the sciences lying between chemistry, physics and biology, and to foster the international co-operation of scientists. Inspired by this purpose, a General Discussion on "The Reactivity of Free Radicals" was held last year in Canada at the University of Toronto. It proved a stimulating innovation; forty-five members travelled from Great Britain to meet in conference some eighty Canadians and sixty Americans. Those members will long remember their enthusiastic welcome in that great Dominion; they returned richer in knowledge and experience, with an increased appreciation of the high quality of the scientific contribution which Canada is making. The future may see this as the first of many Faraday Discussions to be held in other parts of the Commonwealth, the United States and Western Europe. The Society may hope thereby to contribute still further to "the glory of holding aloft among the nations the scientific name of England", to quote the words of Tyndall in appraising the genius of the man whose name the Society has been proud to assume.

# OBITUARIES

## Prof. J. W. McBain, F.R.S.

On March 12, one of the great pioneers in the field of what is now termed 'colloid science' passed away. The era of regarding colloids as an interesting field for those who desired to prepare chemical substances in curious and unexpected states was just beginning to pass when, as Leverhulme professor at the University of Bristol, James W. McBain commenced what proved to be his main interest in subsequent years at Leland Stanford University, California, namely, a systematic investigation of the properties of soaps and their solutions. We are indebted to McBain not only for the elucidation of the complex series of phases which these systems can exhibit but also for the concept of the 'micelle', both neutral and ionic, which had the most profound influence on subsequent developments in the fields of colloidal electrolytes. While the actual shape of the micelle in any particular system is still a matter of controversy, we may note that McBain recognized two distinct forms, the spherical and the lamellar. Indeed, he postulated the existence of the latter form, re-discovered in 1947, as early as 1925.

The contributions of the McBain school to the thermodynamic properties and physico-chemical behaviour of these molecularly associated colloidal electrolytes would alone justify the inclusion of his name among the fathers of the science.

McBain's researches in molecular association were not confined to aqueous systems. Apart from detailed studies on gels and jellies in non-aqueous systems, a great deal of pioneer work on what is now termed 'solubilization', for example, of water-insoluble dyes and hydrocarbons by means of soaps, has come from his laboratory; and we are indebted to him for an understanding of the factors operative in what he termed 'co-solvency', which is of great importance in blending.

McBain was one of the first to recognize that the uptake of a gas by a porous solid might involve quite a number of distinct and separate processes taking place simultaneously, and, to cover them all, introduced the term 'sorption'.

On the technical side we are indebted to McBain for many interesting and valuable research methods, such as the McBain sorption spring balance, the McBain air-driven centrifuge, as well as his ingenious methods of skimming off the Gibbs layer in a Langmuir trough, and evaluation of the osmotic coefficient by observations on the depression of the dew point.

McBain's contributions to colloid science consist not only in numerous papers to scientific journals; a number of valuable text-books have also emanated from his pen. These books are distinguished for their clarity of exposition, their style and their broadness in outlook on the topics under discussion. His last book, published in 1950, is designed to give the author's concept of the domain of colloid science. It is interesting to note that he does not limit the field to the properties of interfaces, but considers organization and form as equally important.

On retirement from Leland Stanford, McBain spent five years as director of the National Chemical Laboratory in India, a period which he completed only last year.

McBain had many friends, and he kept them. His character is most clearly revealed by his answer to the query put to him by the writer as to what impelled him to accept Pandit Nehru's offer of the Indian appointment. He replied that he was so impressed by the signs of starvation and low economy of many of the Indians that he thought it necessary for him to try to do something about it, and he believed that the infiltration of science and scientific methods was the only way by which anything radical could be accomplished.

Eric K. Rideal

## Father A. Gatterer, S.J.

Father Alois Gatterer, *S.J.*, who died on February 17, was a natural scientist of the best nineteenth-century tradition, student and teacher by turns throughout his career. Born of Austrian stock in 1886, he was educated in Carinthia and there entered the Society of Jesus at the age of nineteen to continue his studies in rhetoric, philosophy and theology. He was ordained as priest in 1915 and joined the staff of the faculty of theology in the University of Innsbruck; there he also studied chemistry and physics, graduated and was appointed to the staff. He was released from lecturing in philosophy in order to pursue his scientific studies. At the age of about forty he studied physics for a year at Oxford and developed an interest in spectroscopy, which he pursued on his return to Innsbruck.

In 1930, when he was forty-four, he was invited to join the staff of the Observatory at the Vatican, where he established and developed a spectroscopic laboratory, largely with the aim of analysing a valuable collection of meteorites bequeathed to the Observatory by a French mineralogist. This laboratory has gradually become excellently equipped, with the aid of grants from Pius XI and his successor.

One of Father Gatterer's first tasks was to purify carbon rods for electrodes: a new method of doing this was developed, and then early tests on meteorites showed up the weakness of the atlases of spectra then available. During 1937–49 one of the main tasks of his laboratory was the preparation of photographic atlases of the arc and spark spectra of iron, and then of the most useful lines of the remaining elements—a task which demonstrated Gatterer's endless patience and devotion to precision. These atlases are valued all over the world, and the last of them is one of the few subjects about which there is ever direct communication between Moscow and the Vatican.

In order to obtain pure iron for these reference spectra, pioneer work was done on the purification of iron; the method was eventually applied in an Austrian industrial laboratory in 1938. Another analytical problem which Father Gatterer helped to solve was the spectroscopic estimation of the halogens and of sulphur by the use of high-frequency discharges in vacuum to excite the spectrum. In 1938 Gatterer took the initiative in founding the international journal called *Spectrochimica Acta*, which was published in Germany by Springer, and which continued to appear with the names of its foreign editors on the cover until 1944. In 1947 Gatterer revived the journal and it was published from the Vatican Observatory for two years, after which it was returned to commercial production. Under Gatterer's editorship the printing received the same attention to detail as a spectrum gets.

Father Gatterer was a member of the Joint Commission on Spectroscopy of the International Astronomical Union and the International Union of Pure and Applied Physics; and he was delighted when that Commission and the International Astronomical Union both met in Rome last year, so that many of his friends could visit his laboratory.

Not only natural scientists but also industrial spectroscopists owe much to their contacts with Gatterer, who was an honorary member of national organizations of spectroscopists in both Italy and France. Manufacturers of spectrographs in both hemispheres benefited when he visited them to order apparatus to his own exacting specifications. From the age of twenty-six onwards he suffered from a series of painful illnesses, and he was partly crippled during most of these years. His cheerful fortitude under physical burdens and the humility underlying his devotion to truth made him an inspiring friend and teacher.

E. VAN SOMEREN

## Prof. P. Niggli

PROF. PAUL NIGGLI, who died recently in Zurich after only a few hours illness. was born on June 26, 1888. He had been director of the Mineralogical and Petrographical Institute of the Eidgenössische Technische Hochschule since 1920; and he had been also rector of the Highschool during 1929–32, and of the University of Zurich during 1940–42.

Paul Niggli graduated at the Eidgenossische Technische Hochschule in 1907 as an engineer, but he chose to make mineralogy his special subject and studied for a short time at Karlsruhe and later at the Geophysical Laboratory of the Carnegie Institution at Washington and published several papers with G. W. Morey. In 1914 he returned to Zurich, but later in the year he accepted a professorship in mineralogy and petrography at Leipzig and went to Tübingen in a similar capacity in 1918. On Grubenmann's retirement, Niggli was called to succeed him as professor at Zurich in 1920, and there then began the building up of an institute renowned for the high standard of its teaching and research. He was assisted there by a devoted team of able professors and assistants. Germany made one attempt to lure him back to take the chair of mineralogy and petrography at Charlottenburg, but Niggli decided to remain at Zurich, to the great delight of staff and students, who celebrated the occasion by a torchlight procession in his honour.

Niggli was a man of great ability, wide knowledge, and immense industry. His masters at Zurich were Albert Heim and Grubenmann, and his earliest published works as a student were on the chloritoid schists of the Gotthard massif and a geological map of Zofingen, his own birthplace. A list of his very numerous books and papers was published in the "Festschrift" issued in honour of his sixtieth birthday in 1948. He ranged over the whole field of crystallography, mineralogy and petrography, and sought especially to expound the principles of physical chemistry that apply to the paragenesis of minerals and the differentiation processes and metamorphism of rocks. In his "Geometrische Kristallographie des Diskontinuums" (Leipzig, 1918–19), he brought up to date Schoenflies's "Krystallsysteme und Krystallstruktur" (1891), introducing the new work based on X-ray analysis. This was followed by many papers and chapters in his "Lehrbuch", and others on crystal structure and stereochemistry. He was an editor of the *Zeitschrift für Kristallographie* during 1920–40.

His "Lehrbuch" (Berlin, 1920) ran to three editions; but each 'edition' was really a different book presenting various parts of the subject of crystallography and mineralogy from new angles and in the light of new knowledge. Unfortunately, Part 3 of the third edition, written in 1944 and set up in type, was twice destroyed in Berlin during the War, and Niggli had not the heart to write it again.

Petrology and the working out of methods of handling and studying the mass of chemical data available on igneous and metamorphic rocks, and the application of physical chemical principles and phase rule to the problems, figured largely in his work at Zurich. He collaborated with Grubenmann in a new book on metamorphism (1924) and with Burri in a vast survey of the mineral-chemical characters of the younger eruptive rocks of the Mediterranean orogeny, covering, in fact, a region stretching from America eastwards to the western shores of the Pacific. This work, in which more than two thousand chemical analyses were handled, used to the full Niggli's method of recalculating analyses in 'Niggli values', a method which, together with his later system of molecular norms and his graphical methods for comparing and exhibiting chemical characters of rocks, have all had considerable influence on petrography throughout the world.

Niggli was somewhat reserved in manner, especially in later years. Much of his writing was in rather difficult German, and he rarely wrote in English although he spoke it fluently. His great ability received world-wide recognition. He received honorary doctorates from the Universities of Stuttgart, Budapest, Liège and Sofia; he was given the Hayden Award of the Philadelphia Academy of Natural Science, the Roebling Medal of the Mineralogical Society of America, and the Orville Derby Medal (Rio de Janeiro), 1952. As a corresponding or honorary member he had been elected to no less than twenty-seven academies and societies, including the Geological Society of London and the Mineralogical Society, of which he was the senior honorary member, having been elected in 1933.

W. CAMPBELL SMITH

# NEWS and VIEWS

## National Physical Laboratory Standards of Radioactive Isotopes

Dr. E. C. Bullard, director of the National Physical Laboratory, has issued the following announcement: "The National Physical Laboratory has at present the main responsibility for standards of certain radioactive isotopes in Great Britain. It is proposing to issue standards of these isotopes at regular intervals to meet the needs of those whose use of such materials justifies absolute standards and to supplement the normal calibrations which can be obtained on request from the Atomic Energy Research Establishment, Harwell. Standards of iodine-131, based on the British Standard (see *Nature*, 170, 916; 1952) for this isotope, will be issued on or about October 15, 1953. Future issues will take place twice-yearly in mid-April and mid-October. The iodine-131 standards will be in the form of sealed ampoules of solution. Two different levels of activity will be available, one of 1 millicurie in 1 ml. of solution and one of 100 microcuries in 4 ml. of solution. Issues of standards of phosphorus-32 (100 microcuries in 4 ml. of solution) are planned to take place on June 15 and December 1, 1953. Applications for these standards should reach the National Physical Laboratory not later than a fortnight before the appropriate date of issue, and should include a statement of the purposes for which the standards are required. A fee of £10 will be charged for each 1-millicurie standard and of £5 for each 100-microcurie standard. It is requested that applicants should make their own arrangements for the collection of their standards from the Laboratory. An announcement relating to the issue of cobalt-60 standards will be made in the near future."

## Research in Coal Mining: Dr. L. C. Tyte

The National Coal Board has appointed Dr. L. C. Tyte to be director of its second Central Research Establishment at Isleworth, Middlesex, which is engaged on investigations of the underground problems of the industry. Dr. Tyte will be responsible to the Director-General of Research, Dr. W. Idris Jones, at headquarters. Dr. Tyte, who is forty-six, was educated at Queen Mary College, University of London, where he carried out research under Prof. C. H. Lees. Later he joined the Government Scientific Service at the Research Department at Woolwich Arsenal and latterly has been engaged on projectile research. He was promoted deputy chief scientific officer in 1950 and was technical director under Sir William Penney at the Monte Bello trial.

## Wigan and District Mining and Technical College

The Wigan and District Mining and Technical College, now in its ninety-sixth session, celebrated Founders' Day for the first time for fifteen years on March 25, when Sir Hubert Houldsworth, chairman of the National Coal Board, was the chief speaker. Sir Hubert, who paid tribute to the work of the College in providing leaders in many industries, referred to the scholarship scheme of the National Coal Board. Although Great Britain is suffering, among other things, from an insufficiency of qualified technical men, the Board is unable to find sufficient candidates for its hundred scholarships each year, although those selected have done well. Sir Hubert referred in particular to the desirability of more applications from those leaving school with a leaning towards physics, chemistry, mathematics and geology. Although many of the key positions in the industry are filled to-day by those who had no previous connexion with mining, he believes that a restricted mentality towards mining in schools outside the mining areas may be hindering recruitment. Emphasizing the need for attracting more men and the opportunity for those who have had their scientific—and preliminary—training at such a college or at a university, Sir Hubert welcomed the contribution of the Wigan Mining College to training for leadership for other industries. More than technical skill is required if the efficiency of the mining industry, or others, is to be raised and the lag between discovery or invention and application to practical purposes reduced. Besides technical knowledge, integrity, boldness in conception and soundness in judgment, leadership in industry demands interest in and understanding of human beings. Sir Hubert also stressed the importance of watching for originality and seeing that it is given full scope, particularly in research, and concluded by stressing the need for inculcating a spirit of service to the whole community.

In his report as principal, Dr. E. C. Smith said that, since Founders' Day was last celebrated, the number of students has increased from about 1,800 to some 3,000. Evening students have tended to decrease in numbers; but those attending on part-time day release have increased continuously from 220 in 1938 to 1,200. Such co-operation is specially marked with the National Coal Board. Full-time students have increased from 155 to more than 400. Dr. Smith referred to the extent to which the College has supplied training in technical teaching and administration to those who have since become heads of technical colleges or departments elsewhere, and stated that more officials of the National Coal Board have been trained at Wigan than at any other technical college or university in the country. The College library provides a first-rate service not only for the staff and students of the College, but also for research workers within the field covered, and the Manchester Geological and Mining Society now has its headquarters at the College.

## Technical Resources of Industrial Firms

In reply to a question in the House of Commons on March 31, Mr. A. H. E. Molson, Parliamentary Secretary to the Ministry of Works, representing the Lord President of the Council, stated that the Manchester Joint Research Council's survey of the technical resources of industrial firms is complete, and that the Council is preparing a report for possible publication. The Department of Engineering Production in the University of Birmingham is continuing its survey under a research contract with the Department of Scientific and Industrial Research. A pilot survey of the technical resources of industrial firms in two small selected areas has been carried out by the Social Survey; but it is not proposed to publish a report of this survey. Mr. Molson added that the Department of Scientific and Industrial Research is considering the preparation of a general paper covering all three surveys.

## Scientific Instruments of George III

A collection of more than three hundred and fifty scientific instruments and pieces of apparatus was made for the instruction of George III (1738–1820), when a youth, and was afterwards used for the education of his children. From 1769 onwards, these instruments were housed at the King's private observatory at Richmond, Surrey, a building now known as Kew Observatory. In 1841 they were presented to King's College, London, where they remained until they were transferred on loan to the Science Museum, London, S.W.7, in 1926. The collection has been on view to the public on only two previous occasions, namely, for short periods in 1928 and 1949, and the recent completion of the first stage of the rebuilding plan for the Science Museum now makes it possible for approximately one-half of this collection to be placed on permanent exhibition in one of the reconstructed galleries. The instruments, the majority of which were acquired between 1740 and 1768, cover the field of study known, in the eighteenth century, by the title of 'experimental philosophy'; although the collection is particularly rich in material designed for experiments in mechanics, pneumatics and electricity, numerous examples are also included of instruments used in astronomy, optics, surveying, magnetism, acoustics, chemistry and heat. The collection thus affords not only a valuable display of the type of science being taught during an important era in scientific development, but it also provides a fine example of the skill and craftsmanship of the scientific instrument maker of the period. A descriptive catalogue of the complete collection is now available from the Science Museum (price 7*s.* 6*d.*), and there is also a guide book (price 6*d.*) which gives a brief outline of the history of the collection, together with notes about some of the more important scientific instruments represented in the exhibition.

## Bibliography of Geiger–Müller Counters

A SHORT but useful bibliography of articles that have appeared during 1931–50, inclusive, on Geiger–Müller photon counters has been compiled by J. E. Walker, of the Electronics Division of the United States National Bureau of Standards (Report 1050; pp. 16; Washington, D.C.: Nat. Bur. Stand., 1952). Eighty-one papers or books, arranged in alphabetical order of authors, are listed. Most of the papers in English and German have been included, but only a selection of those in French, Russian and Italian; and it is a pity that no attempt was made to make the bibliography complete. Each reference is followed by either the author's abstract or comments by Mr. Walker. Those of historical interest only are dealt with very briefly.

## Oil Exhibition at the City Museum, Bristol

A SCIENTIFIC and technical oil exhibition, designed expressly for a museum public, is now on view in the City Museum, Bristol, until May 2, prior to touring other provincial museums. Developed by the Shell Petroleum Co., Ltd., the exhibition aims both at attracting and educating, and is readily understandable without the need for accompanying lectures or explanatory talks. Starting with the origin of oil, the exhibition goes on to deal with exploration, drilling and the development of oil fields and with the different means of transport; the chain of events from refining, manufacture and research to the distribution of products to consumers is also outlined. The whole arrangement is made up of twenty-two portable display cases, one or more of which are devoted to each of the fifteen subjects into which the activities of the industry have been divided. The treatment of the displays differs: some include models, reliefs or dioramas; others are purely photographic, with pictures of artistic merit as well as of technical interest. Each display is labelled, and there is a descriptive leaflet available to visitors.

## Flora and Fauna of South Carolina

THE first number of *University of South Carolina Publications: Series 3, Biology*, has recently been published (1, No. 1; pp. 41; 1952; from the University, Columbia, S.C.; 75 cents). This is a new journal that is to be devoted to taxonomic studies of the flora and fauna of the State of South Carolina. It is published by the Research Committee of the University at irregular intervals as the material is available, and the first number consists of two contributions, the first of which, by J. T. Penny, is on the amphibians and reptiles of the State. Of the amphibians, fifty-five species with eleven sub-species are listed and, of the reptiles, fifty-nine species and fifteen sub-species, which gives an idea of the richness of this fauna in South Carolina. In each instance the type locality of the form is given. The second paper, by Harry W. Freeman, on the "Fishes of Richland County", is based upon a collection from thirty-seven localities, all listed, and reports forty-nine species and one specimen considered as a hybrid. Up to the time of this collection only eighteen species had been recorded, and the author obtained thirteen of these, so that the total number of species recorded from the county is fifty-four. Both papers start with a short historical introduction, a point to be commended; the first reptile to be recorded was the alligator in 1682, but the first serious beginning was Catesby's classical "Natural History of Carolina, Florida and Bahama Islands" (1730–48). Both papers also conclude with a complete bibliography. The printing, paper and layout are very satisfactory.

## First International Polarographic Congress, Prague

THE third volume of the proceedings of the First International Polarographic Congress, held in Prague during February 1951, has now been published (pp. 774; from Orbis-Export, 30 Ve Smeckach, Prague II; 10.80 dollars). The volume contains eight reports on the field of modern polarography, including its applications in chemical analysis, biochemistry and medicine, and these are followed by fifty-six contributions to the Congress, with discussions. The text is in Czech, with versions in Russian and extensively in English and German. This adds considerably to the bulk of the volume, but will be appreciated by readers not familiar with the first two languages. The volume is impressive as showing the great advances made in the important subject of polarography, and should be found of considerable interest.

## Second International Congress on Rheology, Oxford

THE detailed programme of the Second International Congress on Rheology (see *Nature*, 170, 487; 1952), to be held in Oxford during July 26–31, has now been published. The address by the president of the Congress, Sir Geoffrey Taylor, will be on "Rheology for Mathematicians", and other general lectures will be given as follows: on the electroviscous effect (in French), by Mme. A. Dobry Duclaux (Paris); rheological problems in the fabrication of plastics, by R. S. Spencer (Midland, Mich.); rheology and applied mechanics, by R. N. J. Saal (Amsterdam); rheological behaviour and the molecular jumping mechanism, by F. H. Müller (Marburg); water association and hydrogels, by E. Forslind (Stockholm); and biological problems for the rheologist, by P. Eggleton (Edinburgh). The other papers in the programme will be read at one of the three sections of the Congress; it is noteworthy that a number of the authors of these papers come from countries other than Great Britain, namely, Brazil, France, Germany, Holland, Sweden, United States and Yugoslavia. The Congress fee is £4, which includes preprints of all the papers to be read; orders for additional copies of the proceedings and for off-print copies of individual papers should be addressed to the publishers, Butterworths Publications, Ltd., 436 Strand, London, W.C.2. Application forms for the Congress (to be returned by May 1) and further details can be obtained from the honorary organizing secretary, Dr. G. W. Scott-Blair, University of Reading.

## Oxidation of Oils and Fats: Symposium in Cambridge

A symposium on the oxidation of oils and fats will be held by the Oils and Fats Group of the Society of Chemical Industry on April 24 at the Low Temperature Research Station, Downing Street, Cambridge. Prof. C. E. H. Bawn will give an introductory address, and he will be followed by talks on recent research, as follows: Dr. C. H. Lea, on oxidative deterioration of lipids; Dr. A. Banks, on autoxidation of linoleic acid; Dr. L. A. O'Neill, on autoxidation of drying oils; and Dr. J. H. Skellon, on oxidation of monoethenoid fatty acids and esters. Further information can be obtained from the General Secretary, Society of Chemical Industry, 56 Victoria Street, London, S.W.1.

## Chemical Society: Officers

Officers of the Chemical Society have been elected as follows: *President*, Prof. C. K. Ingold; *Vice-Presidents*, Prof. F. G. Donnan, Sir Ian Heilbron, Sir Cyril Hinshelwood, Dr. W. H. Mills, Sir Eric Rideal, Sir Robert Robinson, Prof. G. R. Clemo, Prof. R. D. Haworth, Prof. D. H. Hey, Prof. E. L. Hirst, Sir John Simonsen and Prof. M. Stacey; *Treasurer*, Sir Wallace Akers; *Secretaries*, Prof. H. Burton, Prof. E. D. Hughes and Dr. L. E. Sutton; *New Members of Council*, Prof. F. Bergel, Prof. M. J. S. Dewar, Dr. I. J. Faulkner, Prof. Brynmor Jones and Dr. A. I. Vogel.

## Colonial Service: Recent Appointments

The following appointments have recently been made in the Colonial Service: D. F. Phillips (agricultural assistant, Tanganyika), agricultural officer, Tanganyika; F. A. Rabagliati (assistant agricultural officer, Kenya), agricultural officer, Kenya; B. J. Silk (agricultural education officer, Gold Coast), senior agricultural education officer, Gold Coast; F. Durocher-Yvon (director of agriculture, Seychelles), agricultural officer, Northern Rhodesia; S. J. Curry (entomologist, Cyprus), entomologist, Kenya; Major the Hon. P. L. A. O'Brien (geologist, Northern Rhodesia), senior geologist, Northern Rhodesia; Gunn Lay Teik (chemist, Agricultural Department, Federation of Malaya), senior chemist, Agricultural Department, Federation of Malaya; D. F. Laing and F. E. Trevitt, veterinary officers, Nigeria; B. McCulloch, veterinary research officer, Tanganyika; R. Blower, soil conservation officer, Kenya; C. Bos, arrowroot processing chemist, Windward Islands; T. D. Rees, geochemist, Geological Survey Department, Tanganyika.

## Announcements

The Royal Astronomical Society has elected Prof. V. A. Ambartsumian, of the University Observatory, Leningrad, and Prof. A. Unsöld, of the University Observatory, Kiel, to be associates.

Dr. Detlev W. Bronk, president of the Johns Hopkins University and president of the United States National Academy of Sciences, has been elected by the Paris Academy of Sciences to be a *correspondant* for the Divisions of Free Academicians and of the Application of Science to Industry in succession to the late Prof. F. Marguet.

Mr. J. A. Ratcliffe, of the Cavendish Laboratory, Cambridge, has been awarded the Holweck Medal and Prize for 1953 and will deliver the eighth Holweck Lecture in Paris on May 22; his subject will be "Some Aspects of Diffraction Theory". The Holweck Medal was founded by the Physical Society as a memorial to Fernand Holweck, director of the Radium Institute, Paris, and to other French physicists who were killed during the occupation of France in the Second World War, and the award is made annually by the Physical Society and the Société Française de Physique jointly. The recipient is alternately a French and a British physicist, distinguished for his work in experimental physics.

The Television Society's Silver Medal has been awarded for 1953 to Mr. George Cansdale, for his feature on the B.B.C. television programme in presenting animals from the London Zoo. This Medal, which was instituted in 1948, is intended to acknowledge the work done by an author, actor, producer, or any member of the television service in promoting the artistic or entertainment side of television programmes; and, in making the award this year, the Society has recognized that the function of television is not only entertainment but also education, both of which are combined in Mr. Cansdale's programmes.

The James Cook Medal for 1952 of the Royal Society of New South Wales has been awarded to Emeritus Prof. W. L. Waterhouse, of the University of Sydney, in recognition of his work in the field of agricultural science, particularly in the breeding of rust-resistant wheats. The James Cook Medal is awarded for "outstanding contributions to Science and Human Welfare in and for the Southern Hemisphere". The first award was made to Field-Marshal J. C. Smuts a short time before his death in 1950.

Dr. G. P. Contractor, who for the past three years has been the acting director of the National Metallurgical Laboratory of India, Tatanagar, of the Indian Council of Scientific and Industrial Research, has recently resigned from the Council.

Dr. C. J. Stubblefield, chief palæontologist since 1947 of the Geological Survey of Great Britain, has been appointed assistant director of the Survey and curator of the Museum of Practical Geology, London.

The following have been appointed to readerships tenable at St. Mary's Hospital Medical School, London: Mr. A. d'A. Bellairs (anatomy) and Dr. K. W. Cross (human physiology). The title of reader has been conferred on the following in respect of the posts held by them at University College, London: Dr. J. T. Aitken (anatomy) and Dr. G. E. Fogg (botany).

# PETROLEUM CHEMICALS INDUSTRY IN GREAT BRITAIN

UNDER the joint auspices of the Society of Chemical Industry (London Section) and the Institute of Petroleum, a full day was devoted to a symposium on the "Production and Utilization of Petroleum Raw Materials in the U.K. Chemical Industry", which was held on March 2 at the Institution of Electrical Engineers, Savoy Place, London. Twelve papers, previously circulated, were briefly outlined by their authors, and discussion followed. The questioning was direct, though an understandable desire of industrial firms to retain their trade secrets led on occasion to reticence in giving equally direct replies. Throughout, the discussion was spirited; the wide range of subjects considered led, not to a diffusion of interest, but to a shaping and crystallization of views that was informative and helpful.

In opening the symposium, Mr. E. J. Dunstan (Manchester Oil Refinery, Ltd.) compared the earlier development of the petroleum chemicals industry in the United States with the growing British effort in this field. The natural conservatism in Britain of old-established industries and the inability of industrial organizations to pay for development projects out of earnings have impeded that growth and proliferation which are essential if the chemical industry is to make an adequate contribution to the well-being of the people and to the balance of trade. After making due allowance for the different economic climates of the United States and Great Britain and the industrial and commercial requirements and trends peculiar to the latter country which may invalidate arguments based on simple analogy, Mr. Dunstan concluded that the British petroleum chemicals industry requires substantial additional resources of capital, an increased intake of technically trained men (particularly chemical engineers) and the full collaboration of labour; otherwise its energetic beginnings which promised so much may die away, and the opportunities that this young industry offers for strengthening the national economy may well be lost.

This theme of the economic effect of the industry on our trading position was elaborated by Dr. R. F Goldstein (British Oxygen Co., Ltd.). The chemical industry as a whole has increased its production capacity since 1948 from £327 to nearly £500 million—an increase which compares very favourably with the expansion-rate of other industries in Great Britain and with that of the chemical industry in other European countries. To this increase, the petroleum chemicals industry has made a substantial contribution, at the cost of capital investment in the region of £40–50 million. If the British industry were to continue to grow at the same proportionate rate as the United States petroleum chemicals industry is expected to develop, according to the Paley Report, during the next twenty-five years, then additional capital investment at the rate of £14 million a year would be required, and the whole chemical industry would demand about £70 million a year for comparable expansion. The threat of capital starvation of the industry is real, and the hope of survival lies in the probability that the profit record of the chemical industry as a whole will prove a sufficiently strong attraction to new risk capital.

The technical basis of the industry was outlined by Dr. H. K. Whalley (British Industrial Solvents, Ltd.). Oil refining offers a range of raw materials extending from methane (which may be used for the production of synthesis gas, acetylene, hydrocyanic acid, etc.), ethylene, ethane, $C_3$s and $C_4$s, to the light distillates such as naphtha, kerosine and gas oil, which are the feed stocks for cracking processes specially developed for making olefines and aromatics for subsequent chemical conversion. Oil-refining processes such as thermal and catalytic reforming and thermal and catalytic cracking, which are designed primarily to give increased quantities of high-quality gasoline, also yield gases as by-products which serve as starting materials for the petroleum chemicals industry. Further, catalytic reforming processes developed by the oil industry for the octane-number improvement of gasoline and naphtha may be adapted for aromatics production. The conventional oil-refining industry is therefore making a dual contribution to the development of petroleum chemicals: it provides the charge stocks from which the essential olefines and aromatics may be made, and it aids the technological growth of the new industry by its own research, development and experience in cracking, alkylation, reforming and polymerization processes. These ties between petroleum refining and petroleum chemicals production are not restrictive: mutual benefits, both technical and economic, must come from the closest association of the two industries.

Two aspects of plant design and construction were dealt with by Mr. E. Smith (Firth-Vickers Stainless Steels, Ltd.) and Mr. E. O. Curtiss (The Lummus Co., Ltd.). The dangers of intergranular corrosion of unstabilized 18/8 austenitic steels, due to deposition of chromium carbide at grain boundaries, was strongly emphasized. Ordinary 18/8 steel, when reheated to 500–800° C., is rendered susceptible to this defect, but the risk can be eliminated if titanium or niobium is added to the steel. Though full details of a wide range of corrosion- and heat-resisting steels were given, Mr. Smith stressed the desirability of designers, fabricators and users consulting with steel manufacturers, so that the needs of each particular job could be more satisfactorily met.

Some problems in the design of plants for the recovery of light olefines from refinery and cracker gases were described by Mr. Curtiss, with emphasis on the absorption–fractionation method. The preliminary removal of sulphur and acetylene, followed by drying of the gas stream, was outlined, and the design and operation of the absorption–fractionation system were described in detail. The alternative process relying on low-temperature distillation and cascade refrigeration systems was also discussed, and the point was made that the relative merits of the two processes are dependent upon the nature of the feed stock and the required recoveries and purities of the product gas streams. In discussion, Mr. Curtiss observed that the hypersorption process, which relies upon the adsorption of gases by charcoal and their selective desorption, is less widely used, and the reason may lie in the difficulties in stripping the adsorbent and in its attrition.

The synthesis of ethyl alcohol by the catalytic hydration of ethylene at the Grangemouth factory of British Petroleum Chemicals, Ltd., is an outstanding manifestation of two of the major lines of the petroleum chemicals industry, which were well recognized by the symposium. The first is the tendency of the industry to offer an alternative route to chemicals previously made from vegetable products, and the second is the application of catalytic methods which dispense with the need for heavy inorganic chemicals that contribute no essential ingredient to the finished compound. The cost of producing alcohol by fermentation of molasses is dependent largely on the price of molasses, which is itself dependent upon world sugar production, cattle feed requirements (particularly in the United States) and the varying demand for industrial alcohol. So influential have these and other factors been that, during the past twenty years, the price of Cuban molasses has ranged from £3 10*s.* to £25 a ton. By basing the production of ethyl alcohol on petroleum-derived ethylene, it is confidently expected that a more stable price-structure, and one set at an economically lower level, will result. In the United States, half of the industrial alcohol produced is synthetic alcohol. The decision having been made to adopt petroleum as the base for alcohol manufacture, a choice had to be made between the two methods available, namely, by the well-established process of absorbing the ethylene in sulphuric acid to obtain the ethyl esters which are afterwards hydrolysed, or by the Shell method of hydrating ethylene directly, phosphoric acid on 'Celite' (a diatomaceous earth) being used as the catalyst. Mr. A. J. Johnson, presenting the paper prepared by Mr. C. R. Nelson and himself (Shell Development Co.), described this second and preferred course which eliminates the problems involved in the use of sulphuric acid, including those of reconcentration of the acid, disposal of impure acid, and corrosion effects. The direct hydration of ethylene is conducted at about 1,000 lb./sq. in. gauge and 300° C.; the molar ratio water/ethylene is 0·6, and the conversion of ethylene per pass is low (about 4 per cent). The choice of these reactor conditions is largely determined by economic considerations.

Two other instances of new processes, which avoid the use of substantial quantities of inorganic chemicals, were the subject of papers. The economics of the catalytic direct oxidation of ethylene by air over a silver catalyst to yield ethylene oxide, in contrast to the older chlorhydrin process which consumes large amounts of chlorine and lime (about two tons of each per ton of ethylene oxide made), were presented by Dr. E. T. Borrows and Mr. D. A. Caplin (Petrochemicals, Ltd.). On the basis of conservative estimates of capital costs and yields, the direct oxidation process shows significant advantages, particularly under competitive market conditions, which may be expected to force down the selling price of ethylene oxide. The meeting showed a lively interest in the technical aspects of the process, which the economic calculations tacitly assumed, and questions were put on the patent position, the catalysts used, the need for moderators to suppress 'hot spot' formation, the tolerable acetylene concentration in the feed gas, and the carbon monoxide in the recycle. Published data on these points are, however, scanty, and those members of the meeting who may have been in a position to contribute information on these matters withheld their views. The strong attitude of caution in accepting the claimed merits of the direct oxidation process might be dispelled if at least some of the data from existing plants in the United States were made available and if performance reports on the plants at present under construction in the United States and on the Continent of Europe, couched in something better than meaningless general terms, could, in due course, be released. Though it would be foolish to expect trade secrets to be given away, the paucity of performance data prevents impartial assessment, and retards, by some years, the more widespread adoption of a process that may well be as good as the paper economics imply.

Mr. F. E. Salt (The Distillers Co., Ltd.) provided the third example of an elegant process which dispenses with the use of heavy inorganic intermediates. The well-established methods for synthesizing phenol from benzene rely upon using sulphuric acid or chlorine as basic raw materials, and involve corrosive conditions. The new process developed by the Distillers Co. and the Hercules Powder Co. converts benzene and propylene, via *iso*propyl benzene, to phenol and acetone. Its advantages have been judged to warrant the construction of a number of plants overseas which are expected to come into production soon. The essential basis of the process—that is, alkylation, followed by oxidation to the hydroperoxide and its decomposition to the corresponding phenol and ketone—is of wide applicability; for example, *sec.*-butyl benzene yields phenol and ethyl methyl ketone; *m*- and *p*-di*iso*propyl benzenes yield acetone with resorcinol and quinol, respectively. The capital cost of a plant to produce 10,000 tons phenol a year and 6,000 tons acetone a year is estimated to be £1·75 million, which is slightly less than that required for phenol plants of the same capacity employing older processes. Further, if reasonable values (for example, 1952 price-levels) are taken for raw materials, utilities, labour and for the acetone credit, then the cost of production of phenol by this route is about 70–80 per cent of that by any of the other routes.

An outline of the production of polystyrene and its utilization in a variety of industries, as presented by Dr. V. G. Bashford and Mr. S. D. Eagleton (Monsanto Chemicals, Ltd.), raised questions relating to the use of methyl styrene. It appears that the use of methyl styrene offers the possibility of more rapid polymerization, and though the polymers are less suitable for injection moulding, they promise well for incorporation in surface coatings. The advantages of toughened polystyrene in comparison, say, with toughened polyvinyl chloride were discussed, and doubt was expressed as to the ability of the product to retain over periods of three to four years the high impact strength and improved elongation that the freshly prepared material possesses.

The paper by Mr. W. G. Oakes and Mr. H. C. Raine (Imperial Chemical Industries, Ltd.) on polythene was of outstanding merit in demonstrating the best features of the scientific approach in carrying a project through research and development to full-scale production, followed by the subsequent elaboration of the first direct course, so that a wider range of products of desired and predictable properties may be made. The fundamentals of polythene formation have been carefully examined, and many techniques and approaches have been used to elucidate the polymerization process and the structure and nature of the product. At first believed to be a straight-chain polymer, polythene is now known to be made up of molecular chains that are branched. The application of X-ray diffraction, infra-red spectrographic analysis, studies of osmotic pressure and viscosity of solutions, light scattering and other techniques have contributed to the present conception of the structure of polythene, but even now it is not fully resolved. Each finite sample of polythene is made up of molecules having quite a wide spread of molecular weight. The physical properties of the polymer depend upon both the chemical features and also on the arrangement of the molecules in relation to one another in the solid state. Polythene is partly crystalline: in the commercial material, probably about 70 per cent of the molecules are in the ordered state. The authors of this paper correlated chemical and structural features with electrical conductivity, melt viscosity, melt elasticity, softening point and mechanical and physical properties in the solid state. A point of interest which the discussion evoked was that, under the action of gamma-rays, cross-linking is caused, resulting in the transformation of polythene to a glassy, brittle solid. This effect is similar to that produced by a very prolonged photo-oxidation; the mechanism of the change is a matter for speculation.

A second paper from Imperial Chemical Industries, Ltd., on butane dehydrogenation, by Mr. E. Beesley and Dr. B. Whipp, was equally creditable as a record of the rapid development, in collaboration with Universal Oil Products, Ltd., of a process under the stress of war-time conditions of emergency and improvisation. A mixture of *iso* and *normal* butanes (usually 70 per cent *iso*) was dehydrogenated over an alkali-promoted chromia–alumina catalyst to the corresponding butenes. This essential step in the production of *iso*octane for aviation gasoline was brought to successful operation; one major difficulty, namely, the random choking of the reaction tubes due to excessive and unpredictable coke formation, was cured by introducing 30–40 p.p.m. carbon disulphide in the charge. The carbon disulphide was thought to passivate the tube material against alternate oxidation and reduction, thus preventing the catalysis of carbon formation by finely divided metal. In the discussion, it was said that the process is now in operation for the production of *iso*butene from *iso*butane in an integrated plant, wherein this step fits in with other industrial processes.

The separation and utilization of $C_4$ olefines, which are becoming increasingly available from the new oil refineries and petroleum chemicals cracking-plants, was reviewed by Dr. E. T. Borrows and Mr. W. L. Seddon (Petrochemicals, Ltd.). It is of particular interest that whereas the $C_4$ stream from oil-refinery catalytic crackers contains virtually no butadiene, the plants installed by petroleum chemicals works for the cracking of naphtha, gas oil, etc., yield a $C_4$ stream containing substantial amounts of butadiene. This constitutes both an opportunity and a problem. Considerable interest was shown in the authors' suggestion that, from a mixed $C_4$ stream containing butadiene, the *iso*butene may first be removed by selective absorption in sulphuric acid without absorbing appreciable amounts of the butadiene present; in fact, more than 90 per cent of the butadiene may be afterwards recovered.

The series of specialist papers was concluded by the paper by Dr. D. P. Dodgson (Monsanto Chemicals, Ltd.) on the use of additives based on petroleum for improving the quality of various petroleum fractions. A wide range of products, including chlorinated waxes, sulphonation products, naphthenic acids, viscosity index improvers, pourpoint depressants, etc., were dealt with. In the discussion, interest was shown in the use of additives to give oils of both high- and low-viscosity indices, and in the liability of viscosity index improvers to break down at high rates of shear. Dr. Dodgson gave the assurance that conventional lubricating oils containing additives from different manufacturers are, in general, mutually compatible.

Sir Robert Robinson, in the closing address, pointed out that the world chemical industry is highly competitive, and, if the British complement is to survive, it must keep in the race: any early financial losses in establishing the petroleum chemicals industry must be accepted; national and strategic interests make it imperative that the necessary capital to sustain development and growth of the industry must be found. The symposium, he said, rightly laid stress on an essential theme of this new industry: that is, its facility for developing alternative processes which do not require the use of substantial quantities of heavy inorganic chemicals, for example, in the production of acetone and phenol by the Distillers Co., Ltd., process, and of ethylene oxide by the catalytic oxidation of ethylene. This theme should be vigorously developed. Research over a broad front on catalysis should be conducted, and in this attack, continued Sir Robert, government departments such as the Chemical Research Laboratory and the Fuel Research Station of the Department of Scientific and Industrial Research should play an outstanding part. Recent research has demonstrated that there are many reactions and processes which hold high promise of industrial exploitation in Britain: the Fischer–Tropsch reaction and the Oxo syntheses are well-known examples. The recent work of Ziegler on the use of lithium and aluminium hydrides as catalysts in controlled polymerization processes may also lead to economic routes to both known and new products. These are only examples of the many opportunities, some known, some awaiting discovery, that lie before us, and only by our own energy and unsparing effort can they be won.

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# CLAY – WATER RELATIONSHIPS

A MEETING of the Clay Minerals Group of the Mineralogical Society, held at the laboratories of the British Ceramic Research Association, Stoke-on-Trent, during November 7–8 last, was devoted to a discussion upon clay – water relationships. The meeting was preceded, on the morning of November 7, by a visit to the laboratories of the Association. At the scientific sessions the chair was taken on the afternoon of November 7 by Dr. G. W. Brindley (University of Leeds), and on the morning of the following day by Dr. G. Nagelschmidt (Safety in Mines Establishment, Sheffield).

The discussion was opened by a review of the significance of clay – water relationships in ceramics by D. A. Holdridge and F. Moore (British Ceramic Research Association). Plasticity and strength data as well as the Pfefferkorn and modified Pfefferkorn numbers for ball and china clays were related to dehydration data, and discussed in relation to the concept of 'planar' and 'broken-bond' water; the former is removed below 110° C., but removal of the latter is incomplete below about 250–275° C. In describing the rheological properties of importance for clay slips and pastes, particular attention was paid to the methods for determination of viscosity and plasticity and their applicability. The rheology of thixotropic gels was also discussed. In the discussion, the different dehydration characteristics of china clay and ball clay were commented upon by R. Greene-Kelly (Rothamsted Experimental Station, Harpenden) and by Dr. Brindley, who also referred to recent dehydration data for nacrite[1]. G. K. Jones (Fuller's Earth Union, Redhill), Dr. N. O. Clark (English Clays, St. Austell) and Mr. Moore discussed the relationship of dilatancy, turbulence and shearing, and R. H. S. Robertson (Glasgow) inquired about the relationship of the modulus of rupture to the moisture content.

Soluble salts may have deleterious effects upon clay products—for example, efflorescence in bricks—and the determination of these in clayey raw materials was discussed by Prof. H. Lehmann (Bergakademie, Clausthal-Zellerfeld), who showed that extraction by a percolation method after firing gives the most useful information. Using this technique, it has been found that efflorescence is not related to the amount of soluble salts alone, but that it is also dependent upon pore space, pore characteristics, firing temperature and the density and chemical characteristics of the specimen. Correlation of efflorescence with firing temperature, the effect of various ions and the possibility of control of conditions leading to efflorescence were discussed. In reply to comments by B. Butterworth (Building Research Station, Watford), Prof. Lehmann stressed that he had considered only clays in which his laboratory is interested, and agreed that higher sulphate contents are not uncommon; he also mentioned that, in Germany, determination of soluble salts in the raw material is still used to assess a clay. Other speakers referred to the effect of association of bricks with cement products and the question of the total soluble salts. In reply to W. Noble (British Ceramic Research Association), Prof. Lehmann remarked that the effect of the *p*H of the extracting solution has not yet been considered.

The deflocculation of kaolinite suspensions and its relationship to chloride adsorption has been investigated by Dr. R. K. Schofield and H. R. Samson (Rothamsted Experimental Station), who found that a flocculated sodium–kaolinite suspension in contact with less than a critical amount of sodium hydroxide takes up chlorine ions from dilute sodium chloride solution; when deflocculation occurs, full negative adsorption is observed. These results are related to questions of cation-exchange by kaolinite, since, from the observations made, exposed hydroxyl groups at the surface would only be expected to give exchangeable hydrogen ions under alkaline conditions. In addition, montmorillonoids might, under certain conditions, be sorbed by kaolinite to neutralize positive charges. Mr. Greene-Kelly and Dr. Clark both commented upon the significance of the above results in work involving dispersion of mixtures of clay minerals, where one mineral may be preferentially deflocculated. Dr. D. M. C. MacEwan (Rothamsted Experimental Station) pointed out that the remarks upon dissociation of hydroxyl groups were in disagreement with the views of Edelman and Favejee[2], and that the results might be significant in determining the true structure of montmorillonite[3].

To investigate the relationship between viscosity and concentration for three clays of the kaolin group, T. E. Currie and Dr. R. W. Grimshaw (University of Leeds) employed electron-optically checked samples of uniform particle-size. The viscosity/concentration curves were all similar in shape and could be derived from equations employing a series of constants dependent upon degree of dispersion, upon particle-size, and upon type of clay mineral present. In general, the viscosity was more dependent upon particle-size than upon type of mineral. Dr. Grimshaw, replying to Dr. Nagelschmidt, reported that constant shearing stress had been used, although the same general conclusions were applicable under different conditions. Dr. Clark questioned whether the relatively constant thickness-ratio for kaolinite grains in the various fractions could be taken as a universal rule, and in this connexion Mr. Robertson referred to some work upon the relationships of viscosity to rugosity[4] and to particle size for various kaolin clays[5]. The rigidity of the water envelope around clay particles and its effect upon results were also discussed by Dr. Clark and Dr. Grimshaw.

In a review of the subject of thixotropy and the internal swelling of crystals, Prof. U. Hofmann (Technische Hochschule, Darmstadt) described a very neat method, employing freeze-drying technique, of obtaining dry undisturbed clay-gel structures for examination under the electron microscope. These structures alter very little in volume during drying, and it is considered that the relative positions of particles are virtually unchanged; the framework is reasonably solid, very stable and even has a certain elasticity—properties which were demonstrated by a sample passed among members of the meeting. The effect of electrolytes upon the volume of coagulated clay gels, and the forces operative here and in maintaining the solidity of the framework were discussed. Prof. Hofmann also reported the results of an investigation upon thixotropy in non-aqueous liquids, for example, hexane and benzene. In the discussion, Dr. Nagelschmidt referred to the occurrence of thixotropy in systems with spherical particles, and Mr. Samson, Dr. Clark and Prof. Hofmann discussed general questions upon thixotropy and the arrangement of particles in flocculated systems. The formation of dipoles, and the dielectric constants of suspensions were referred to by Dr. Clark and Mr. Jones, and finally Prof. Hofmann, in addition to Dr. Clark and Dr. P. Howard (University of Leeds), suggested other methods whereby dry, undisturbed clay structures might be produced.

The conditions under which montmorillonoids lose their expanding properties on heating were described by R. Greene-Kelly, who related the changes occurring with crystal structure[6]. For example, if lithium-saturated montmorillonoids are heated to 200° C. and treated with glycerol, only dioctahedral components with the charge in the tetrahedral layer (that is, the beidellite type) will swell. Reference was made to the sorption of water by sodium-montmorillonoids, and some notes were given upon the information to be derived from such measurements. Mr. Greene-Kelly, in reply to Dr. R. C. Mackenzie (Macaulay Institute, Aberdeen), reported that he had not examined beryllium-montmorillonoids because of the hazards of the acidity of stable solutions of $Be^{2+}$ salts. Further discussion took place upon the effect of lithium ions upon the cation-exchange capacity of montmorillonoids and the possibility of such ions entering the lattice, these points being raised by Dr. Nagelschmidt and Dr. B. S. Neumann (Fuller's Earth Union).

Dr. G. W. Brindley and R. F. Youell (University of Leeds) showed that, during the oxidation of ferrous to ferric chamosite, there occurs a partial dehydration which can be related to the lattice positions of the hydroxyl groups. The retention of water and structural order to high temperatures during the dehydration of nacrite[1] was also demonstrated. These results were considered in relation to oxidation–dehydration processes in other minerals, and, as an example, it was shown that chemical analyses for decomposition products of biotite[7] can only give reasonable structural formulæ using assumptions derived from the above experiments. The derivation of good structural formulæ was commented upon by Dr. MacEwan, Dr. Nagelschmidt and Dr. Mackenzie, while Dr. S. J. Gregg (University College, Exeter) compared the retention of water by silicates to a high temperature with the retention of water and carbon dioxide by other compounds. Dr. H. P. Rooksby (General Electric Co., Wembley) referred to the retention of water by $\gamma$-$Al_2O_3$, and, in reply to his questions on the structural dehydration data, Dr. Brindley stressed the slowness of heating and the reproducibility of results even with broken crystals. The mechanism of the dehydration of kaolinite, with special reference to the work of White *et al.*[8], was also discussed by Dr. Nagelschmidt, Dr. Grimshaw, Dr. Howard, Mr. Youell and Dr. Brindley.

The final paper was not upon the subject for discussion although it had an indirect connexion. In order to determine the effect of grinding on kaolinite, Dr. S. J. Gregg, T. W. Parker (English Clays, St. Austell) and Mrs. M. J. Stevens (University College, Exeter) ball-milled a sample for a thousand hours, withdrawing aliquots at intervals for various physical and chemical tests—for example, X-ray examination, air sedimentation, loss on ignition, etc. Up to six hundred hours, the primary particles were decomposed chemically as well as broken physically, and the products formed an amorphous layer on the somewhat disorganized, undecomposed particles. The resultant particles, which possess an internal area, resisted complete dispersion and, after six hundred hours, the proportion of stable aggregates increased. During discussion, questions were asked by Mr. Greene-Kelly, Mr. Henderson, Mr. Jones, Dr. Neumann, Dr. MacEwan, I. L. Freeman (London Brick Co., Stewartby) and Dr. Mackenzie upon the method of sampling, the wear on the ball-mill, the uniformity of particle size, density measurements and the stability of aggregates. The possibility of interference of electrostatic charges with air-sedimentation tests was suggested by Dr. P. L. Plesch (University College, Stoke-on-Trent), and, in reply to a question by Mr. R. Johnson (British Ceramic Research Association), Dr. Gregg pointed out the significance of the inter-relationship of measurements of bulk density, sedimentation and surface area. The X-ray results were discussed by Dr. Brindley and E. K. Cundy (English Clays) and the amorphous coating, or 'Beilby layer', by Mr. Robertson.

Before the end of the meeting, two brief reports—one on the conference on clays and clay technology, held at the University of California during July 21–52, 1952, and one on the meetings of the Comité International pour l'Étude des Argiles, held in conjunction with the Nineteenth International Geological Congress, Algiers, during September 8–15, 1952—were presented by Dr. MacEwan and Dr. Mackenzie, respectively.

This meeting, as a whole, proved most valuable, giving ample proof of the significance of clay – water relationships in all aspects of clay studies, both pure and applied. Its value was enhanced by the concentration on problems which our present knowledge is insufficient to solve, but which might well form the subject of future research.

ROBERT C. MACKENZIE

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[1] von Knorring, O., Brindley, G. W., and Hunter, K., *Min. Mag.*, 29, 963 (1952).

[2] Edelman, C. H., and Favejee, J. Ch. L., *Z. Krist.*, A, 102, 417 (1940); and Edelman, C. H., *Verres et Silicates Indust.*, 12 (Supp.), 3 (1947).

[3] For example, see *Nature*, 168, 107 (1951).

[4] Robertson, R. H. S., and Emodi, B. S., *Nature*, 152, 539 (1943).

[5] Meldau, R., and Robertson, R. H. S., *Ber. deut. keram. Ges.*, 29, 27 (1952).

[6] For earlier work see Greene-Kelly, R., *Clay Min. Bull.*, 1, 211 (1952).

[7] Walker, G. F., *Min. Mag.*, 28, 693 (1949).

[8] For example, see Vassiliou, B., and White, J., *Clay Min. Bull.*, 1, 80 (1949); and Murray, P., and White, J., *ibid.*, 1, 84 (1949), and *Trans. Brit. Ceram. Soc.*, 48, 187 (1949).

# RADIO RESEARCH IN THE BRITISH COMMONWEALTH

AT the meeting of the British Commonwealth Scientific Official Conference in 1946, a Specialist Conference on Radio Research was convened and was held in London during August 1948 under the chairmanship of Dr. R. L. Smith-Rose. The proceedings of this Conference, which were published (S.O. Code No. 47-148-1949; London: H.M.S.O.; 4*d.* net), included a number of recommendations designed to encourage the Commonwealth countries to participate more actively in a comprehensive programme of fundamental radio research. This programme included such items as proposals for the location of ionospheric recorder equipment for determining the characteristics of the ionosphere at vertical incidence, the study of the propagation of radio waves at oblique incidence and the comparison of radio transmission forecasts with the results of the practical operation of radio circuits. Other matters were concerned with radio noise of both terrestrial and extra-terrestrial origin, the investigation of meteors by radio methods, and with a study of the effect of meteorological conditions on the propagation of very short radio waves. Suggestions were also made for extending the limited services of standard frequency transmission, and for collecting information to increase our knowledge of the electrical constants of the ground in all parts of the Commonwealth.

The progress made towards the implementation of these recommendations has been reviewed on two occasions by correspondence through the British Commonwealth Scientific Liaison Offices in London; and last August in Sydney, Dr. Smith-Rose held another meeting of the Specialist Conference, taking advantage of the presence there of a number of radio scientists attending the General Assembly of the International Scientific Radio Union. It was noted that considerable progress has been made in extending the network of ionospheric recording stations throughout the Commonwealth. In addition to the stations in Great Britain at Slough and Inverness, the United Kingdom has maintained similar stations at Singapore and in the Falkland Islands; and more recently an experimental equipment has also been in operation at Port Lockroy in Antarctica. Furthermore, similar recorder equipment has been installed by the United Kingdom Department of Scientific and Industrial Research at Ibadan, Nigeria, and at Khartoum, where it is now being operated by the University

College authorities at those places. The Canadian authorities have installed new stations at Fort Chimo, Resolute Bay and Baker Lake; and South Africa has assisted the Belgian Congo authorities to build a station at Leopoldville. The Australian Radio Research Board responded very actively to the recommendation that a chain of ionospheric observatories should be operated in the vicinity of longitude 150° E. by setting up recorders at Hobart, Canberra, Brisbane and Townsville. Furthermore, a station has been set up at Macquarie Island which should be of great assistance in the study of ionospheric conditions in antarctic regions. In India, ionospheric recorders of various types have been installed at Delhi, Calcutta, Ahmadabad and Kodaikanal.

Research on the absorption of radio waves travelling through the ionosphere is being actively pursued in the United Kingdom and in Australia, Canada and India; and the results are used, with other ionospheric information, in a comparison of radio transmission forecasts with practical results. Investigations are also in progress in most Commonwealth countries with the view of improving the forecasting of ionospheric storms, which on occasions cause serious interruption of practical radio services, including communication and broadcasting.

For several years past, measurements of the atmospheric radio noise-level prevailing at frequencies of 2–20 Mc./s. have been made by a subjective method at some twelve stations in various countries; and development work is in hand to extend this investigation to frequencies of 15–500 kc./s. in order to provide more direct information on the performance of low-frequency radio aids to navigation. Fundamental investigations on atmospheric disturbances, including in some cases a detailed study of waveforms, are in progress in the United Kingdom, India and South Africa. A recommendation was made at the Sydney meeting that the high-frequency noise-measuring equipments in Australia and New Zealand should be put into operation again as soon as possible, since continuity of the study of atmospheric noise for several years all over the world is essential for the ultimate improvement of the efficiency of operation of all radio services.

Following a recommendation made at the London meeting in 1948, the New Zealand authorities have been able to initiate in the southern hemisphere the study of meteors by radio methods, as a field of research complementary to that pursued in the United Kingdom. The collaboration between the two countries has been very effective, and it is now recommended that the work in New Zealand should be continued and extended so far as practicable.

The extremely short-wave portion of the radio spectrum is likely to be of very great importance to the future of radio services of all types. With this in mind, a strong recommendation was made at the Sydney meeting that research on tropospheric wave propagation should be vigorously pursued in all countries in order to improve our knowledge of the influence of different climatic conditions on the possible correlation between radio propagation and meteorological conditions. A considerable amount of investigation work in this field has been conducted during recent years in New Zealand, and in the United Kingdom; but there is a need for a continued study of the effects experienced under different conditions and at various frequencies in order to assist those responsible for planning future radio systems and services.

The extensive research work on solar and cosmic noise, which is now embraced under the general title of 'radio astronomy' and which has been pursued in several countries, notably in Australia and the United Kingdom, is too well known to need any detailed reference here. It may be remarked, however, that the meeting in Australia of the International Scientific Radio Union provided an excellent opportunity for some of the workers in this field to meet and discuss matters of mutual interest, and particularly to compare the results of experience in the northern and southern hemispheres.

In February 1950 the United Kingdom established a limited regular service of standard-frequency transmissions from the Rugby radio station of the General Post Office, using the call-sign *MSF*. The service provides transmissions for short periods daily on frequencies of 60 kc./s. and on 5 and 10 Mc./s. These transmitted frequencies are monitored by the National Physical Laboratory, and the latter's observations show that over a period of a day the frequency remains constant to about 1 part in $10^8$, a slow drift of frequency over longer periods being corrected whenever the deviation from the nominal value approaches 2 parts in $10^8$. Apart from this service, the Union Observatory in South Africa radiates time signals, and a standard frequency transmission is made on low power from Johannesburg. The Australian authorities are also exploring the possibilities of establishing a standard-frequency service to meet local requirements in that continent.

With regard to the measurement of the electrical characteristics of the ground at radio frequencies, in Canada, South Africa and South-West Africa, surveys of conductivity by radio methods have been in progress for some years; and the All-India Radio organization is starting systematic measurements of the electrical properties of the ground throughout India. It is realized that this type of investigation should be pursued in close association with a study of the effects of the contours of the terrain on ground-wave propagation at various frequencies. It is considered, however, that the original recommendation should be retained with the view of encouraging Commonwealth radio organizations to collect all appropriate information on measurements made in their own countries, to facilitate the preparation by the United Kingdom of a survey of existing knowledge of the electrical constants of the ground at radio frequencies.

# HUMAN FACTORS IN INDUSTRY

TWO committees to work on human problems in industry have been set up jointly by the Department of Scientific and Industrial Research and the Medical Research Council, one being concerned with human factors in individual efficiency, and the other with human relations. The division of interest between the committees is broadly that the first will study the individual worker and his job, and the second such things as the relation between the manager and the worker, between the worker and his mates and between the foreman and the technical specialist.

The subjects to be considered can be listed under four headings, the first three of which are, in general, the responsibility of the committee on industrial efficiency, and the fourth is that of the committee on human relations: fitting the job to the man—work on the design of tools and working equipment to suit the man who uses them (which is getting more important as machines become more complicated), time and motion study, and the effect of factory lighting, heating and noise, etc., on performance; selection and training; assessing the job—work measurement, job appraisal, time and motion study as a means of assessing a fair day's work, etc.; human behaviour and human relations—joint consultation, attitudes to work and the structure of informal groups in the factory. For research on matters relating to occupational health, the Medical Research Council will continue to be responsible, advised by its own special committees. However, in order to secure co-operation on technical aspects, the Department of Scientific and Industrial Research will be asked to appoint assessors to these committees where appropriate; for example, the elimination of dust from factories, although primarily a medical problem, may bring in the Department or the research associations to develop means of combating dust.

The scientific study of the human factors in industry is not, of course, a new venture: notable contributions have come in the past from the researches of the Medical Research Council's Industrial Health Research Board on, for example, how hours of work affect output and health, the influence of environmental factors such as lighting and heating, and the effects of incentives; and the Panel on Human Factors of the post-war Committee on Industrial Productivity has also done important work, including an investigation of the foreman in British industry. However, the need for much more of this kind of research is realized, and the aim of the two new committees will be to develop knowledge which can be used to make definite recommendations, the underlying object being to improve industrial production in Great Britain. For this reason, the committees include persons from industry, trades unions and universities.

*Committee on Individual Efficiency in Industry.* The terms of reference of this committee are: "(1) To keep under review the progress of knowledge bearing on the technical efficiency of the individual in industry. (2) To advise on general policy in research, including applied research and field study. (3) To call attention to gaps, and make recommendations for filling them. (4) To consider and report from time to time on the requirements for the training of research workers and technologists in this field". Its members are as follows: Sir Frederic Bartlett (*chairman*) (formerly professor of experimental psychology, University of Cambridge), W. V. Beard (general secretary, United Patternmakers' Association), J. O. Blair-Cunynghame (chief personnel officer, British Overseas Airways Corporation), Prof. J. V. Connolly (Department of Aircraft Economics and Production, College of Aeronautics, Cranfield, Beds), J. Crawford (general president, National Union of Boot and Shoe Operatives; member of the Advisory Council, Department of Scientific and Industrial Research), Prof. J. Drever (Department of Psychology, University of Edinburgh), Dr. C. B. Frisby (director, National Institute of Industrial Psychology, London), L. V. Green (head of the Personnel Research Department, Dunlop Rubber Co., Ltd.), Prof. Esther M. Killick (Department of Physiology, Royal Free Hospital School of Medicine, London), Prof. W. E. Le Gros Clark (Department of Human Anatomy, University of Oxford), N. G. McCulloch (deputy chairman, Calico Printers' Association, Ltd.; chairman, Council of the British Cotton Industry Research Association), Prof. R. W. Russell (Department of Psychology, University College, London), Miss Nora Wynne (director, Carr's Biscuits, Ltd.), and an assessor from the Ministry of Labour and National Service. The joint secretaries are Dr. B. S. Lush (for the Medical Research Council) and Winston Rodgers (for the Department of Scientific and Industrial Research).

*Committee on Human Relations in Industry.* The terms of reference of the committee are: "To examine current activities concerning the study of human relations in industry and to call attention to problems of special timeliness or promise on which research, including applied research and field study, might be undertaken or supported by the Department of Scientific and Industrial Research, the Medical Research Council, or other bodies". Its members are as follows: A. B. Waring (*chairman*) (chairman and managing director, Joseph Lucas Industries, Ltd.), J. Foster Beaver (chairman, Beaver and Company (Bingley), Ltd.), J. O. Blair-Cunynghame (chief personnel officer, British Overseas Airways Corporation), A. D. Bonham-Carter (head of the Personnel Division, Unilever, Ltd.), Prof. T. Ferguson (Department of Public Health, University of Glasgow), E. Fletcher (member of the Advisory Council, Department of Scientific and Industrial Research; head of the Productivity Department, Trades Union Congress), Miss Beryl Foyle (joint managing director, Boxfoldia, Ltd.), Prof. A. J. Lewis (Institute of Psychiatry, University of London; and member of Medical Research Council), Prof. R. W. Russell (Department of Psychology, University College, London), Miss B. N. Seear (Department of Social Science, London School of Economics), Prof. T. S. Simey (Department of Social Science, University of Liverpool), W. R. Verdon Smith (managing director, Bristol Aeroplane Co., Ltd.), T. Williamson (General Council, Trades Union Congress), Dr. A. T. M. Wilson (director, Tavistock Institute of Human Relations), and an assessor from the Ministry of Labour and National Service. The joint secretaries are J. R. Gass (for the Department of Scientific and Industrial Research) and Dr. B. S. Lush (for the Medical Research Council).

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# TEACHING OF NATURAL SCIENCE IN SECONDARY SCHOOLS

In view of the pressing needs for a more thorough and efficient teaching of science, a comparison and free flow of ideas between teachers, of all nations, of this subject would be useful. A number of accounts of different aspects of comparative education have been published by the United Nations Educational, Scientific and Cultural Organization, and a recent volume, "The Teaching of Natural Science in Secondary Schools"*, is compiled from information supplied to the International Bureau of Education, Geneva, by the ministries of education of all countries, apart from the U.S.S.R. and its satellite States. This is a valuable piece of work, and such efforts are to be encouraged; but it suffers from undue compression, as well as vagueness and scrappiness of treatment at times. Sometimes it gives a statement of intentions and ideals rather than of achievements; some of the accounts of science-teaching are clearly derived from those of other nations, and at times we do not get a clear idea of what is meant by secondary education. The vagueness of the official statement which does not want to commit itself to well-defined terms seems to be common to many countries. An example of this (which could be multiplied many times throughout the book) taken from the United Kingdom (England and Wales) Section will show the difficulties of the compiler: "Natural Science teaching is sometimes optional. It is left to the discretion of the individual school. The same importance is given to Natural Science in comparison with other subjects in promotion examinations and the Secondary School leaving examination".

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* Unesco: International Bureau of Education. Publication No. 139: XVth International Conference on Public Education, convened by Unesco and the I.B.E., Geneva, 1952. Teaching of Natural Science in Secondary Schools. Pp. 216. (Paris: Unesco. Geneva: I.B.E. London: H.M.S.O., 1952.) 5 Swiss francs or 8s. 6d.

The book is a sequel to an "Introduction to Natural Science in Primary Schools", prepared by the International Bureau of Education for the Twelfth International Conference on Public Education, held in 1949. The teaching of physics and chemistry is reserved for a later inquiry, and so the present work is confined to biology and its branches, physiology and anatomy, geology and mineralogy. To take away physics and chemistry from a report on science teaching would seem to be unfortunate. A definition of natural science which purposely excludes the fundamental studies of the physical sciences is unwise, and in any event they are not excluded in the reports which are sent in by some of the ministries. The information was given under a number of headings: the place of natural science in the curriculum, the aims of natural science teaching, syllabuses, teaching methods (including visual aids and text-books), teaching staff and future intentions. It is impossible to summarize further the results of the inquiry as they are set forth in the general survey in the early part of the book; but much of the information sent from forty-eight countries would have been grasped more readily had it been set out in tabulated form. It is evident that the countries concerned are unanimous in wishing to make natural science teaching more experimental and to bring it into closer touch with life, and that there is an increasing emphasis on the biological aspects of the subject. Science teaching in nearly all countries is related to human needs—individual, national and social. Some countries, including Germany, stress the ethical and philosophical aspects of science, its disciplines and opportunities for patience and criticism; the United Kingdom mentions its interest and hobby values; other countries indicate its relation to geography and its value as a means to a better understanding and use of the natural resources of the country.

The account of science teaching in England and Wales is disappointing, and does not do justice to work which is being carried on. To a foreign reader it must seem unimpressive. A clear statement should have been given of the division of secondary education in Britain, since the 1944 Act, into 'grammar', 'technical' and 'modern'. The report is chiefly concerned with modern schools (the old 'central schools'); grammar schools are only mentioned in passing, and secondary technical schools not at all. Although it is important that all citizens should leave school with some knowledge of biology, particularly in regard to the nature and needs of mankind, the fact remains that in Britain it is the grammar and public schools to which we must look for the type of science teaching which in the end produces scientists and technologists. The national and international value of the science teaching in these schools from 1902 until 1944 cannot be over-estimated. The need of the future for the type of scientific worker who comes from these schools is greater than ever before; indeed, there will be no future for Britain unless its life is sustained by an increasing number of workers thoroughly trained in the skills and disciplines of science. With the best will in the world, the modern schools do not meet these needs, in spite of the fact that they cater for the majority of children. Some of them do not teach science, many of them have no adequate course for the important age-group of 14–15 years, and, in spite of the optimistic Ministry of Education booklets mentioned in the report under review, some of these schools have not yet given adequate thought to their schemes of work. So far as the scientific life of the nation was concerned, the grammar and public schools laid the golden eggs; but they have been inhibited in their work by factors which could have been foreseen in 1945. No science graduate with a good honours degree needs to consider teaching as a career unless he has strong vocational leanings. Recruitment for the science staffs of grammar schools is suffering in both the quantity and quality of applicants to fill the vacancies. This has its repercussions on the attainments of students reaching the universities and on their subsequent value to society. Nor is this improved by feeble official attempts to assure us that the position is not unsatisfactory.

The document makes no attempt at appraisal of the various aims and methods, nor does it stress particularly good or original points where they appear. It will be of more interest to the student of comparative education than to the practical science teacher, who will find that it does not touch the fringe of most of the matters so admirably dealt with in the report on the "Teaching of General Science", prepared by the Science Masters' Association in 1950.

W. L. SUMNER

# SOCIAL ANTHROPOLOGICAL STUDIES OF LATIN AMERICA

THROUGHOUT Latin America there is a desire to improve conditions and to overcome difficulties which hinder national development, the greatest being the low estate of the Indian. In order to do this the first necessity is adequate information about things as they are, and the Institute of Social Anthropology of the Smithsonian Institution is helping to provide it by publishing a series of descriptive studies, of which Nos. 10–14 have been published during the past two years or more*. The policy of the Institute is to co-operate wherever possible with the various national organizations, and the present series owes much to students of the Mexican Escuela

* Smithsonian Institution: Institute of Social Anthropology. Publication No. 10: Nomads of the Long Bow; the Siriono of Eastern Bolivia. By Allan R. Holmberg. Pp. iv+104+7 plates. 65 cents. Publication No. 11: Quiroga, a Mexican Municipio. By Donald D. Brand, assisted by José Corona Núñez. Pp. v+242+35 plates. 1·75 dollars. Publication No. 12: Cruz das Almas, a Brazilian Village. By Donald Pierson and others. Pp. x+226+20 plates. Publication No. 13: The Tajin Totonac, Part 1, History, Subsistence, Shelter and Technology. By Isabel Kelly and Angel Palerm. Pp. xiv+369+33 plates. 2·75 dollars. Publication No. 14: The Indian Caste of Peru, 1795–1940: a Population Study based upon Tax Records and Census Reports. By George Kubler. Pp. vi+71+2 plates. 75 cents. (Washington, D.C.: Government Printing Office, 1950–1952.)

Nacional de Antropología e Historia, the Brazilian Escola Livre de Sociologia e Política of São Paulo, and the Peruvian Instituto de Estudios Etnológicos.

The author of No. 10 spent about eighteen months studying the unacculturated remnants of the Siriono, a very primitive naked tribe living in the tropical forests of Eastern Bolivia. For a third of this time he and a Bolivian companion lived alone with a small group. Conditions were very difficult, and his time was cut short by the entry of the United States into the Second World War in 1942, so he is not satisfied that he really understood the Siriono; but he collected a lot of information about their material culture, activities, beliefs and social organization, which is set forth in a good straightforward description. In the final chapter, he analyses their culture in terms of "drives", of which the chief is hunger.

No. 11, dealing with a municipality of mixed white, mestizo and Tarascan Indian population near Lake Pátzcuaro in Michoacan, Mexico, is by a human geographer. It is a detailed and interesting description of selected aspects of life in Quiroga, with emphasis on land settlement, government and economy, little attention being paid to sociology because a colleague was studying it in a neighbouring town (No. 6 of the series). The area is well known to ethnologists from the survival of primitive methods of hunting birds on the lake, and is at present the scene of a Unesco welfare project.

A detailed account is given in No. 12 of a village near São Paulo, to which the imaginary name of Cruz das Almas was given to preserve anonymity. It was picked out as a typical Brazilian rural community of mixed European, Indian and African descent, depending mainly on agriculture. It proved to be homogeneous and stable, with no very striking features and practically no vestiges of aboriginal Indian culture.

By contrast, No. 13 deals with the district around Tajin, a Mexican area of great historical and archæological interest, with a rich material culture about which it is a mine of useful information. The population is Totonac, and their culture is a living one compounded from old and new elements. The historical background is particularly necessary to its understanding, and a good deal of the report is devoted to this, Isabel Kelly, as an archæologist, being well qualified to deal with it. This first part, covering history, subsistence, shelter and technology, makes a substantial volume; and clothing, with several other aspects of material culture, together with what is described as non-material culture, will form Part 2.

No. 14, "The Indian Caste of Peru, 1795–1940", is a product of Dr. George Kubler's researches among the official archives of Peru while working in Lima during 1948–49. Although the word 'caste' is used in the title in association with the Indians, the Spanish word *casta* was generally used in Peru to refer to mestizos, albeit rather loosely as the author explains in detail. The work is a study of the variations in the percentage of Indians in the total population since just before the Independence. It seems that the Indian proportion rose during the first few years of the period studied, thus reversing a trend that had existed since the Spanish conquest, but that the fall afterwards continued, so that Indians now form about 40 per cent of the population. The problem is much complicated by the difficulty of defining an Indian, since the definition depends not wholly on biological factors but very considerably on social ones also.

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# ACCELERATING EFFECT OF AN EXTRACT OF VERNALIZED EMBRYOS OF WINTER RYE ON FLOWER INITIATION IN UNVERNALIZED EMBRYOS

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THE theory that flowering requires the presence of some specific flower-forming substance is rejected by some writers on the grounds that the application to uninduced plants of extracts of induced plants has not led to flowering or at best given inconclusive results. This argument is not, however, valid, since the active materials, which are known to move about in the plant and to pass a graft union, may well be inactive in a plant extract. Possible causes of failure are manifold: the solvent may fail to extract the substance, or may inactivate it; it may not be absorbed by the test plant in sufficient quantity to produce a determinable effect, or it may only be active in association with the living protoplasm.

Small effects of plant extracts have been reported from time to time. Bonner and Bonner[1] induced flowering in *Xanthium* by applying an aqueous extract of the stem apex of *Washingtonia robusta*. Loehwing[2] and Behrens[3] report activity of extracts of *Zea mays* and *Sempervivum*, respectively. Sironval[4] obtained an oil from leaves of induced strawberry plants which, applied to leaves of young plants, led to normal flowering in a proportion of the plants treated, while the control plants produced rather fewer inflorescences and no fully developed flowers. Roberts[5] found that extracts of various plants in a flowering condition had a slight inductive effect on *Xanthium*. On the other hand, Melchers and Lang[6] report that careful experiment has failed to extract any florigenic substance.

In these examples the extracted plants were brought into the flowering condition by photoperiodic treatment. It therefore seemed necessary to determine if extracts of vernalized grain could confer the vernalized condition on plants which had not received this treatment. In 1951, embryos were removed from rye grain which had been vernalized for ten weeks, and were extracted with water, chloroform, ethyl alcohol or ether. The extracts, after removal of the solvents, were added to a sucrose agar medium[7]. Unvernalized embryos were excised and grown for six days on this medium, at a concentration which presented to each test embryo the extract of ten vernalized embryos. A control series was germinated on medium without extract. The seedlings were planted out in sand culture.

The results of this experiment are given in Table 1. Unfortunately a single plant in the control series flowered in 118 days: such early flowering had not been encountered in unvernalized plants grown from excised embryos, though it is fairly frequent when intact unvernalized grain is used. In the table it will be seen that despite the inclusion of this obviously aberrant plant the 'score', that is, progress to flowering[8], of the control series is more than six points below that of the series treated with chloroform

Table 1. EFFECT OF EXTRACTS OF VERNALIZED EMBRYOS ON PLANTS GROWN FROM UNVERNALIZED EMBRYO 'SCORES'

| No extract | | Extracts of vernalized embryos in various solvents | | | |
|---|---|---|---|---|---|
| Whole grain | Excised embryos | Water | Chloroform | Ether | Alcohol |
| (20)<br>27±2·0 | (14)<br>22±3·6 (*a*) | (13)<br>24±3·1 | (13)<br>29±2·2 | (10)<br>19±1·4 | (9)<br>20±2·4 |
| | (13)<br>19±1·6 (*b*) | | | | |

Differences: No extract (*a*) and chloroform, 6·4 ± 4·3; no extract (*b*) and chloroform, 9·6 ± 2·8; no extract (*b*) and water, 5·4 ± 3·5. Control including one aberrant plant (*a*); control excluding this plant (*b*). Number of replicates in brackets

extract, which equals that of the intact grain series. This difference is not significant, but by omitting the aberrant plant (second row in Table 1) a highly significant difference is shown. The use of extracts in water, ethyl alcohol and ether produced negligible differences in flowering behaviour.

This result was inconclusive, but indicated the need for further investigation; the experiment was therefore repeated in 1952, using only chloroform as solvent. To ensure contact between the roots of the test embryos and the extract, the fatty material was deposited on fine angular sand while the chloroform was being removed by evaporation under reduced pressure. A fixed volume of the sand holding the amount of extract required was moistened with sterile water and added to the surface of the agar slopes on which the test embryos were grown. Care was taken to avoid fungal contamination, which occurred in less than 1 per cent of the cultures. After six days at 15° C. the embryos were planted out in sand culture. The 'scores' are given in Table 2: the concentration of the extracts is given in terms of the number of vernalized embryos in the extract presented to each test embryo. As additional control a series with extract of unvernalized embryos was added.

Table 2

| | Extract from varying numbers of vernalized embryos | | | | Extract from unvernalized embryos |
|---|---|---|---|---|---|
| | 10 | 4 | 2 | 0 | 10 |
| Excised embryos | (18)<br>29±1·8 | (15)<br>21±1·9 | (21)<br>24±1·7 | (21)<br>24±1·7 | (14)<br>22±2·0 |
| Whole grain | (24)<br>28±1·5 | | | (23)<br>20±1·5 | |

Differences: Extracts from vernalized and unvernalized embryos, 6·9 ± 2·7; extracts from vernalized embryos and no extract, 5·3 ± 2·4; extracts from 10 and 2 embryos, 5·6 ± 2·4. Number of replicates in brackets

Here the effect of using *vernalised* embryos for the extract is highly significant, and the possible effect of the chloroform or of the other normal constituent of the embryos is eliminated. Lower concentrations were without effect. The acceleration of flowering is small and not commensurate with the amount of vernalized material put into each culture. The effect on the unvernalized embryos is, however, equivalent to that of nearly three weeks of vernalization. This may be due to the limitations of the extraction technique enumerated above, or it may be that the active substance is not identical with that produced by the complete vernalization reaction. It would be premature to speculate on this result in terms of the substances postulated in our hypothetical scheme for the vernalization reaction[8].

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# CHEMICAL DOSIMETRY AT HIGH DOSE-RATES

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CHEMICAL methods for the measurement of dosage of ionizing radiation have lately assumed increasing importance, and are now in wide use, particularly in studies of the radiation chemistry of aqueous media[1]. There has, however, been some doubt as to whether the methods so far proposed can be used successfully at high dose-rates of X- or γ-radiation such as are encountered, for example, close to kilocurie sources of γ-emitters.

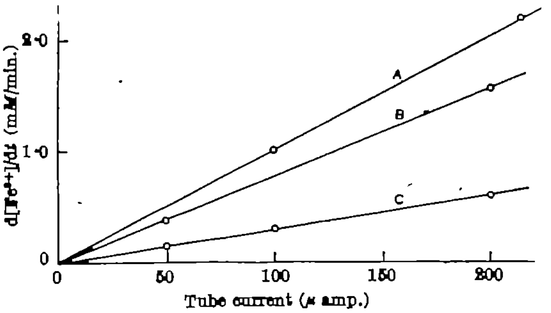
The method of radiation actinometry in most favour at present, the oxidation of ferrous ions in 0·8 *N* sulphuric acid solution, suffers from the disadvantage that the solution must remain effectively oxygen-saturated at all times for reproducible results to be secured, while the oxygen originally present in a solution in equilibrium with the atmosphere at room temperature is used up after a dose of about 50,000 r. has been administered[2]. At the dose-rates envisaged, this will happen in a matter of seconds. Moreover, at these high dose-rates there will not be time for the oxygen concentration within a solution to equalize itself by diffusion processes, so that if the release of energy within a given volume of solution is inhomogeneous, the elements of volume receiving the highest dose-rates will become deaerated before the remainder, with a consequent lowering of the overall yield before the solution as a whole has received an integral dose of 50,000 r.

These considerations have carefully to be borne in mind in any extension of the existing work on ferrous sulphate actinometry to high dose-rates, and it is apparent that in such studies means must be provided for starting and stopping the radiation virtually instantaneously, so that irradiation times of the order of seconds can be accurately measured.

Such facilities were recently made available to me by the Radiation Chemistry Group at the Atomic Energy Research Establishment, Harwell. Mr. John Milne, of this Group, designed and installed a magnetically operated device within the extension to the accelerator tube of the 2-million volt Van de Graaff generator, whereby a water-filled cell 9/16 in. deep, through which water was allowed to flow continuously, having a 1/16-in. aluminium window facing the electron beam, could be put into or withdrawn from the beam at a position 35 in. above the normal 1-mm. gold target by means of a switch operated at the control desk. The insertion of this cell cut down the X-ray intensity at the irradiation position just below the normal target by a factor of approximately 300.

By means of an auxiliary electric circuit, the beam current could be measured while the beam was impinging on the water target, and then adjusted to the desired value before the irradiation commenced. Corrections for the dose received during the preliminary build-up of tube current and voltage were made when necessary, but amounted to only about 1·5 per cent for an irradiation time of 15 sec.

Using this device, with irradiation times down to 10 sec., I have been able to show that the yield for the oxidation of ferrous ions in aerated 0·8 *N* sulphuric acid solution is independent of dose-rate up to the highest dose-rate obtainable from the machine, namely, approximately 100,000 r./min. The basis of the method is to study the rate of oxidation of ferrous ions in a 'Pyrex' cell of 2·8 cm. internal diameter and 8 mm. depth, totally filled with solution, as a function of the tube current in the machine at constant voltage. The dose-rate obtained from the machine was found, using a Baldwin 'Ionex' meter along the axis of the X-ray field, to be strictly proportionate to the tube current at constant voltage, while lateral surveys of the beam with the same meter showed that the geometrical distribution of dose-rate within the beam was not appreciably different at widely differing tube currents. The existence of a strictly linear relationship between the rate of oxidation of ferrous ions and the tube current was established at voltages of 1·5, 2·0 and 2·25 MV. (see graph), and with tube currents of 5–200 μ amp. Each of the points in the graph represents the average value obtained from at least four separate irradiations carried out under each set of conditions. At a tube current of 5 μ amp. and a voltage of 1·5 MV., the average dose-rate in this system corresponded to about 800 r./min.



Initial rate of increase of ferric ion concentration in aerated 0·8 *N* sulphuric acid solution as a function of the tube current in the Van de Graaff generator when run at 2·25 MV. (curve *A*), 2·0 MV. (curve *B*), and 1·5 MV. (curve *C*)

Similar studies have now been made by Ebert[3], using electron beams from the Van de Graaff generator at the Radiotherapeutic Research Centre, Hammersmith Hospital, London, who has found the initial yield for ferric ion production unaffected by dose-rate up to 3 million rep./min.; while Allen[4] reported similar results in the region 100–10,000 r./min. using X-ray beams from the 2-MV. generator at the Brookhaven Laboratory, New York.

In order to provide a further check on the absolute chemical yield at 800 r./min., experiments similar to those carried out previously[1] using the same machine were conducted. In these a cylindrical 'Perspex' irradiation cell of internal dimensions 30 mm. diameter and 3 mm. thickness, and 'Perspex' front wall thickness 6·4 mm., which could be regarded as effectively water-wall, was fixed at a position 18·5 cm. below the target, where the release of energy varied by no more than 8 per cent at all positions within the irradiated solution. The chemical change was compared with the integral dose within the solution by measuring the local dose-rate at many positions within the irradiated volume and carrying out appropriate integrations. As the Baldwin 'Ionex' meter used had been calibrated against an N.P.L.-standardized chamber to within ± 3 per cent, it was felt that this method was as accurate as any available. To ensure the presence during the ionization measurements of an electron atmosphere closely similar to that prevailing within the solution during the irradiations, the 'Ionex' meter was placed behind a 'Perspex' sheet of 6·4 mm. thickness; and the necessary small correction (< 0·3 per cent) for the absorption of the primary radiation within the solution was made using further data acquired with 'Perspex' absorbers of thickness from 3 to 13 mm. A value of the quantity *G* (ferric ions produced per 100 eV. expended in the solution) of 20·3 ± 1·0 was obtained, in further confirmation of my earlier work[1,2] and that of Hardwick[5], and Rigg, Stein and Weiss[6]. Values close to this have since been obtained by Ebert and Boag[3], and by Magat and Shapiro[7], and a figure of about 20 is now favoured by a great preponderance of evidence over that of 15·5 ± 0·3 obtained by Hochanadel and Ghormley[8]. The evident, if somewhat surprising, absence of any effect of dose-rate, or of any other source of irreproducibility so far detected in the system[1], signifies that the conditions were comparable in the various cases, and the reason for this discrepancy has still not come to light.

Similar studies were made using ceric sulphate solutions, which have the advantage of giving a yield independent of oxygen concentration[9], and the absolute *G* value for this reaction was estimated, by comparison with that for ferrous oxidation, as 3·0 at 59,500 r./min., in fair agreement with the figures of Hardwick[5] (3·2) and Milling, Stein and Weiss[10] (3·6), obtained at lower dose-rates. I am not entirely satisfied, however, as to the reproducibility of the behaviour of this system, as stated in an earlier publication[1]. Direct spectrophotometric analysis was used for both ferric and ceric ions, corrections being made for the variation of the extinction coefficient of ferric ion with temperature. The conditions for preparation of the solutions were identical with those described in my previous publications[1,2], with the exception that the water used was triply-distilled in an all-silica system.

Whereas the production of cerous ion was found to be proportional to dose up to 300,000 r. at 59,500 r./min., studies of ferrous oxidation at a dose-rate of 71,500 r./min. showed that the break in the oxidation – time plot at the point of oxygen depletion, which is normally observed to be sharp at low dose-rates[2], had become diffuse, signifying that conditions such as those described in the second paragraph of this communication had become operative. These conditions may partly explain the anomalously low yield obtained by me[2] and by Hardwick[11] using a General Electric 2-million volt X-ray unit; but doubtless the pulsed nature of the radiation in this case must, as Hardwick points out[11], also be taken into account.

Summarizing, it appears probable that chemical methods of dosimetry may be used for measuring continuous fluxes of X- or γ-rays up to the highest dose-rates at present envisaged.

Further experimental details of this work are included in an unclassified report from the Atomic Energy Research Establishment now in the press.

I am indebted to the Ministry of Supply for the tenure of a consultancy during which this work was carried out, to Dr. W. Wild and the members of the Radiation Chemistry Group at the Atomic Energy Research Establishment, Harwell, for the hospitality of their laboratories, and to Dr. F. T. Farmer and Mr. M. J. Day for a useful discussion on the accuracy of the physical measurements. Permission by Sir John Cockcroft to publish this communication is gratefully acknowledged. [Nov. 21.

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# REDUCTION OF FERRIC ION IN AQUEOUS SOLUTION BY γ-RADIATION

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ALTHOUGH the oxidation of dilute aqueous solutions of ferrous ion by ionizing radiation is a well-established fact, there is still some doubt concerning the reduction of ferric ion[1]. We have found that at sufficiently low acidities reduction may be effected[2], and that a steady state is set up with respect to ferrous and ferric ions if one irradiates either ferrous or ferric solutions, the position of the steady state depending upon the *p*H in sulphuric acid solutions[3]. Since publication of the latter work, further irradiations, particularly of ferric solutions, confirm this view, and in addition indicate that the initial reduction yield at low acidity is quite high.

Cobalt γ-radiation was employed under conditions similar to those previously described[3]. In addition to analysis of ferrous ion as the *o*-phenanthroline complex, direct estimation of ferric ion by its absorption at 304 mμ has also been employed in some cases; the two methods gave identical results. In order to avoid errors due to post-irradiation reactions arising from the slowness of the ferrous ion plus hydrogen peroxide reaction at low ferrous concentrations, all solutions were stood at room temperature for at least one hour between irradiation and analysis. The time of standing was varied up to six hours without any change in ferrous or ferric concentration greater than that found after one hour, and irradiations were carried out in a completely random order; the fact that the curves obtained still showed that a state is ultimately reached where no further oxidation or reduction can be detected appears to indicate that a true steady state is attained. The irradiation of solutions of *p*H > 2·5 presents some difficulty, since the second hydrolysis of ferric ion to $Fe(OH)_2^+$ becomes appreciable; this frequently leads to loss of ferric ion from solution, either by precipitation on the walls as $Fe(OH)_3$ or by formation of colloidal solutions. This leads to a depletion in strength of the original ferric solutions, and sometimes of the solutions of both ions formed on oxidation. In general, we have found it possible to carry out the oxidation of ferrous solutions up to *p*H 3·8 without serious difficulty; but in the case of ferric solutions above *p*H 2·5 frequent difficulties arise. All runs in which formation of $Fe(OH)_3$ had obviously occurred, or where ferrous solutions of low acidity had undergone aerobic oxidation, were rejected. Ferric solutions were prepared by oxidizing a ferrous solution with a slight excess of hydrogen peroxide, after which the excess peroxide was destroyed by boiling and the solution suitably diluted.

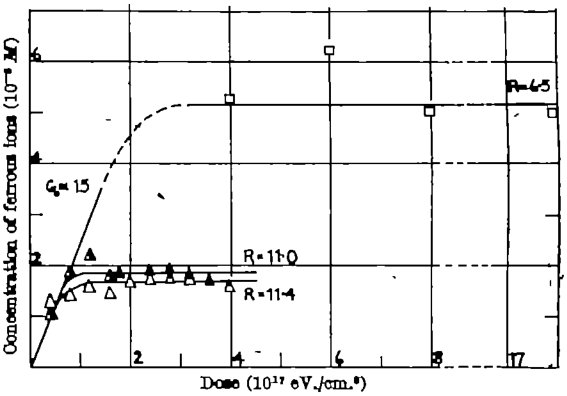


Fig. 1. Irradiation of ferric solutions in sulphuric acid in the presence of air, *p*H 2·46. □, $[Fe^{3+}]_0$ = 3·86 × $10^{-4}$ *M*; ▲, $[Fe^{3+}]_0$ = 2·11 × $10^{-4}$ *M*; Δ, $[Fe^{3+}]_0$ = 2·23 × $10^{-4}$ *M*

Fig. 1 shows the results obtained on irradiating three different ferric solutions in sulphuric acid, in the presence of air, at *p*H 2·46; the horizontal scale has been broken above 8 × $10^{17}$ eV./cm.$^3$ in order to conserve space. Reduction occurs, with an initial yield (ions reduced per 100 eV.) of approximately 15; a steady state is set up with the values of *R* (ratio of ferric ion to ferrous ion) given on the curves. Fig. 2 shows the result of irradiating a solution containing approximately equal proportions of ferrous and ferric ions at the same *p*H. Oxidation occurs initially, and a steady state is attained when approximately 77 per cent of the total iron is in the ferric state.

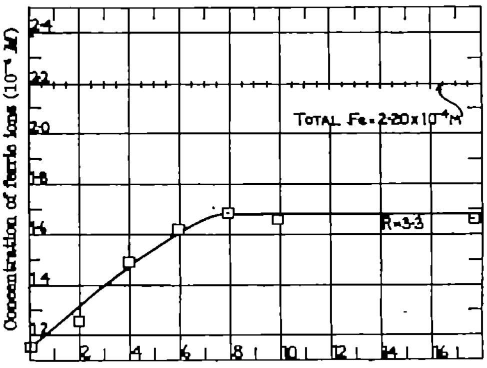


Fig. 2. Irradiation of solution containing both ferrous and ferric ions in sulphuric acid in the presence of air, *p*H 2·47. $[Fe^{3+}]_0$ = 1·05 × $10^{-4}$ *M*; $[Fe^{2+}]_0$ = 1·15 × $10^{-4}$ *M*

The initial reduction yield at this $p$H is comparable with the initial oxidation yield ($G_0 \sim 17$[3]), but its measurement presents some difficulty, owing to the fact that the steady state is soon attained. With higher total iron concentrations the difficulties attendant upon hydrolysis are greater, but more precision should be attainable at a suitably lower dose-rate. The reduction of ferric ion in oxygen-free and in hydrogen-saturated solutions has been reported by Weiss and his co-workers[4], the yield increasing with increasing $p$H and being much greater in the case of hydrogen-saturated solutions. These yields were obtained at constant dose, and not from the initial slopes of reduction curves; a rough calculation based on the dose and concentration which they quote suggests that these single points probably correspond to steady-state values, so that their yields may be low. Haissinsky *et al.*[5] quote a value of $G_2 = 0{\cdot}07$ for the reduction by X-rays in $0{\cdot}8\ N$ sulphuric acid, but this is probably within the limits of experimental error; under these conditions the steady state corresponds to complete oxidation, or nearly so, and would be attained very rapidly on reduction.

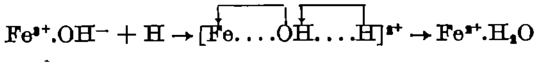
In the ferrous–ferric system under the above conditions of $p$H, oxidation may be effected by hydroxyl radicals, hydroperoxide radicals ($HO_2$) and hydrogen peroxide, and reduction by hydrogen atoms and by $O_2^-$ ions; the $HO_2$—$O_2^-$ couple is expected to play an important part in the balance between oxidation and reduction[3,6,7], and the hydrolysis of ferric ion to $FeOH^{2+}$ must also be considered. Baxendale *et al.*[8] have given evidence to support the view that the $p$H-dependence in the $Fe^{2+} + H_2O_2$ reaction arises from a combination of the dissociation of hydroperoxide radicals with hydrolysis of ferric ions. In the irradiation reaction a further consequence of the hydrolysis is possible, namely, that the hydrogen atom reduction of ferric species may be more effective for the hydrolysed ions than for the aquo-ferric ion (or the sulphate complexes in strong solutions of sulphuric acid). Both the reactions:

$$Fe^{3+}_{aq.} + H_{aq} \rightarrow Fe^{2+}_{aq.} + H^+_{aq.} \qquad (1)$$

and

$$\left.\begin{array}{l} FeOH^{2+}_{aq} \\ Fe^{3+}.OH^-_{aq} \end{array}\right\} + H_{aq.} \rightarrow Fe^{2+}_{aq.} \qquad (2)$$

are quite exothermic[6], but (2) may be favoured by entropy considerations. In the first case, the completed hydration shell may act as a barrier to electron-transfer between the hydrogen atom and the central ion, whereas in (2) the reaction may effectively occur at the boundary of the shell, resulting in completion of the shell and attainment of a much more symmetrical configuration. The transfer of electrons between ferrous and ferric ions through the outer electronic orbits of hydroxyl ions has been postulated to explain the colours obtained when ferrous hydroxide precipitates are oxidized in air[9], and it is possible that a similar mechanism operates in (2) above to produce a net electron transfer from hydrogen to ferric ions. The calculation of the energetics of this step is made difficult by the fact that the reaction is assumed to occur within the complex, whereas most of the measured and calculated heats and entropies refer to the separation of the complexing ion from the central ion. The process may be written schematically as follows:



$$Fe^{3+}.OH^- + H \rightarrow [Fe\ldots OH\ldots H]^{2+} \rightarrow Fe^{2+}.H_2O \quad (2a)$$

in which the other five co-ordinated water molecules are omitted, and the arrows indicate the direction of electron-flow.

Such a process may readily be envisaged in the absence of dissolved oxygen, and is, in fact, formally analogous to the back-reaction in the photo-induced reduction of water by ferrous ion[10]. It is usually assumed that, in the presence of oxygen, all the hydrogen atoms are removed by reaction (3):

$$H + O_2 \rightarrow HO_2. \qquad (3)$$

This appears to be beyond doubt at acidities greater than $0{\cdot}1\ N$, where the change from the oxygenated yield to the oxygen-free yield occurs at a point corresponding to the stoichiometry $\Delta[Fe^{2+}] = 4[O_2]$, without appreciable production of hydrogen. Although it is thus clear that (1) is negligible compared with (3), there is no evidence to suggest that similar considerations apply to (2) and (3) at higher $p$H. Owing to the more complex nature of the oxidation curve at higher $p$H, and to the changing value of the ratio of oxygenated to oxygen-free yield, such evidence would probably best be sought by measuring the consumption both of ferrous ions and of oxygen, as well as production of hydrogen, in an irradiation. It is suggested that, at sufficiently high $p$H, (2) may compete appreciably with (3); since the hydroperoxide radical can oxidize three ferrous ions, while $O_2^-$ reduces only one ferric ion, there will be a net gain in reduction so far as the effect of the hydrogen atoms originally formed are concerned. The decrease in initial oxidation yield in the presence of excess ferric ion at high $p$H might be due in part to (2), which would then also be partly responsible for the fall in yield as oxidation proceeds. Competition between ferric species and dissolved oxygen for hydrogen atoms would not lead to a dependence of initial oxidation yield upon initial ferrous concentration, but to an initial reduction yield dependent upon initial ferric concentration.

It will be noted that the value of the ratio of ferric to ferrous ion obtained by oxidation of a ferrous solution ($R = 3{\cdot}3$) is appreciably less than that from reduction of a corresponding ferric solution ($R = 11{\cdot}2$), and that in the latter case the value appears to vary with initial ferric concentration; we believe that these differences lie outside the limits of experimental error. An inspection of earlier results (ref. 3, Table 3) shows a similar behaviour at $p$H 2·1, although here the difference is less. This appears to indicate that the steady state obtained on reduction differs from that produced by oxidation, that is, that the ferrous–ferric couple is not thermodynamically reversible with respect to hydrogen atoms and hydroxyl radicals; this would have important consequences for the concept of equivalent reduction potential[11]. The lower value of $R$ obtained at higher initial ferric concentrations may be connected with the dependence upon concentration which would arise if reaction (2) is operative. [Aug. 20.

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## LETTERS TO THE EDITORS

*The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications*

### Origin of the Solar Corona

If the distributions of electron density and temperature in the sun's atmosphere are known, thermal emission at any frequency in the radio spectrum may be calculated. Conversely, properties of the atmosphere may be deduced from the observed thermal emission spectrum[1]. In the range above 600 Mc./s. the observed level of radiation can be correlated with visible sunspot area. Excess radiation appearing with spots has been interpreted[2] as thermal emission from very hot ($10^7$ ° K. or more) high-pressure (perhaps a hundred times that of surrounding regions) regions above the sunspots. There is optical evidence[3] of similar regions, and the good agreement between theory and radio observations lends weight to the suggestion.

If these hot regions do exist, they are a likely source of at least some of the energy needed to maintain the corona. To investigate this possibility, a statistical analysis was made of measurements of solar radio noise at frequencies between 600 Mc./s. and 9,400 Mc./s. on most days over a period of several years. The total radiation was separated into two components—one appearing with sunspots (but not necessarily disappearing with them) and a residual or basic component. The intensities of the components were then used for determining corresponding volumes of gas at suitable temperatures and pressures. The results may be summarized as follows:

(1) The sunspot component diminishes less rapidly than the dying spots, and remains more than a month after the spots have vanished. Previous observational evidence of this effect in particular cases is available.

(2) Previous determinations of the basic component are too high. They were obtained[4] by plotting daily values of radio noise against sunspot area as in Figs. 1 and 2 for 600 Mc./s. where a basic component of about $5 \times 10^5$ ° K. is indicated. The persistence of radiation, as indicated above, results in many plots of high noise and very low area; for this and other reasons the basic component found is too high. The errors are corrected and correlation improved by using rotational mean values of noise and area, reducing the value to about $2 \cdot 8 \times 10^5$ ° K. If allowance for dead spots is made, as in Fig. 3, the value falls further to $1 \cdot 7 \times 10^5$ ° K. The corresponding reductions at 1,200 Mc./s. are even larger (by factors of 2·3 and 4·7 respectively). In the investigation, arithmetic rather than graphical methods were used, and care taken to avoid errors due to the statistical processes.

This result explains the reported large fall in the basic component during 1950[5] as merely a fall in the sunspot component due to a prolonged decrease of sunspot activity.

(3) These and earlier[2] results suggest that volumes of very hot high-pressure gas appear with sunspots, mainly (perhaps entirely) near the spots, and remain after the spots have vanished, spreading and merging with the surrounding cooler gases. During the period 1947–51, these gases at all times comprised most of the corona and were formed at a rate capable of completely replacing the average (Allen – van de Hulst) corona in a few days. They are suggested as the principal source of the corona.

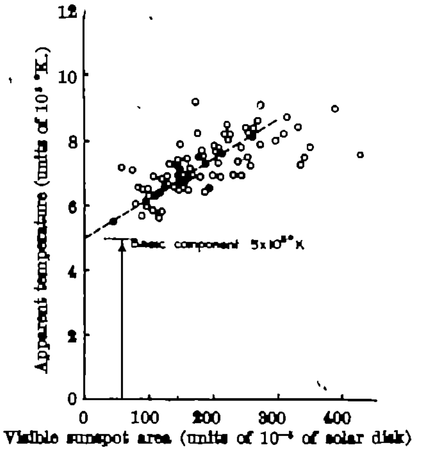

Fig. 1

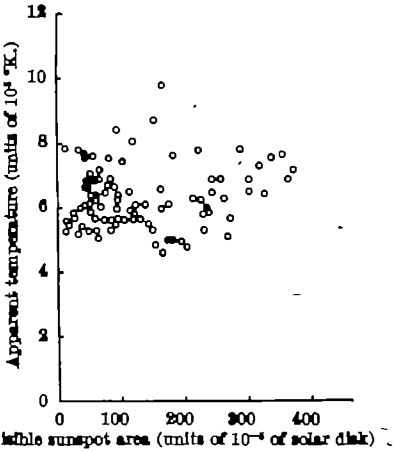

Fig. 2

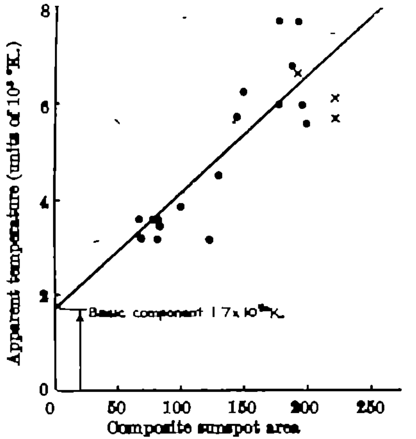

Fig. 3

Figs. 1–3. Radio noise plotted against sunspot area.
(1) Daily values for the period August–November 1947.
(2) Daily values for the period January–July 1950.
(3) Average value of radio noise for a given solar rotation plotted against a composite spot area $0 \cdot 4A_0 + 0 \cdot 3A_{-1} + 0 \cdot 2A_{-2} + 0 \cdot 1A_{-3}$, where $A_{-n}$ is the average spot area $n$ rotations earlier. The period concerned is December 1949–April 1951

It is estimated that if sunspots were entirely absent for some months and no other additional source of energy became available, the corona would diminish to one-tenth the extent, or one-third the electron density, observed during relatively quiet periods in 1948.

The results may provide a step towards an understanding of coronal heating and evidence against some existing theories, notably accretion theories[6]. Full details will be published elsewhere.

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## Distances of the Magellanic Clouds

THE distances of 26 and 23 kiloparsecs derived by Shapley[1] for the two Magellanic Clouds depend upon assuming the same absolute magnitudes for the Cepheid variables in the Clouds and in our own galaxy. The absolute magnitudes of the galactic Cepheids are still subject to considerable uncertainties, and it would be more satisfactory to use as distance-indicators the *RR* Lyræ variables (with periods less than 1 day) the absolute magnitudes of which are known more accurately and which are found in great abundance in our own galaxy. Very few such variables, however, have been found in the Small Cloud[2], and none so far has been reported in the Large Cloud.

A search for *RR* Lyræ variables in the Clouds was begun soon after the installation of the Radcliffe 74-in. reflector. *NGC* 1866, one of the largest and brightest clusters in the Large Cloud, was first selected as a region for investigation, but failed to reveal any variables of *RR* Lyræ type; instead, surprisingly enough, some classical Cepheids turned up[3]. It is now possible to report successful searches for *RR* Lyræ variables in three clusters as follows:

| (1) Cluster | (2) Region | (3) No. of variables | (4) Short period | (5) $m_{pg}$ | (6) Deduced distance (kpc.) |
|---|---|---|---|---|---|
| *NGC* 121 | Edge of Small Cloud | 4 | 3 | 18·6 | 44 |
| *NGC* 1466 | Edge of Large Cloud | 28 | 21 | 18·7 | 44 |
| *NGC* 1978 | Within Large Cloud | 4 | 2 | 18·7 | 42 |

*NGC* 121 lies within and *NGC* 1466 lies just outside the faint extension borders found by Shapley[4]. Column (3) gives the total number of variables so far found on Radcliffe plates apparently associated with these clusters; column (4) gives the number of variables so far shown to have short periods. Column (5) gives the mean apparent photographic magnitude of the stars in column (4) as derived from comparisons with the Selected Areas 68 and 94, at the same altitude. The comparisons are subject to uncertainties partly because of the large change in azimuth required, and partly because old magnitudes in Selected Area 94 had to be used. The deduced distances in column (6) depend on assuming $M_{pg} = 0$ for these variables, and on a correction for interstellar absorption amounting to 0·31 mag. cosec *b*, as given by Oort[5].

These newly discovered faint variables therefore indicate that the distances of the Magellanic Clouds are larger than believed hitherto. A precise redetermination must await revised magnitudes in Selected Area 94. The uncertainty in the distances given in column (6) must be of the order of 25 per cent, mostly arising from the difficulty of comparison with the Selected Areas, but partly also from the uncertainty in the assumed absolute magnitude of *RR* Lyræ variables. The indications are that an error in the comparison is likely to have underestimated the distances. The conclusion supports the results reported by Baade for the Andromeda nebula at the International Astronomical Union meeting in Rome, 1952.

The increased distance, which has been supported by Shapley[6], implies an increased luminosity for classical Cepheids and hence a change in the shape of the period – luminosity curve. Such a change in shape, especially at about $P = 1$ day, was already suggested by the variables in the Sculptor System[7], which showed a difference of about 1 magnitude between $P = 1$ day and $P = 0·5$ day.

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## Travelling Disturbances in the Ionosphere: Diurnal Variation of Direction

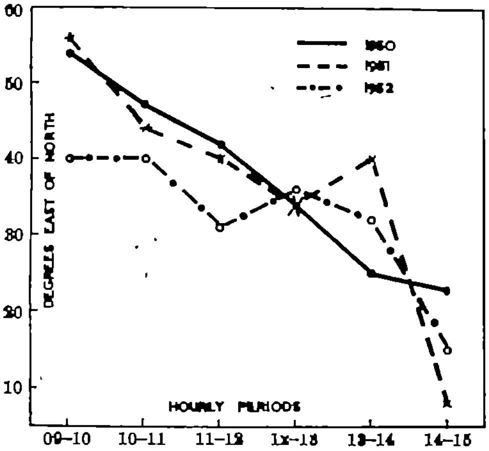
THE detection of travelling disturbances in the *F*-region of the ionosphere has already been reported[1]. In the last-mentioned paper, it was stated (p. 221): "It has not yet been possible with the limited data available to detect any definite diurnal variation". This has been interpreted in some more recent publications by other authors as implying that there is no diurnal variation.

Since the publication of the original papers, more observations of greater accuracy and extending over a greater part of the day have provided definite evidence of diurnal variation in the direction of horizontal movement. This is most marked in the month of June. The accompanying graph shows the median values of all directions observed for each hourly interval for all days of June in each of the three years 1950–52. Each point is the median of the appropriate number of values listed in the table.

It will be seen that there is a similar trend in the three years, the direction of movement changing from approximately 50° (E. of N.) at 0930 to 15° at 1430. In addition, some recent night observations, though not sufficient for definite conclusions, suggest that there is consistently an east–west component of

NUMBER OF INDEPENDENT OBSERVATIONS OF DIRECTION

| | 09h–10h | 10h–11h | 11h–12h | 12h–13h | 13h–14h | 14h–15h |
|---|---|---|---|---|---|---|
| 1950 | 2 | 15 | 28 | 44 | 30 | 14 |
| 1951 | 29 | 44 | 52 | 72 | 40 | 19 |
| 1952 | 39 | 70 | 74 | 81 | 41 | 27 |



Diurnal variation of direction of movement in June

movement present at night, in contrast with the consistently west–east component present in the daytime, indicating a significant change in direction of travel as between day and night. These observations are being extended, and the results and implications will be discussed more fully elsewhere.

This work has been carried out in the Electrical Engineering Department of the University of Sydney as part of the investigations of the Radio Research Board of the Commonwealth Scientific and Industrial Research Organization, and is published with the consent of the Executive. The invaluable assistance of the technical staff of the Radio Research Board is gratefully acknowledged.

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[1] *Nature*, 161, 886 (1948); **163**, 812 (1949); *Proc. Roy. Soc.*, A, **202**, 208 (1950).

## Beta-Spectrum of Radium E

The shape of the β-spectrum of radium E differs from the Fermi allowed form. It has been investigated thoroughly; but there are many effects which usually distort the spectrum in the low-energy region[1]; for example, straggling and back-scattering in the source, electron scattering in the spectrometer, distortion introduced by the detector and many others.

Different ways of eliminating these disturbances have been tried lately; for example, Waltner and Rogers[1] observed the beta-tracks in a cloud chamber, Langer and his co-workers[2] used a windowless Geiger counter. Nevertheless, the results obtained by different authors showed marked discrepancies in the low-energy region.

We tried to solve the problem by preparing a very thin source and using electron-sensitive nuclear emulsions (Ilford *G*5) as a detector. The intensities were found by counting the β-tracks recorded in a magnetic lens spectrograph. In all, 35,000 tracks were counted. The shape of the spectrum was investigated down to 4·6 keV. Very thin sources were prepared by a volatilization method. They were suspended on a 'Zapon' film which was coated with an extremely thin layer of gold to increase the conductivity. The whole thickness of the source, 'Zapon' and gold was not greater than 4–4½ μgm./cm.[3]. From an examination of images obtained in the spectrograph, it was found that the uniformity of the sources (1·1 mm. diameter) was satisfactory. The electron tracks were recorded on the surface of the emulsion, which therefore could be only 25 μ thick. During the processing of the emulsion, great care was taken to obtain a clear surface with reduced background grains. For the lowest energy the 'tracks' contained one grain only. In this region, elimination of the background was done by the measurement of the grain density in the vicinity of the spot. In some cases, for better separation of overlapping grains, the emulsion was resoaked in water before microscopic examination. Nuclear emulsions were used to focus the spectrograph and also in the investigation of the relation between the energy and the number of grains.

Analysis of the geometrical distribution of intensity in the images of the source at different energies showed that it was possible to take into account the tracks recorded in a wide zone of each image. It was shown that the measured intensities did not depend much on the position of counting area (zones).

Figs. 1 and 2 represent the results concerning the energy and momentum distribution in the radium E spectrum. The energy distribution curve probably cuts the $I(E)$ co-ordinate. From the experimental points it is evident that below 50 keV. the distribution function cannot be interpreted in terms of $(E-E_0)^4$.

Details of the method of preparation of source and the investigation of the relation between the number of grains and energy below 30 keV. will be given shortly in *Acta Physica Polonica*.

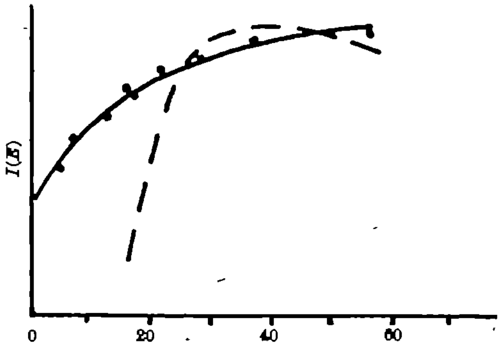

Fig. 1. ————, Waltner and Rogers's results

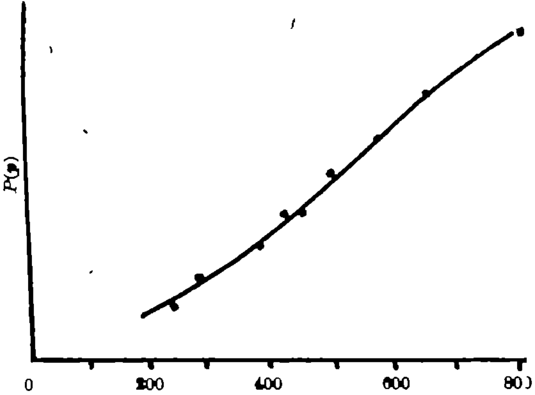

Fig. 2

This work was done in the George Holt Physics Laboratory, University of Liverpool, during 1949–50. We wish to express our gratitude to Profs. S. Pieńkowski, J. Rotblat and H. W. B. Skinner for their encouragement and interest. We are also indebted to Mr. D. G. E. Martin for help and many discussions.

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[1] Waltner, A., and Rogers, F. T., *Phys. Rev.*, **74**, 699 (1948); **75**, 1445 (1949).

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## A Simple X-Ray Micro-beam Technique

A simple method has been devised to enable X-ray diffraction photographs to be obtained from a single plant cell the size of which is of the order of 10 µ × 10 µ × a few mm. long. Although details of methods using micro-focus tubes and micro-beams have been published, they are not suitable in this instance because of the low diffracting power of cellulosic materials.

Small lead-glass capillaries are not satisfactory because scatter from the edges of the aperture is great enough to obscure diffraction from the specimen. Using metal pin-holes, it is extremely difficult to make and adjust the necessary secondary aperture, so that satisfactory results are never obtained.

The system in use at present (Fig. 1) consists of two tilted metal plates mounted over the exit aperture of a collimator with two ¼-mm. pin-holes 50 mm. apart. The geometry of the system is made such that the corners of the plates define the beam (30 µ wide) while the edges prevent scatter from these corners reaching the photographic film. Because long specimens are used and because we are only concerned with the equatorial arcs, only one pair of plates is used; however, a second pair mounted at right-angles to the first could be used if it became necessary either to use a square beam or to remove the meridional streak, or both. The large entrance aperture allows the whole of the X-ray source of normal dimensions to be used.

The specimen is mounted directly on the collimator; to ensure that it will be in the X-ray beam, light is passed through the whole collimator and the specimen adjusted, under a binocular microscope, to be in the light beam. The collimator carrying the specimen is then transferred to a normal flat-film camera. A Geiger counter and rate-meter are essential for lining up the collimator with the X-ray source.

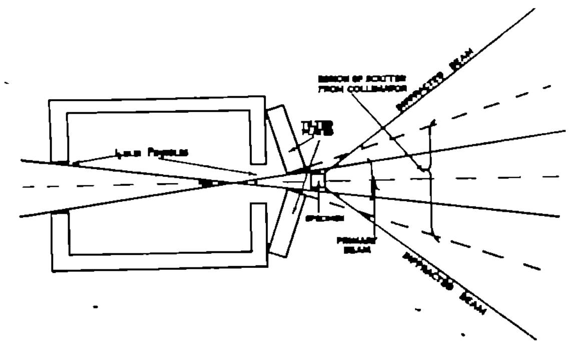

Fig. 1. Diagrammatic section of collimating system

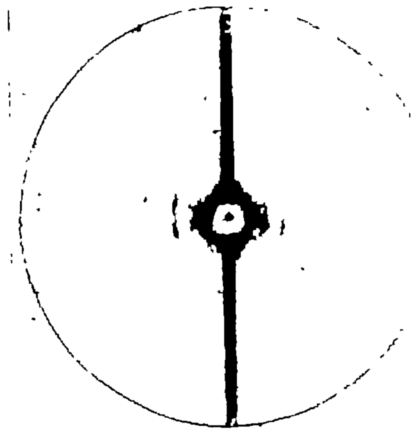

Fig. 2. X-ray photograph from a single sisal cell. Film to specimen, 17 mm.; beam, 30 µ × 400 µ; unfiltered copper *K* radiation; exposed 100 hr. on Hilger *HRX* unit operating at about 35 m.amp and 40 kV.

Fig. 2 illustrates the type of photograph given by a single cell of sisal using this method.

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## Resonance Absorption in Liquid Methyl Palmitate and Methyl Stearate in the Microwave Region

In a previous communication in *Nature*[1], it was pointed out that dielectric measurements on solid methyl palmitate, in the microwave region, showed features which were difficult to explain on the basis of a purely relaxation type of loss, and it was suggested that resonance absorption was occurring at some frequency in this region. This conclusion was criticized[2], and it must be admitted that the evidence was not entirely convincing.

Measurements have since been made on stearic and palmitic acids and their methyl and ethyl esters at temperatures ranging from the melting points to about 30 or 40 deg. C. above the melting points. The measurements at 3·2 cm. and 1·26 cm. were obtained by the Roberts – von Hippel method, and the measurements at the other wave-lengths, 17, 10, 9, 8, 6·5, 5, 4·5 and 4 cm., were obtained by a phase and amplitude balance method using coaxial-line equipment. This method is a development of one described by me elsewhere[3] and is similar to that described by Branin and Smyth[4]. The wave-lengths 5, 4·5 and 4 cm. were obtained by harmonic generation.

The acids show a fairly small loss in the microwave region, with a suggestion of a small relaxation loss near 3 cm. wave-length. The loss in the methyl and ethyl esters was much greater than in the acids. The curves of $\epsilon'$ and $\epsilon''$ as functions of frequency are, in the case of the ethyl esters, normal relaxation loss curves with a spread of relaxation times. The measurements on ethyl palmitate are shown in Fig. 1. Ethyl stearate gives similar curves. The results for

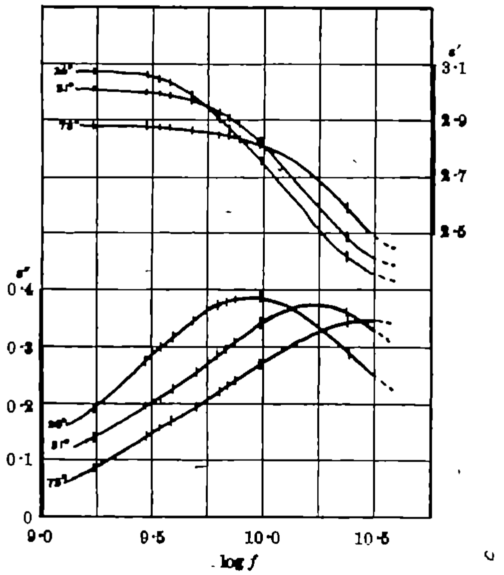

Fig. 1. Ethyl palmitate

methyl palmitate are shown in Fig. 2, and there is a decided irregularity in the ε' curve and a fairly pronounced shoulder in the ε'' curve. These irregularities occur at about 6,000 Mc./s., and this frequency shows little or no change with temperature; but the irregularities diminish as the temperature rises and the curves then tend to become normal relaxation curves with a spread of relaxation times. The curves for methyl stearate are similar to the palmitate curves.

The dotted curves in Fig. 2 indicate the values of ε' and ε'' which would be expected from a purely relaxation process. If we plot the difference between the dotted curves and the experimental curves, we obtain the curves *P* and *Q*, which are very suggestive of a resonance absorption. There is some latitude in the choice of the dotted curves; but any reasonable choice will lead to curves which will not differ very much, in shape, from *P* and *Q*.

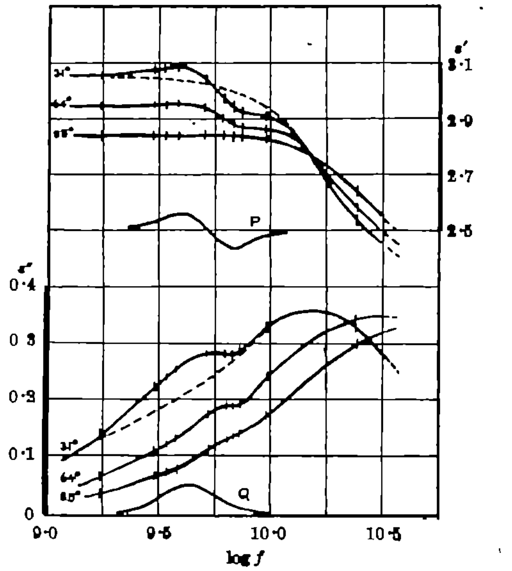

Fig. 2. Methyl palmitate

The central frequency of this resonance absorption is approximately 6,000 Mc./s. and is, within experimental error, the same frequency as obtained with methyl stearate. This frequency is 100–1,000 times smaller than the resonance frequency which one would expect for the type of resonance absorption discussed by Frohlich[5]. Rotation of the molecule around the long axis would give a frequency of the right order of magnitude when allowance is made for the effect of the retarding potential barriers[6].

The resonance absorption decreases and finally vanishes at temperatures about 40 deg. C. above the melting point. It is well known that many long-chain compounds show a state of short-range order in which the molecules tend to lie parallel to each other. This condition is most in evidence near the melting point, and the order diminishes as the temperature rises. It seems likely that this short-range order is necessary for the existence of this form of resonance absorption. If this absorption is due to rotation of the molecules around the long axis, then this can be understood. When the temperature rises and the molecules begin to twist and crumple about the C—C bonds[7], then rotation around the long axis would not occur.

It is a little surprising that the ethyl esters do not show the same effect as the methyl esters, though the ethyl group, being larger than the methyl group, probably projects farther from the axis of the molecule and may give rise to a steric hindrance to rotation.

Thanks are due to Prof. J. E. Roberts for his interest in this work and for the facilities provided; and also to Messrs. Unilever, Ltd., for providing pure specimens of the acids and the methyl esters.

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## An X-Ray Diffraction Study of the Transformation of Retained Austenite by Fracture

During an investigation of the structure of a hardened 1½ per cent chromium steel, the presence of a small amount of retained austenite was observed in the microstructure. Examination of this material by the glancing-angle X-ray diffraction technique revealed retained austenite on a surface mechanically polished and etched for micro-examination, whereas retained austenite could not be found on the surface of a fracture produced by fatigue, or on a freshly produced brittle fracture surface.

That the austenite was introduced during preparation of the microspecimen seemed unlikely owing to precautions taken to avoid overheating in grinding and polishing and from the appearance of the microstructure. This hypothesis was finally disproved by further X-ray pictures showing the presence of retained austenite: (1) on a small flat prepared on a brittle fracture by lightly hand-polishing to a depth of several thousandths of an inch below the fracture surface; (2) on both types of fracture after removing metal from the fracture surface by deep-etching, the largest proportion of retained austenite being observed for the deepest etch.

It would appear impossible to interpret the evidence except by assuming a complete (within the experimental accuracy) transformation of retained austenite at fracture surfaces, presumably as a result of highly localized shear deformation at the position of fracture.

B. L. Averbach, S. G. Lorris and M. Cohen, in their paper on "Stress-Induced Transformation of Retained Austenite in Hardened Steel"[1], have also observed that retained austenite contained in a specimen of hardened 3½ per cent nickel steel transforms completely at a fracture, and, incidentally, that an inverse relation appears to exist between strain and the amount of retained austenite remaining. We do not know of any reference to this phenomenon occurring in a 1½ per cent chromium steel. It is considered likely that other types of hardenable steel which contain retained austenite after hardening will exhibit a similar transformation.

These examples of the complete transformation of retained austenite on fracture surfaces are of particular importance to the X-ray crystallographer in that they throw doubt on the validity of the usual contention that newly fractured surfaces are most suitable for X-ray diffraction tests on bulk metal specimens. Grinding, polishing, etching, electropolishing, machining and filing are all well known to introduce specific dangers of possible errors of interpretation. Our observations indicate that even freshly broken surfaces may show a structure or texture which is not typical of the bulk material. It is imperative that the crystallographer should consider sample preparations most carefully and treat every particular experiment on its merits.

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Nov. 20.

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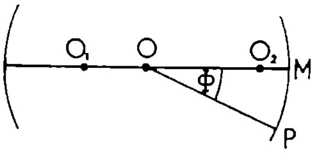
## A New Method of Light Microscopy

THE method described by Prof. A. Wilska[1] appears to be a special case of phase-contrast, generally known as 'amplitude-contrast'. Although not usually employed with fixed phase-contrast objectives, it frequently crops up in variable phase-contrast and interference systems. Oettlé[2], for example, used it in his experiments with a variable amplitude and phase microscope. The basic theory can be simply explained by a vector treatment similar to that given in detail elsewhere[3]. Object details can be represented by points in or on the well-known vector circle, centre $O$, radius $OM$. In conventional microscopy, the origin remains at $O$ and transparent phase-changing details such as $P$, which lie on the circumference of the circle, are all equidistant from $O$ and appear with equal intensity, $OP^2$ ($= OM^2$), so that contrast is zero.

The object of phase-contrast and interference microscopy is to shift $O$ to some new position so that points on the circumference will no longer be equidistant from the origin, but will appear with intensities depending on $\varphi$, the phase change introduced by the detail. In ordinary phase-contrast this is achieved by rotating the vector $OM$, which represents the direct light, and changing its amplitude, that is, by altering the phase and intensity of the direct or diffracted components. We can, however, shift $O$ by changing only the amplitude of $OM$ without rotation. In this case pure amplitude-contrast is obtained and the new origin lies somewhere on $OM$. In Prof. Wilska's second method, the intensity of the direct light is reduced to about 1/12. The amplitude is thus $1/\sqrt{12}$ or 0·29. The new origin is $O_2$, where $O_2M = 0{\cdot}29$, $OM$ being taken as unity. The background intensity is now $O_2M^2$, the detail intensity $O_2P^2$. Thus for all except very small phase changes, the image detail will be brighter than the background and it will not be possible to distinguish phase advances from phase retardations. If all the direct light were absorbed, the new origin would coincide with $M$, giving central dark-ground illumination in which theoretically all details will be bright on a black background.

In his first method, Prof. Wilska absorbs 50 per cent of the diffracted light. In this case the new origin will be at $O_1$, where $O_1M = \sqrt{2}$. This is an example of $B$-type amplitude contrast[3,4]. The detail intensity $O_1P^2$ is now always less than the background intensity $O_1M^2$, so that dark contrast occurs. However, for small phase changes, $O_1P$ is very nearly equal to $O_1M$, so that contrast is inherently poor, and becomes worse as the transmission of the diffracted light decreases, that is, as $O_1$ moves farther away from $M$. This latter method is therefore only useful for rather refractile objects such as thick cells and fibres.



The halo effect[4] is inherent in all phase-contrast and interference systems in which there is incomplete separation of the interfering beams (in this case the direct and diffracted components). It becomes much more conspicuous with heavy absorption of the direct light and is particularly noticeable in Prof. Wilska's photographs, for example, around the sperm tail in Fig. (c) and the edge of the epithelial cell in Fig. (e). The halo will be much less obvious in $B$-type contrast as observed by Prof. Wilska, and it will also depend on the width of the annular ring in the objective, which determines the degree of overlap between direct and diffracted light.

These considerations are based on the assumption that it is possible to affect the transmission of the light wave without altering its phase. If the partly absorbing layer introduces a phase change, then some degree of phase-contrast will occur and $O_1$ and $O_2$ will no longer lie on $OM$. In Prof. Wilska's first method the phase of the direct light will be advanced, and in the second case it will be retarded, relative to the diffracted light. This will give rise to positive and negative phase-contrast respectively, thus heightening the effects already predicted.

Prof. Wilska's letter should be useful in directing the attention of microscopists to the value of amplitude-contrast and central dark-ground illumination in some cases. His photographs show that excellent results can be obtained by very simple means.

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Feb. 21.

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Without criticizing the vector treatment of amplitude and phase-contrast microscopy kindly given by Dr. Barer in his comment on my letter[1], I would like to make the following comments: (1) Using my second method, phase-advancing objects appear darker than the background. The soot layer appears to cause a considerable phase retardation in addition to the absorption. (2) If the absorbing annulus is made substantially darker, the resulting image becomes peculiarly glossy and too unsharp to be of any value. Thus the "central dark-ground illumination" does not seem to be very promising in this connexion. (3) According to Oettlé[2], as well as from my own observations, ordinary negative phase-contrast methods do not produce images comparable with those of positive phase-contrast in clarity. The inherent haziness and glare of the negative phase-contrast picture may be due entirely to the light reflected from the phase plate and converged back to the area under observation. Due to the reflectivity of absorbing annuli evaporated by ordinary means, this additional surface illumination may reach higher values than the light passing the objective annulus. My method does not suffer from this in the same degree since the reflectivity of soot is small.

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## Ability to smell Solutions of Potassium Cyanide

It has been known for many years that some individuals are unable to smell hydrogen cyanide, and the possibility that this inability may be genetically controlled was mentioned at a recent conference on the origin and evolution of man[1]. A short time ago our attention was directed again to this phenomenon, and we have since used a simple method of ascertaining the frequency of the inability to smell hydrogen cyanide among the white population of Australia and carried out a preliminary study of the mode of inheritance of this character.

The sample of the adult population comprised 244 individuals ranging in age from sixteen to sixty. The method of testing finally adopted consisted of presenting alternately tubes containing respectively 5 ml. distilled water and 5 ml. 20 per cent potassium cyanide soaked into cotton-wool. The tubes were stoppered between tests. Fresh tubes were made up at the beginning of each day. Subjects were asked to state if they could smell anything in either tube. Those that could were classified for the strength of their response on a subjective five-point scale. Independent observers achieved similar results using this method. Subjects whose response was doubtful or negative were retested after a rest of several minutes. Non-smeller individuals were retested in nearly all cases on subsequent days.

There is a striking difference between the sexes in the incidence of non-smellers when this method of testing is used, 24 out of 132 males, and 5 out of 112 females being unable to distinguish the cyanide tube from that containing distilled water. Of the remaining individuals tested, 31 males and 26 females could distinguish the smell from the potassium cyanide tube only faintly, but all were able to pick out the correct tube when retested. All the other subjects could distinctly and immediately recognize a smell in the tube containing the cyanide, though the nature and strength of the response varied considerably from person to person. The proportion of non-smeller males and females suggests that the inability to smell is a sex-linked recessive. The observed frequency of females (4·46 per cent) corresponds closely with what would be expected (3·33 per cent) from the observed number of males (18·2 per cent) if sex-linkage were operating. The difference between the frequency of the recessive gene calculated from the number of non-smeller males and that calculated from the number of non-smeller females does not differ significantly from zero when tested by the method of Snyder[2].

In an attempt to examine further the possibility of sex linkage, we have tested 61 families containing two or more children older than ten years. The 122 parents of these children are included in the larger sample of 244 individuals discussed above. Table 1 gives the number of smellers and non-smellers among the offspring in various mating groups.

Table 1

| Group | No. of families | Parents | | Children | | | |
|---|---|---|---|---|---|---|---|
| | | Males | Females | Male | | Female | |
| | | | | S. | N.S. | S. | N.S. |
| 1 | 45 | Smeller | Smeller (expected) | 53<br>(48) | 4<br>(9) | 54<br>(54) | 0<br>(0) |
| 2 | 12 | Non-smeller | Smeller (expected) | 11<br>(11) | 2<br>(2) | 13<br>(13) | 3<br>(3) |
| 3 | 4 | Smeller | Non-smeller (expected) | 2<br>(0) | 2<br>(4) | 4<br>(4) | 0<br>(0) |
| 4 | 0 | Non-smeller | Non-smeller | — | — | — | — |
| Total | 61 | | | 66 | 8 | 71 | 3 |

Though the number of families tested so far does not enable a decisive answer to be given by gene frequency analysis, the results indicate that a sex-linked recessive gene is possibly involved in the control of the ability to smell hydrogen cyanide. There is a deficiency of non-smeller males in group 1 and there are two exceptions in group 3. In this latter group all male children should be non-smellers. One of these children is a very doubtful smeller, but the other has no difficulty in detecting the presence of cyanide. One explanation of such discrepancies may be the operation of other genetic factors which

Table 2

| No. of. families | Parents |  | Children |  |  |  |
|---|---|---|---|---|---|---|
|  |  |  | Weak |  | Strong |  |
|  | Males | Females | ♂ | ♀ | ♂ | ♀ |
| 10 | Strong | Strong | 2 | 2 | 9 | 10 |
| 9 | Weak | Strong | 4 | 4 | 5 | 6 |
| 14 | Strong | Weak | 9 | 10 | 9 | 6 |
| 12 | Weak | Weak | 11 | 11 | 4 | 5 |
| Total 45 |  |  | 26 | 27 | 27 | 27 |

affect the degree of manifestation of the smeller characteristic. We have demonstrated that other factors are involved for people who are classified as smellers by grouping individuals into 'weak' and 'strong' categories. Table 2 gives the distribution of 'weak' and 'strong' smellers among the 45 families in group 1.

There is no difference between the sexes for the strength of response of individuals who are smellers; but there is a highly significant tendency for parents who are 'strong' smellers to have children who are 'strong' smellers, and parents who are 'weak' smellers to have children who are 'weak' smellers ($\chi^2 = 16.173$ with 3 degrees of freedom; $0.001 < P < 0.01$).

Any hypothesis which seeks to explain the inability to smell solutions containing potassium cyanide in terms of a sex-linked recessive gene must take into account, therefore, the possibility that some smeller individuals may be wrongly classified because of the intervention of other genetic factors affecting the strength of the response.

A fuller account of this work will be published elsewhere.

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## Serum Iron and Iron-binding Capacity in the South African Bantu

Excessive amounts of iron are frequently present in various organs and tissues of adult South African Bantu[1]. Among these people, the iron intake is often high, as much as 200 mgm. per diem[2]. Further, occasional high values for serum iron have been reported among the Bantu of Bechuanaland[3]. In view of these facts, serum iron-levels, iron-binding capacity and other data have been determined in groups of adult Bantu from different regions of Southern Africa.

The Johannesburg group, of ages up to sixty years, were from a local non-European hospital; they were either on the staff or were suffering from complaints unlikely to influence levels of serum iron or iron-binding capacity. The Bantu males, 18–40 years, were workers from different territories, passed as medically fit for service in the gold mines. The European controls were members of the staff of this Institute.

Means, Standard Deviations and Ranges of Serum Iron and Total Iron-binding Capacity in Different Bantu Groups

|  | Remarks | Serum iron ($\gamma$ per 100 ml.) | Total iron-binding capacity ($\gamma$ per 100 ml.) |
|---|---|---|---|
| Bantu females | Johannesburg area | 180 ± 40 (20)* (60–215) | 335 ± 55 (17)* (240–435) |
| Bantu males | Johannesburg area | 230 ± 75 (14) (110–380) | 385 ± 50 (14) (320–475) |
|  | Group *A*† | 105 ± 45 (39) (15–225) | 375 ± 70 (39) (225–590) |
|  | Group *B*‡ | 285 ± 100 (68) (110–550) | 520 ± 90 (42) (395–830) |

* Number of subjects.

† Bantu with serum iron and total iron-binding capacity within normal range; Pondoland (13), N. Transvaal (Bapedi) (14), Tanganyika (12).

‡ Bantu with increased serum iron and total iron-binding capacity, significantly higher than those of group *A*; Mozambique (44), Angola (12), Nyasaland (12).

Samples were taken by venipuncture between 9.30 and 11.30 a.m., the usual precautions being taken to prevent contamination with iron. Serum iron was determined using the thioglycollic acid method. The iron-binding capacity was determined by the method of Rath and Finch[4]. The total iron-binding capacity was obtained by adding the value for serum iron to the iron-binding capacity. The difference between duplicates was never more than 10 per cent; all figures, therefore, including means and standard deviations, are given to the nearest 5 $\gamma$.

Our results for control groups of Europeans were in close agreement with values reported by other workers[4,5].

Several of the individual values obtained for serum iron and total iron-binding capacity were higher than any reported for such diseases as idiopathic hæmochromatosis or transfusional siderosis[4]. In no case has serum iron saturation been found. Further, among the Pondos and Bapedi examined, a few very low values for serum iron were obtained, which were, however, consistent with normal hæmoglobin levels.

Whether or not our groups with high serum iron and total iron-binding capacity values correspond with groups having high iron intakes, or displaying abnormal deposition of iron, is being investigated.

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## 'Private' Blood Factors, Homozygosis, and the Search for New Blood Groups

Levine[1], in a review of the newer blood factors, classed several of them as 'private'. These, he said, "are characterized by the positive or negative reactions being limited to members of a particular family". He cited as 'private' five antibodies reported by various investigators. J. J. van Loghem and van der Hart[2] have since reported a sixth.

How 'private' a blood factor appears to be may depend upon the population studied with the antibody defining the factor. For example, a year or so ago, we received blood from an American Indian woman who, in her ninth pregnancy, gave birth to a baby who died of erythroblastosis. Her blood contained an antibody which agglutinated the blood of her husband and of some, though not all, of her seven living children, but did not agglutinate the blood of 794 other American Indians. Using the antibody on this population only, the factor it defined fell into the class of a 'private' blood factor; but when the antibody was tested with the blood of whites it was readily shown to be anti-*Kell*. The husband was found to be heterozygous *Kk*. On inquiry it was found that his mother was white. From this observation, we suggest that one should inquire into the racial origin of the stimulator of an antibody defining a 'private' blood factor, and if he be found to be of different race from the person who has developed the antibody, members of his race should be tested.

Sometimes, when questioning does not suggest that a person carrying a particular blood group antigen has a foreign ancestor, a hint may be obtained by detailed blood grouping. When we found anti-*D* in the blood of an *Rh*-negative woman, we genotyped the family. The husband was $R_1R_z$ and the three children $R_zr$. $R_z$ is rare in whites but common in American Indians. When we questioned the woman, she said that her husband's mother was born in Scotland, his father in Canada in a district where many Scots settled 140 years ago. She thought of him as a Scottish Canadian, or, as we would say, Caucasoid. But we know that originally the marriage of a white man to an Indian woman was the rule rather than the exception in the area where the husband's father was born. We have little doubt that his $R_z$ came from an Indian ancestor. The finding of $R_0$ suggests the possibility of a negro ancestor, perhaps via a Mediterranean ancestor[3]. When no racial difference between stimulator and producer of an antibody is proved or suggested, members of as many racial groups as possible should be tested with the antibody, before the factor it defines is set down as 'private'. These 'private' antibodies may be of great ethnological value.

Other observations on American Indians led us to give some thought to homozygosis. In a study of the blood groups of the Blood and Blackfoot tribes of southern Alberta in the summer of 1952, we concluded that pure-bred Indians of these tribes were probably homozygous for the following blood antigens: *k*, $Lu^b$, 'not $Le^a$', *P* and possibly *D*. In such a population, so long as it remains pure-bred, and so long as any member, when transfused, receives blood from his own people only, an immune antibody against a factor for which the population is homozygous cannot be produced. So, for example, the pure-bred Indian cannot produce anti-*k*. On the other hand, the introduction of foreign blood antigens, whether through pregnancy or through transfusion, makes the probability of production of an antibody against one of these antigens greater than in the foreign population. In a random sample of 83 sera of Indian men, women and children, we found a second example of anti-*Kell*, whereas we have identified this antibody only half a dozen times in the examination of sera of some thousands of whites. Further, in such a population, naturally occurring antibodies against a blood factor having a frequency of zero may be present, but cannot be recognized by tests of the population. We have found several examples of anti-$Le^a$ in the sera of Indians, while no Indian blood we have tested has reacted with this antibody. Indian blood, of itself, can give no hint of the *Lewis* system. Many Indian tribes are homozygous for *O*, or, to put it the other way about, have a frequency of zero for *A* and *B*. Their sera, of course, contains anti-*A* and anti-*B*. It comes as something of a shock to think what the history of the *ABO* system would have been had the American Indians been the population of primary investigation: for many tribes there would have been no evidence of its existence; for others the classification could only have been $A+$ and $A-$, for perhaps one tribe in South America $B+$ and $B-$.

Since some Indian populations are homozygous for some blood groups, it seems reasonable to believe that Caucasoid, Negroid, Mongoloid and Australoid populations may be homozygous for other blood groups. This is more likely to be true for populations which have resisted interbreeding or have had, until recently, relatively little opportunity for interbreeding, than it is for those which are highly interbred. In a population exhibiting homozygosis for any blood group, that group must remain unknown so long as tests are carried out only with sera of that population. It is our suggestion that a systematic examination of the sera of persons who have been transfused with the blood of donors of a different race or sub-race, and of the sera of women married to men of a different race or of a mixed race, may bring to light several unrecognized blood-group systems. An experimental programme of inter-racial immunization of volunteers would also be worth while. It need scarcely be said that it will be necessary to test the sera against the blood of persons of the race of the donor, or of the husband. It would be desirable, through exchange of sera between laboratories having access to other racial populations, to test the sera against the blood of several races.

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## Adsorption of DDT on Suspended Solids in River Water and its Role in Black-fly Control

Recent investigations on the Saskatchewan River[1] indicate that DDT associated with suspended solids gave outstanding results in the control of black flies. Black-fly larvæ have been practically eliminated from other streams and rivers by the application of DDT at rates as low as 0·1 p.p.m.[2]; but the maximum distance of effectiveness was approximately nine miles and some of the treatments were destructive to other aquatic life as well as black-fly larvæ. In contrast with these results, during 1948–51 larvæ of *Simulium arcticum* Mall. were largely eradicated from sections of the Saskatchewan River for as long as 98 miles by single applications of DDT. The DDT was applied at rates as low as 0·09 p.p.m. for 16 min. as a 10 per cent solution in methylated naphthalene and kerosene.

Outstanding characteristics of the Saskatchewan River include its large rate of discharge (up to 120,000 cusec.), its freedom from aquatic vegetation, and the turbidity of the water during certain seasons of the year. During the tests, the suspended solids content of the water ranged as high as 551 p.p.m., and samples obtained by sedimentation from river water collected so far as 68 miles downstream from the point of application contained 0·24–2·26 μgm. of DDT per gram of solids. This material consisted mainly of clay and fine silt, and laboratory experiments showed that it would adsorb DDT from suspensions of 0·1 p.p.m. of DDT in distilled water.

A study of the feeding habits of the larvæ of *S. arcticum* showed that suspended particles in the river water, including much inorganic material, were consumed. It was also noted during the larvicide tests that the treatments produced much greater mortality of black-fly larvæ than of other aquatic insects, which normally do not feed on small particles suspended in the water. Quantitative samples of aquatic organisms collected before and after single applications of DDT indicated that, whereas black-fly larvæ were almost eliminated for distances ranging from 40 to 98 miles, populations of other aquatic insects were reduced by an average of 50 per cent in two tests and were unchanged in two others.

The results suggest that other fast-flowing rivers in which the water is turbid at the time of treatment might be treated similarly, and perhaps in certain clear-water streams and rivers, finely divided inorganic material with marked DDT adsorptive properties could be added along with the larvicide and kept in suspension.

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## Terminology in Bacterial Genetics

THE increasing complexity of bacterial genetics is illustrated by several recent letters in *Nature*[1]. What seems to us a rather chaotic growth in technical vocabulary has followed these experimental developments. This may result not infrequently in prolix and cavil publications, and important investigations may thus become unintelligible to the non-specialist. For example, the terms bacterial 'transformation', 'induction' and 'transduction' have all been used for describing aspects of a single phenomenon, namely, 'sexual recombination' in bacteria[2]. (Even the word 'infection' has found its way into reviews on this subject.) As a solution to this confusing situation, we would like to suggest the use of the term 'interbacterial information' to replace those above. It does not imply necessarily the transfer of material substances, and recognizes the possible future importance of cybernetics at the bacterial level.

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## Histochemical Demonstration of Amine Oxidase in Liver

DIANZANI[1] has shown that ditetrazolium can be used for demonstrating the activity of, among other enzymes, tyramine (amine) oxidase in mitochondria isolated from liver and kidney. The essential reaction here is a dehydrogenation[2], and hydrogen acceptors other than oxygen may be used in the oxidation of tyramine by amine oxidase[3]. It is therefore of interest that amine oxidase activity can be demonstrated in frozen sections of the tissue, using a tetrazolium compound as the hydrogen acceptor; even though the method is not entirely satisfactory, it shows the general distribution of the enzyme. Neotetrazolium[4] was found to be much more satisfactory than blue (di-)tetrazolium.

Frozen sections (15–20 μ thick) of guinea pig and rabbit liver were well washed in phosphate buffer for about thirty minutes to remove all endogenous substrates and then incubated with equal parts of 0·1 per cent neo-tetrazolium, 0·1 *M* phosphate buffer of *p*H 7·4 and 0·5 per cent tyramine solution, for 2–4 hr. At the end of the incubation period, the sections were washed in distilled water, fixed in 10 per cent neutral formalin and mounted in dilute glycerol. The use of very thin slices of liver instead of frozen sections for the incubation was found to be advantageous; they can then be fixed in formalin and sectioned on the freezing microtome. Control sections were incubated with (1) octyl alcohol[5] for three hours before incubation with tyramine and (2) potassium cyanide in a final concentration of $3 \times 10^{-3}$ *M*, which inhibits other oxidases but has no inhibitory effect on amine oxidase.

Fat stains red with neo-tetrazolium and, together with the precipitated blue formazan, gives a general purple colour. Large fat globules can be seen in the liver, staining a bright red. This red colour can be eliminated by treating the sections with acetone, which dissolves away the fat, leaving the true (blue) colour of the precipitate. The acetone is removed by washing with water. In many cases the red colour is of advantage as it serves as a counter stain.

For the same period of incubation guinea pig liver showed a more dense precipitate than rabbit liver.

The reaction was not uniform throughout the liver, being more marked in the periphery of the lobule, the centre being comparatively free. The precipitate was always in the cytoplasm of the cell; the nucleus did not show any reaction and was unstained. Octyl alcohol completely inhibited the reaction, no blue colour being visible anywhere in the tissue. Potassium cyanide had no effect on the reaction.

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## Lactate-oxidizing Systems in the Mycobacteria

In a recent communication, Y. Yamamura, M. Kusunose and E. Kusunose[1] described two "lactic oxidases" prepared from *Mycobacterium avium*. "Lactic oxidase I" is said to be a new type of lactate-oxidizing system which catalyses the reaction:

$$CH_3.CHOH.COOH + O_2 \rightarrow CH_3.COOH + CO_2 + H_2O. \quad (1)$$

The authors are apparently unaware that a soluble aerobic dehydrogenase catalysing the same oxidation of L-lactate was extracted from *Mycobacterium phlei* several years ago[2]. Preparations of a similar, if not identical, enzyme have been obtained from *Mycobacterium smegmatis* and *Mycobacterium tuberculosis* var. *hominis* (*H*37 strain)[3]. For these and other reasons, it was suggested that L-lactic acid oxidase is an enzyme common to all species of acid-fast bacteria[4].

One of the hypotheses originally put forward to explain reaction (1) postulated three consecutive steps[2]:

$$CH_3.CHOH.COOH + F = FH_2 + CH_3.CO.COOH \quad (2)$$

$$FH_2 + O_2 = F + H_2O_2 \quad (3)$$

$$CH_3.CO.COOH + H_2O_2 = CH_3.COOH + CO_2 + H_2O \text{ (non-enzymic)} \quad (4)$$

Sum of reactions (2) to (4) = reaction (1).

In this scheme, *F* was assumed to be an autoxidizable flavoprotein containing flavin-adenine-dinucleotide because this class of protein was found in the enzyme preparations; but it was pointed out that the hypothesis could not be tested satisfactorily until purer preparations became available[2,4]. Yamamura *et al.* have likewise assumed that "lactic oxidase I" is a flavoprotein with flavin-adenine-dinucleotide as its prosthetic group.

Our assumption identifying the lactic enzyme with a flavoprotein has proved to be false. Using large quantities of bacteria, one of us (F. B. C.) has achieved a considerable purification of the L-lactate-oxidizing enzymes extractable from *Mycobact. phlei*, *Mycobact. smegmatis* and *Mycobact. stercoris*. These preparations exhibit identical enzymic behaviour. Flavins (free and combined) are removed during the purification, details of which will be published elsewhere. The most active preparation from *Mycobact. smegmatis* has $Q_{O_2}$ (per mgm. nitrogen) = 166,000 at the optimum *p*H (5·2) and at 38°. This is sixty times as active as the best preparation of Yamamura *et al.*

Concentrated solutions of partially purified enzyme are orange-yellow in colour and exhibit three electrophoretic components, one of which contains the enzyme. The pigment migrates with the enzyme. The absorption spectrum shows typical protein bands in the ultra-violet region with additional absorption at 380–403 mμ due to the pigment. It is possible that the pigment is a prosthetic group of the enzyme, but this is unlikely since the pigment is removed progressively as the enzyme is purified.

*Mechanism of reaction.* Yamamura *et al.* consider that their experiments exclude the possibility of formation of hydrogen peroxide. The evidence seems to be that oxygen consumption and carbon dioxide production in reaction (1) are unaffected by addition of catalase or catalase plus ethanol. This evidence shows (*a*) that catalase does not inhibit the oxidation of lactate, and (*b*) that coupled oxidation does not occur in the presence of ethanol and catalase (carbon dioxide production unaltered). Though significant, this evidence is not conclusive. If pyruvate and hydrogen peroxide react spontaneously on the enzyme surface where they originate, there may be limited diffusion of hydrogen peroxide to an indicator system.

Our purified enzyme preparations behave in a similar way with catalase. Nevertheless, the experiment illustrated in the accompanying table supports the view that hydrogen peroxide is formed in accordance with reactions (2) and (3). The experiment employs horseradish peroxidase and *p*-aminobenzoic acid as a means of detecting hydrogen peroxide[5]. In the presence of peroxidase, *p*-aminobenzoic acid is oxidized only when lactate is oxidized simultaneously; in the absence of peroxidase there is no coupling.

Detection of Hydrogen Peroxide during the Oxidation of Lactate

| Additions | Oxygen uptake (μl./60 min.) | Dye formation |
|---|---|---|
| Nil | 0 | Nil |
| *p*-Aminobenzoic acid + peroxidase | 0 | Nil |
| Lactate | 381 | Nil |
| Lactate + *p*-aminobenzoic acid | 394 | Nil |
| Lactate + peroxidase | 345 | Nil |
| Lactate + *p*-aminobenzoic acid + peroxidase | 384 | Red |
| Pyruvate + *p*-aminobenzoic acid + peroxidase | 0 | Nil |

Warburg manometric cups contained: 0·2 ml. enzyme solution (L-lactic acid oxidase from *Mycobact. smegmatis*) and 0·9 ml. 0·2 *M* acetate buffer, *p*H 5·2. Gas, air. Temp., 38. Inseal, 0·2 ml. 2 *N* sodium hydroxide. Additions: 1·0 *M* DL-lactate (0·5 ml.); 0·2 *M* pyruvate (0·5 ml.), peroxidase solution (0·2 ml.); 0·025 *M* *p*-aminobenzoic acid (0·2 ml.); water to make total volume, 2 ml. in each case.

We have not encountered a DPN-linked anaerobic dehydrogenase like "lactic oxidase II" in the organisms we have studied.

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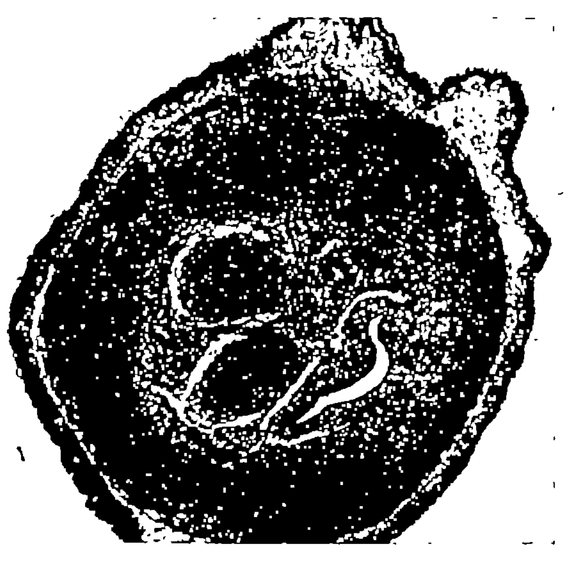
## A Sphincter in the Umbilical Ring of the Rabbit

During the course of some experiments on fœtal rabbits, a very marked constriction was observed in the umbilical cord at the umbilical ring; the abrupt narrowing in this region accompanied the closure of the length of the umbilical vessels in response to traction or to cooling of the cord. A circular band of smooth muscle in the umbilical ring region has been described for the horse[1] but for no other animal, and Sir Joseph Barcroft suggested that the structure of the rabbit's umbilical cord should be studied in more detail.

Serial sections of the umbilical vessels, in the full-term fœtal rabbit, showed that there is a thin layer of unstriped muscle fibres surrounding their adventitia; this was recognizable around the branches of both the arteries and the vein a few millimetres from where they emerge from the placenta. When the three large umbilical vessels lie side by side in the umbilical cord proper, the outer portions of this muscle layer fuse and the muscle fibres can be seen circularly arranged under the amniotic sheath; the inner portions of the muscle layer between the three umbilical vessels gradually disappear. The circular fibres increase in number and the sphincter attains its maximal thickness 2–3 mm. in front of the abdominal wall; it continues thus for 2–3 mm. inside the abdomen, and gradually tapers to its connexion with the abdominal muscle. Ranson impregnation, together with control positive material, revealed no nervous supply to the sphincter. It was already present in the cord of 20-day rabbit fœtuses. No similar structure was found in the rat, in the human or in the guinea pig umbilical ring.

It is doubtful whether this sphincter has any physiological function *in utero*, since it is not innervated and responds most readily to local stimulation. At birth it is obviously an efficient mechanism for ensuring closure of the three umbilical vessels, for in the region of the sphincter there is more complete reduction in the size of the lumen of the three vessels than is found on either the fœtal or placental side of the umbilical ring. It is difficult to understand its special relationship to the mechanism of birth in the rabbit. However, effective closure of umbilical vessels may be a function of their length as well as the relative contractile properties of the vessel walls. The latter is impossible to assess from histological specimens; but it is noteworthy that the umbilical cord proper in the rabbit is comparatively short, and the sphincter may have been developed as an extra safeguard.



Transverse section of umbilical ring of the rabbit showing unstriped muscle sphincter surrounding umbilical vessels

This work was begun in the Department of Physiology, Bedford College for Women, London. My thanks are due to Miss Beryl Shilton, who prepared many of the slides. Miss Helen Perry, of the Department of Zoology, Birkbeck College, London, is carrying out an exhaustive study of the umbilical rings in other animals.

I. Maureen Young

Sherrington School of Physiology,
St. Thomas's Hospital,
London, S.E.1.

Oct. 24.

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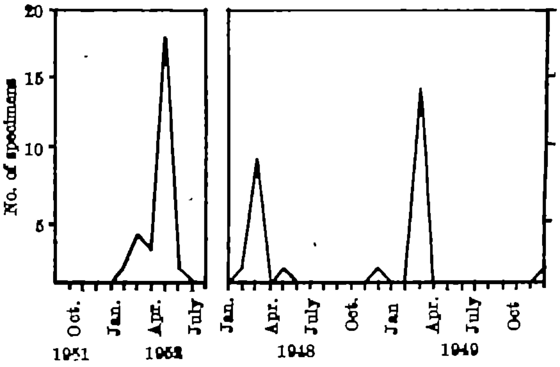
[1] Hauptmann, E., *Arch. Anat. Physiol. Lpz.*, Anat. Abt., 103 (1911).

## Catches of *Coryphæna hippurus* (L.) in the Western Indian Ocean

While carrying out a survey of the pelagic fishes of East African waters, twenty-seven specimens (twenty-four female, three male) of the dorade or dolphin fish were caught during multiple trolling operations during September 1951–August 1952. All the dorade were taken close inshore, and from the graph it can be seen that the catches were limited to the months February–June. Although the total catch is not large, it must be remembered that the dorade is of widespread distribution in tropical seas and is nowhere abundant. In all specimens the state of maturity of the gonads was determined.

Reference to unpublished data of the Mauritius–Seychelles Fisheries Survey, 1948–49 (Wheeler and Ommanney), provides evidence of the capture of twenty-seven dorades (seventeen female, ten male). With one exception, they were taken on or near the many shallow-water banks of this area. No ripe females were noted; but ripening females occurred in March in both years. In East African waters ripening females occurred from March to May, and ripe females in May.

These observations suggest that *Coryphæna* makes an inshore spawning migration between February and June in the western Indian Ocean. Confirmation



Catches of *Coryphæna hippurus* (L.)

or otherwise of the movement indicated should be obtained during the future work of the survey.

F. Williams

Inter-Territorial Marine Fisheries
Research Organization,
Zanzibar.
Nov. 19.

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## A Biological Agent for securing Large Numbers of *Amœba proteus*

The role of *Oscillatoria* for purifying freshwater reservoirs is well known. For some years now, I have been applying successfully this biological agent to 'cleaning up' amœba cultures. Ordinary laboratory cultures, unless rigidly controlled, tend to become choked with algæ in the course of time. It is a tiresome manipulation to separate out the amœbæ in sufficient numbers when it is desirable to make a quantity of stained preparations, or to secure the large numbers of young amœbæ which are required when a study of mitosis is being made. If, however, among the algal contents one introduces *Oscillatoria*, the filaments of this grow over and bind together the wheat grains and the algal contents into a cylindrical mass. The rest of the vesicle is quite free from weed; but young amœbæ, some rotifers and small flagellates creep out on to it and multiply, and so a white carpet is formed consisting mainly of amœbæ quite free from debris. These can then be pipetted off into the fixative, or used for a study of mitosis.

If now a new receptacle with water and wheat be prepared, the cylindrical mass can be removed bodily, placed into the prepared receptacle and squeezed, when a new culture results, which will be ready for use in about three months.

Monica Taylor

Notre Dame College,
Dowanhill, Glasgow.

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## Laws of Addition and Substitution in Atomic Reactions of Halogens

Quantitative developments of the observations communicated some time ago[1] on the reaction of N-chlorosuccinimide with toluene has led to a clarification of the reaction mechanism.

Let us, however, consider first the reactions between an organic substance ($R$H) and a halogen ($X_2$) in homogeneous gaseous systems or in non-polar solutions. If the reaction proceeds by atoms and free radicals, the following reactions (substitution *s*, addition *a*) must be expected:

$$X_2+M \rightarrow 2\,X+M \qquad (1)$$

$$X+\mathrm{H}R \rightarrow \mathrm{H}X+R \quad (2s) \qquad X+R\mathrm{H} \rightarrow XR\mathrm{H} \quad (2a)$$

$$R+X_2 \rightarrow RX+X \quad (3s) \qquad XR\mathrm{H}+X_2 \rightarrow XR\mathrm{H}X+X \quad (3a)$$

$$R+\mathrm{H}X \rightarrow R\mathrm{H}+X \quad (4s) \qquad XR\mathrm{H} \rightarrow R\mathrm{H}+X \quad (4a)$$

$$X+XR \rightarrow X_2+R \quad (5s) \qquad X+XR\mathrm{H}X \rightarrow X_2+XR\mathrm{H} \quad (5a)$$

$$2X+M \rightarrow X_2+M \qquad (6)$$

$$X+R \rightarrow XR \quad (7s) \qquad X+XR\mathrm{H} \rightarrow XR\mathrm{H}X \ (\text{or } X_2+R\mathrm{H}) \quad (7a)$$

$$R+R \rightarrow R_2 \quad (8s) \qquad XR\mathrm{H}+XR\mathrm{H} \rightarrow XR\mathrm{H}R\mathrm{H}X \ (\text{or } XR\mathrm{H}X+R\mathrm{H}) \quad (8a)$$

By applying the usual stationary state method, the rate laws in $(X_2)^{1/2}$, $(X_2)$ or $(X_2)^{3/2}$, which were found empirically by Bodenstein, Kistiakowsky, Schumacher, Van Artsdalen and others[2], are obtained. But it can be shown, in agreement with all previous observations, which of these rate laws must be expected in any specific case, by estimating the rate constants, that is, activation energies and partition functions for the eight different elementary steps. A quite satisfactory 'first approximation' is obtained in the following way: it is assumed that activation energies exceed endothermicities by 2 to 5 k.cal.; electronic and vibrational partition functions are assumed to be equal for all particles, and rotational partition functions are calculated neglecting structural particularities.

Further, the rules governing the competition of addition and substitution may be calculated; the ratio of addition to substitution being:

$$r(a/s) = k_{2a}/k_{2s}(1 + k_{4a}/k_{3a}\,(X_2)\,),$$

or for low concentrations of $(X_2)$—the order of magnitude of which can be estimated satisfactorily:

$$r(a/s) = k_{2a}k_{3a}\,(X_2)/k_{2s}k_{4a}.$$

Thus addition is favoured by high, substitution by low, values of $(X_2)$; this explains the 'perturbations' of addition reactions observed, for example, by Schumacher[3].

It has been shown that in the reaction of N-chlorosuccinimide with toluene, traces of impurities (for example, $10^{-6}$ water) lead, in the course of an induction period[4], to formation of H$X$, which yields with N-chlorosuccinimide halogen molecules ($X_2$); the latter give by thermal dissociation the primary halogen atoms. These could now react according to (2*s*) or (2*a*). In the first case, the following reaction chain would be started:

$$X + \mathrm{H}R \rightarrow X\mathrm{H} + R \qquad (a)$$

$$\mathrm{SN}X + X\mathrm{H} \rightarrow \mathrm{SNH} + X_2 \qquad (b)$$

$$R + X_2 \rightarrow RX + X \qquad (c)$$

It can easily be understood that (2*a*) cannot be followed by a rapid reaction: (i) actually the above substitution–addition rule means that (3*a*) is slow as compared to (4*a*) so long as ($X_2$) is low; (ii) the alternative reaction, $\mathrm{SN}X+XR\mathrm{H} \rightarrow \mathrm{SN}+XR\mathrm{H}X$, is only possible if the dissociation energy of the SN—$X$ bond is smaller than or equal to an $X$—$X$ bond; we have several indirect arguments for the contrary. (This reaction is certainly negligible compared with 3*a* because of its high (negative) entropy of activation.)

Thus the reactions (*a*), (*b*) and (*c*) are the only alternative. They explain all the observed facts[4], and we believe that they can be applied also in the case of other reagents giving atomic halogenations. It is not necessary to admit *ad hoc* a 'specificity' of the SN radical, as has been done previously[5].

Actually it appears, for the first time quantitatively, that the high specificity of reagents is due to the concentration at which reagents are maintained in a system, much more than to the inherent specificity of these reagents. We believe that this may have general importance in biological reactions. In fact, more than twenty years ago, one of us (P. G.) was able to discuss this possibility many times with the late Profs. F. Haber and R. Willstätter, when they first suggested the role of atomic and free radical reactions in enzymatic processes[6]; we did not succeed then, however, in putting forward an adequate quantitative model[7].

Two of us (J. A. and P. A. G.) wish to express our thanks to the Institute of Applied Scientific Research (I.R.S.I.A.), Brussels, for fellowships, which have enabled us to carry out this investigation.

JEAN ADAM
P. A. GOSSELAIN
P. GOLDFINGER

Department of Physical Chemistry,
Université Libre de Bruxelles.
Oct. 20.

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[2] For example, Noyes, jun., W. A., and Leighton, P. A., "The Photochemistry of Gases" (Amer. Chem. Soc. Monograph 86, N.Y., 1941).

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[4] Cf. ref. 1 and further details in a forthcoming publication in *Bull. Soc. Chim. Belg.*

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## Dissociative Chemisorption of Carbon Dioxide on Solid Catalysts

THE chemisorbed state or the degree of dissociation of a polyatomic molecule on the surface of a solid catalyst may be important for understanding the catalysed reaction. We know little, however, for example, of the state of carbon dioxide, ethylene and other molecules, or even of such a simple diatomic molecule as carbon monoxide; in the latter case, contradictory views as to whether its chemisorbed state on a metallic surface is molecular or atomic have been put forward.

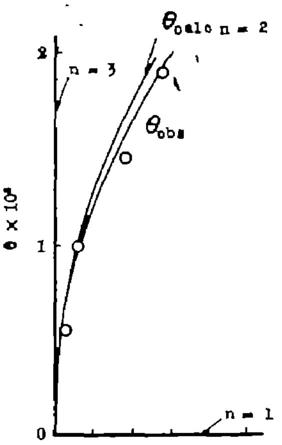
Kwan and Fujita[1] have recently investigated the chemisorption of carbon dioxide on reduced nickel at 200° C. with particular reference to its chemisorbed state, using statistical mechanical considerations, and we conclude that it is completely dissociated into three statistically independent atoms. This statement was borne out by the following fact. Using the heat of chemisorption of carbon dioxide derived from the isotherm for a sparsely covered surface, the fraction of surface covered, θ, was calculated from the expression:

$$\theta^n = \frac{P}{P_0}\exp \Delta\varepsilon/RT, \qquad (1)$$

where $n$ is 1 when the substrate molecule is undissociated at the surface and 2 or 3 respectively for the case when dissociated into two or three parts, $\Delta\varepsilon$ is the heat of chemisorption, $P$ the equilibrium pressure and $P_0$ a constant, being expressed for the present case as:

$$P_0 \doteq kT\,\frac{(2\pi mkT)^{3/2}}{h^3}\,\frac{4\pi^2 IkT}{h^2}\prod^{i}\{1-(\exp-h\nu_i/kT)\}^{-1}\exp 7/2.$$

The fraction covered was also derived from the amount of carbon dioxide chemisorbed and the Brunauer–Emmett–Teller surface area[2] of the adsorbent, assuming that each metal atom at the surface is equally capable of chemisorbing a dissociated particle. This was compared with the coverage given by equation (1) for three different chemisorbed states respectively. It was found that much better agreement between them can be attained when completely dissociative chemisorption, that is, $n = 3$, is assumed.



Chemisorption isotherm of carbon dioxide on copper ferrite at 300° C.

The method of investigation has now been applied to chemisorption on oxide catalysts of spinel type. Copper ferrite, copper chromite and zinc chromite, respectively, were prepared by the usual precipitation from the stoichiometric mixture of the corresponding salt, and dried and ignited in vacuum at 500° C. The 1 : 1 stoichiometric proportion of MeO—Me$_2$O$_3$ was confirmed in each case by chemical analysis and also the spinel structure by X-ray analysis.

The chemisorption isotherm of carbon dioxide was determined at temperatures ranging from 100° to 300° C. and at pressures from $10^{-3}$ to 1 mm. mercury by the same method as that described in a previous paper[3]. The isothermal heat was found to be 31, 21 and 16 ± 0·5 k.cal./mole, respectively, for copper ferrite, copper chromite and zinc chromite. The plot of the coverage against equilibrium pressure, for example, in the case of copper ferrite when $n = 1$,

$\theta_{\text{obs.}}$ AND $\theta_{\text{calc.}}$ FOR CHEMISORPTION OF CARBON DIOXIDE

| Oxide | Wt. (gm.) | Surface area ($M^2$) | $T$ (° C.) | $P$* (mm. mercury) | $\Delta\varepsilon$ (k.cal./mole$^{-1}$) | No. of chemisorbed CO$_2$ molecules per cm.$^{-2}$ | Fraction of surface covered | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | $\theta_{\text{obs.}}$ | $\theta_{\text{calc.}}$ $n = 2$ | $n = 1$ | $n = 3$ |
| CuFe$_2$O$_4$ | 4·2 | 210 | 300 | 0·01 | 31 | $1·3 \times 10^{12}$ | $2·6 \times 10^{-3}$ | $2·8 \times 10^{-3}$ | $7·6 \times 10^{-6}$ | $1·9 \times 10^{-2}$ |
| CuCr$_2$O$_4$ | 1·0 | 43 | 200 | 0·01 | 21 | $2·3 \times 10^{11}$ | $4·6 \times 10^{-4}$ | $4·9 \times 10^{-4}$ | $2·4 \times 10^{-7}$ | $6·2 \times 10^{-3}$ |
| ZnCr$_2$O$_4$ | 3·5 | 103 | 100 | 0·01 | 16 | $4·5 \times 10^{11}$ | $4·0 \times 10^{-4}$ | $4·1 \times 10^{-4}$ | $1·7 \times 10^{-7}$ | $5·5 \times 10^{-3}$ |

* $P$ was taken arbitrarily within the range of the observed chemisorption isotherm.

2 and 3, respectively (denoted by '$\theta_{\text{calc.}}$'), is shown in the accompanying graph. This shows that only when $n = 2$ does $\theta_{\text{calc.}}$ fit closely the experimental value (denoted by '$\theta_{\text{obs.}}$'), which was obtained by assuming that $5 \times 10^{14}$ metal ions or the average numbers of metal ions per square centimetre of the adsorbent surface are equally capable of chemisorbing each dissociated particle. The result is obviously in contrast to that for nickel quoted above. A similar result was also obtained in the case of copper chromite and zinc chromite, as shown in the accompanying table.

As can be seen from the table, if we assume that $n = 1$ or 3, the fraction covered, or $\theta_{\text{calc.}}$, fails to account entirely for the experimental value ($\theta_{\text{obs.}}$) for any of the oxide catalysts, whereas $\theta_{\text{calc.}}$ corresponding to $n = 2$ gives a good fit. Quite apart from the numerical agreement between $\theta_{\text{calc.}}$ and $\theta_{\text{obs.}}$ in the latter case, it seems very likely that the carbon dioxide molecule is chemisorbed with partial dissociation into two particles, that is, presumably into chemisorbed carbon monoxide and oxygen atoms.

Detailed accounts of this work will be published in *J. Res. Inst. Catalysis, Hokk. Univ.* Our thanks are due to Prof. J. Horiuti for his advice.

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Y. FUJITA

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Sept. 29.

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[2] Brunauer, S., Emmett, P. H., and Teller, E., *J. Amer. Chem. Soc.*, **60**, 309 (1938).

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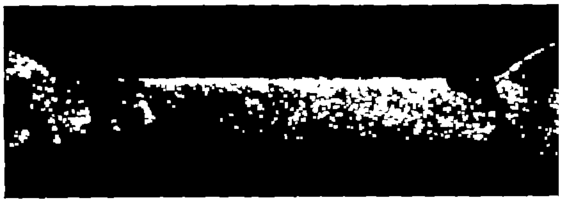
## Preparation of Single Crystals of Titanium and their Mode of Deformation

SINGLE crystals up to 20 mm. × 2·5 mm. × 1 mm. have been prepared in pure titanium by a modified strain anneal technique. Pure titanium of hardness of 90 V.P.N., indicating 0·01 wt. per cent of oxygen plus nitrogen[1], prepared in this laboratory by the van Arkel process, was first arc-melted[2] and then cold-rolled with intermediate annealing at 860° C. to strip in which there was very little preferred texture. By suitably gettering the purified argon used as a protective atmosphere throughout this preparation, the hardness of the titanium was not increased. The grain-size of this strip was fairly coarse and uneven (1–25 grains/mm.$^2$). Tensile strains from 0·05 to 5 per cent did not give large crystals on annealing for 90 hr. at 860° C.; but compressive strains between 0·1 and 1 per cent, followed by similar annealing, produced in one-third of the specimens a crystal occupying the whole cross-section and an appreciable part of the gauge length, as illustrated.

In a less pure titanium (V.P.N. 165, 0·1 wt. per cent oxygen plus nitrogen[1]) the strip had an even grain-size of 20–25 grains/mm.$^2$. Compressive strains produced no appreciable grain growth on the annealing; but a tensile strain of 1¼–2¼ per cent resulted in single crystals.

It is suggested that the purity of the titanium influences the techniques required to produce single crystals because it affects the initial grain size of the strip. It is known that initial grain size is a critical factor in the technique of strain anneal growth[3].



Single crystal of titanium, etched in 8 per cent nitric acid, 8 per cent hydrofluoric acid in water. × about 4

The size required in titanium (25 grains/mm.$^2$) coarse in comparison with the size required in Arm iron (120 grains/mm.$^2$) and is thought to be necessa to reduce deformation twinning during the critic straining. In a specimen with an initial grain si of 100 grains/mm.$^2$ the critical straining induced considerable amount of deformation twinning, an subsequent annealing produced no enhanced grai growth, but the deformation twins did disappear.

During tensile tests in a rigid machine at roo temperature it has been shown that, when suitabl oriented, single crystals of pure titanium slip o (0001) [11$\bar{2}$0] as well as on (10$\bar{1}$0) [11$\bar{2}$0] and (10$\bar{1}$ [11$\bar{2}$0]. Rosi, Dube and Alexander[4] only observe slip on (10$\bar{1}$0) [11$\bar{2}$0] and (10$\bar{1}$1) [11$\bar{2}$0] in work wit coarse polycrystalline titanium made by the Kro process. Slip on (0001) [11$\bar{2}$0] has been shown to b required if the rolling textures in titanium are to b completely accounted for[5]. The critical resolved she stress for slip on the basal plane appears to be high than that for slip on (10$\bar{1}$1), which is in turn high than that for slip on (10$\bar{1}$0). Deformation twinni on (10$\bar{1}$2) and (11$\bar{2}$1) has been observed. Deformatio or kink bands are formed both during basal a (10$\bar{1}$0) slip, and the bend plane has been identifie as the (11$\bar{2}$0) plane at right angles to the operati slip direction. The bent region of the lattice at t boundary of the band exhibits asterism, while t slipped region outside and inside the band does n On annealing, the bent region polyganizes as show by the break up of the asterism into discrete spo and the appearance of boundaries at right angl to the slip lines on the micro structure.

The stress–strain curve at room temperature sho a drop in load required to maintain plastic fl reminiscent of the yield phenomena in iron, b which appears to coincide with the appearance the deformation band.

A more complete survey of these results is in t course of preparation for publication.

I wish to thank Dr. G. A. Geach, leader of t Physical Metallurgy Section of this laboratory, f encouragement and helpful discussion; I also wi to express my thanks to Dr. T. E. Allibone for p mission to publish this paper.

A. T. CHURCHMAN

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April 9.

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[4] Rosi, F. D., Dube, C. A., and Alexander, B. H., *J. Metals*, **5**, (1953).

[5] Williams, D. N., and Eppelsheimer, D. S., *Nature*, **170**, 146 (19

# FORTHCOMING EVENTS

(*Meeting marked with an asterisk * is open to the public*)

## Monday, April 20

Society of Chemical Industry, Crop Protection Panel of the Agriculture Group (at the Chemical Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Annual General Meeting; Dr. J. R. Boer: "Organo-Mercurial Fungicides".

Institution of Electrical Engineers, Education Discussion Circle (at Savoy Place, Victoria Embankment, London, W.C.2), at 6 p.m.—Discussion on "Laboratory Experiments on Protective Gear" (to be opened by Mr. H. P. Young).

Royal Geographical Society (at 1 Kensington Gore, London, S.W.7), at 8.15 p.m.—Mr. Sebastian Snow: "Amazon Adventure".

## Tuesday, April 21

British Psychological Society, Industrial Section (in Room 105, London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 1 p.m.—Dr. Peter F. C. Castle: "The National Institute of Industrial Psychology Foremanship Research, 1948–1953".

Society of Chemical Industry, Agriculture Group (in the Chemistry Lecture Theatre, Royal College of Science, South Kensington, London, S.W.7), at 2.30 p.m.—Dr. H. L. Penman: "Estimating the Water Requirements of Plants".

Institute of Petroleum (at Manson House, 26 Portland Place, London, W.1), at 6 p.m.—Mr. H. S. Gibson: "Two Oilfields in Northern Iraq" (Presidential Address).

## Wednesday, April 22

Institute of Petroleum (at the Institution of Mechanical Engineers, Storey's Gate, St. James's Park, London, S.W.1), at 2.30 p.m.—Symposium on "The Engine Testing of Lubricating Oils".

Institution of Electrical Engineers, Radio Section (at Savoy Place, Victoria Embankment, London, W.C.2), at 5.30 p.m.—Prof. H. M. Barlow and Mr. A. E. Karbowiak: "An Investigation of the Characteristics of Cylindrical Surface Waves"; Prof. H. M. Barlow and Dr. A. L. Cullen: "Surface Waves".

Society of Chemical Industry, Nutrition Panel of the Food Group (in the Chemical Society's Rooms, Burlington House, Piccadilly, London, W.1), at 6.15 p.m.—Dr. W. F. J. Cuthbertson: "Synthetic Food Possibilities"; Mr. P. N. Williams: "Synthetic Fats". Summary of Series by Dr. Norman Wright (Food and the Future, 4).

## Wednesday, April 22—Saturday, April 25

Institute of Metal Finishing (at the Hotel Majestic, Harrogate).—Spring Conference.

## Thursday, April 23

Institution of Chemical Engineers (at the May Fair Hotel, Berkeley Street, London, W.1), at 11 a.m.—Thirty-first Annual Corporate Meeting; at 12 noon.—Mr. Stanley Robson: "Changes in Roasting Practice and Furnace Design" (Presidential Address).

Royal Society (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Sir Geoffrey Taylor, F.R.S.: "Experimental Study of Standing Waves"; Mr. T. V. Davies: "Forced Flow of a Rotating Viscous Liquid which is Heated from Below".

Linnean Society (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Dr. S. M. Manton, F.R.S.: "The Structures, Habits and Evolution of Millipedes".

Royal Society of Arts, Commonwealth Section (at John Adam Street, Adelphi, London, W.C.2), at 5.15 p.m.—Sir Alexander Carr-Saunders: "Colonial Universities To-day" (Holland Memorial Lecture).

Institution of Electrical Engineers (at Savoy Place, Victoria Embankment, London, W.C.2), at 5.30 p.m.—Prof. P. I. Dee, F.R.S.: "The Dilemma of Lord Kelvin" (Forty-fourth Kelvin Lecture).

## Friday, April 24

Society of Chemical Industry, Oils and Fats Group (at the Low Temperature Research Station, Downing Street, Cambridge), at 10.30 a.m.—Symposium on "Oxidation" (Speakers: Prof. C. E. H. Bawn, F.R.S., Dr. C. H. Lea, Dr. A. Banks, Dr. L. A. O'Neill and Dr. J. H. Skellon).*

Institution of Mechanical Engineers (at Storey's Gate, St. James's Park, London, S.W.1), at 5.30 p.m.—Dr. A. T. Bowden, Mr. P. Draper and Mr. H. Rowling: "The Problem of Fuel Oil Ash Deposition in Open-Cycle Gas Turbines".

Television Society (at the Cinematograph Exhibitors' Association, 164 Shaftesbury Avenue, London, W.C.2), at 7 p.m.—Fleming Memorial Lecture.

Society for Visiting Scientists (at 5 Old Burlington Street, London, W.1), at 7.30 p.m.—Discussion Meeting on "Rockets" (Chairman: Prof. A. D. Baxter; Speakers: Dr. A. C. Merrington, Mr. L. Lubbock and Prof. A. D. Baxter).

Royal Institution (at 21 Albemarle Street, London, W.1), at 9 p.m.—Mr. Archibald G. B. Russell: "Tradition and the Coronation".

# APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Assistant Statistician (with a university honours degree in science, mathematics or economics, and some experience of research involving the analysis and interpretation of mass data) in the Central Statistical Office of the Town Clerk's Department—The Town Clerk, Room 30B, Council House, Birmingham 1 (April 25).

Entomologist (male, interest in ecology and mechanical ability important) for work in Insecticides Department primarily in connexion with field experiments—The Secretary, Rothamsted Experimental Station, Harpenden, Herts (April 25).

Mechanical Engineer or Physicist (with first- or second-class honours degree or equivalent in mechanical engineering or physics) at the Royal Aircraft Establishment, Farnborough, to undertake experimental and theoretical work with light mechanisms—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting C.169/53A (April 25).

Physiologist (with good honours degree in physiology or equivalent qualification, and research experience preferably involving the perfusion of isolated organs) for research on the physiology of lactation—The Secretary, National Institute for Research in Dairying, Shinfield, Reading, quoting Ref. 53/3 (April 25).

Statistician (part-time, graduate of a British university, with an honours degree, and statistical experience) in the Health and Welfare Department—The Town Clerk, Town House, Aberdeen (April 27).

Readership in Mathematics at Westfield College—The Academic Registrar, University of London, Senate House, London, W.C.1 (April 28).

University Demonstrator in Animal Nutrition—The Secretary, School of Agriculture, Downing Street, Cambridge (April 28)

University Lecturer in Agricultural Botany—The Secretary, School of Agriculture, Downing Street, Cambridge (April 28).

Assistants (2) in Mathematics, and an Assistant in Statistics—The Secretary, The University, Aberdeen (April 30).

Readership in Chemical Pathology at the Royal Veterinary College—The Academic Registrar, University of London, Senate House, London, W.C.1 (April 30).

Readership in Public Health at the London School of Hygiene and Tropical Medicine—The Academic Registrar, University of London, Senate House, London, W.C.1 (May 1).

Temporary Lecturer (with special reference to horticulture) in the Department of Botany—The Registrar, The University, Manchester 13 (May 1).

Chair of Applied Mathematics—The Registrar, University College, Singleton Park, Swansea (May 2).

Physicist or Engineer (with first- or second-class honours degree or equivalent in physics or engineering) in the Instrument and Photographic Department of Royal Aircraft Establishment, Farnborough, for research and development work in connexion with gyroscopic equipment—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting A.88/53A (May 2).

Readership in Geography, and an Assistant Lecturer in Zoology—The Registrar, Trinity College, Dublin (May 10).

Lecturer in Civil Engineering—The Secretary, Queen's University, Belfast (May 15).

Assistant (male, with a degree in horticulture, agriculture, or botany, together with a keen interest in the scientific aspects of practical fruit culture and ability to convey the results of research to scientists, advisory officers and growers) in the Scientific Liaison Section—The Secretary, East Malling Research Station, East Malling, Maidstone, Kent (May 16).

Organic Chemist (Senior Research Officer grade)—The Director, Laboratory of Human Nutrition, Oxford (May 16).

Senior Lecturer or Lecturer in Coal Mining Engineering at the New South Wales University of Technology—The Agent-General for New South Wales, 56 Strand, London, W.C.2 (May 25).

Assistant Lecturer in Archæology—The Registrar, University College, Cathays Park, Cardiff (May 30).

Senior Lecturer in Physiology—The Dean of the Medical College, St. Bartholomew's Hospital, West Smithfield, London, E.C.1 (June 20).

Assistant Lecturer (with honours degree in physics, preferably with a special interest in illumination or optics) in the Department of Applied Physics—The Principal, Northampton Polytechnic, St. John Street, London, E.C.1.

Assistant Lecturer and a Demonstrator in Organic Chemistry—The Registrar, The University, Nottingham.

Biochemist (with a first- or second-class honours degree in chemistry, and research experience preferably in the field of protein chemistry) in the Endocrine Unit—The Secretary, London Hospital Medical College, Turner Street, London, E.1.

Chemist to assist in laboratory dealing with members' day-to-day production problems—The Printing, Packaging and Allied Trades Research Association, Randalls Road, Leatherhead, Surrey, quoting CH.

Chown Research Professorship in Chemistry—The Principal, Queen's University, Kingston, Ont., Canada.

Engineers or Physicists for Royal Aircraft Establishment, Farnborough: Scientific Officer-Engineer (preferably aeronautical) or Physicist, for research on flutter and vibration problems in aircraft structures (Ref. A.81/53A), and a Senior S.O.-Electrical or Electronic Engineer, for development and application of electrical and electronic equipment in connexion with above research (Ref. D.121/53A)—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting the appropriate Ref. No.

Physicist as Head of the Physics Department—The Personnel Officer, British Iron and Steel Research Association, 11 Park Lane, London, W.1.

RESEARCH STUDENT IN THE CANCER RESEARCH DEPARTMENT, to work on problems concerning the mechanism of enzyme synthesis—The Secretary, London Hospital Medical College, Turner Street, London, E.1.

SCIENTIFIC OFFICERS (with first- or second-class honours degree, or equivalent, in physics or engineering) for operational research on a wide variety of problems, in London and provinces, under direction of Scientific Adviser to the Air Ministry—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.285/52A.

SCIENTIFIC OFFICERS, Grade I and Grade II (with a good honours degree in engineering or mathematics; some research experience in either mechanical or civil engineering is essential for Grade I) IN THE RESEARCH DEPARTMENT (Engineering Division) at Derby—The Director of Research, Railway Executive, 222 Marylebone Road, London, N.W.1.

SENIOR RESEARCH WORKER, and a RESEARCH ASSISTANT, to undertake a fundamental study of the viscosity of liquid metals—The Registrar, The University, Edmund Street, Birmingham 3.

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Air Ministry: Meteorological Office. Geophysical Memoirs No. 89: Temperature and Humidity Gradients in the First 100 m. over South-East England. By A. C. Best, E. Knighting, R. H. Pedlow and K. Stormonth. (M.O.530d.) Pp. 60. (London: H.M. Stationery Office, 1952.) 7s. 6d. net. [92

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Agricultural Research Council. Report Series No. 12: The Technique of Complement-Fixation in Foot-and-Mouth Disease Research. By Dr. J. B. Brooksby. Pp. vi+40. (London: H.M. Stationery Office, 1952.) 6s. 6d. net. [102

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Department of Scientific and Industrial Research: Building Research Station. National Building Studies, Special Report No. 19: The Assessment of Vibration Intensity and its Application to the Study of Building Vibrations. By R. J. Steffens. Pp. iv+18. (London: H.M. Stationery Office, 1952.) 1s. net. [102

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# GOVERNMENT SCIENTIFIC RESEARCH IN GREAT BRITAIN

During the past year there has been evident in Parliament, from time to time, a desire for fuller information regarding the work of the Department of Scientific and Industrial Research. While strong support was forthcoming in a debate in the House of Commons last June for the Advisory Council's plea, in its last year's report, for more continuity in the financial support of the Department's work, members of Parliament are manifestly and rightly concerned to satisfy themselves that the considerable sums concerned, approaching £6 millions in the estimates for 1953–54, are expended wisely and without waste. There has been little criticism of the general basis of the Department's plans to meet post-war needs, though some concern has been expressed at the delay in giving full effect to those plans; and, according to the Department's report for 1950–51, this was even then causing grave anxiety to the Advisory Council.

The report of the Department for the year 1951–52, which has now been published (see p. 716 of this issue), while making a praiseworthy effort to provide the detailed information which Parliament is seeking, is marked by the same note. "Nothing," writes the Advisory Council, "has since occurred to mitigate our anxiety. In fact, we find ourselves reviewing the relation between our scientific needs and our scientific resources with steadily deepening concern." The difficulty of drawing a balance between advisory and *ad hoc* work on one hand, and longer range research on the other, is recognized; but while agreeing with those who, like Sir Henry Tizard, stress the utmost importance of widely disseminating and using to the full existing information, the Advisory Council points to evidence that deficiencies in knowledge have often to be made good before fully satisfactory answers can be found to some of the problems and inquiries put to the Department. These deficiencies will become more serious as industry becomes more conscious of the help to be gained from science, unless the reservoir of scientific knowledge from which answers are derived is enlarged by further research.

"We and our colleagues on the Advisory Boards," continues the Advisory Council, "are already deeply concerned at the inadequacy of the effort the D.S.I.R. Establishments can devote to the longer range research. Basic research is hardly worth doing if the effort that can be devoted to it is insufficient to secure steady progress, and the suggestions made from time to time to reduce the present meagre effort appear to us to be ill-founded. We remain firmly of the view that there is no alternative to the planned expansion of the D.S.I.R. that our predecessors recommended six years ago."

In spite of this comment, however, the Advisory Council gives little or no information as to the present position of what are described in its previous report as the most urgent items in the Department's building programme. After a delay of twelve months due to the standstill on civil building work, work was begun on the second new laboratory building for mechanical engineering research in May 1952, but construction of the Heat Transfer and Creep Laboratories has still not begun. While the expenditure in this field increased from £137,566 in 1950–51 to £267,434 in 1951–52, much work has still to be carried out at the National Physical Laboratory, or at the universities under contract—and this when the industries which the new laboratory will serve are responsible in the aggregate for exports to the value of £750 millions a year and play the most important part in rearmament.

While such slender progress is being made in discharging the Department's obligation to develop the new Mechanical Engineering Research Laboratory as the chief national centre for basic research in all branches of mechanical engineering, progress in the development of the Hydraulics Research Station at Wallingford has been equally slow. The damage done to the coastal defences of Britain by the high tides and gales early this year points to the danger of neglect in this field and the probable cost to the nation of delay. The work of Lord Waverley's committee would probably be greatly assisted had this Station already been fully in operation. Apart from this, as noted in last year's report, important contracts have been lost to Britain through the absence of a centre with facilities for basic research and experiments with models on coast erosion and accretion, the effect of dredging and drainage schemes on estuaries and rivers, and the design of dock and harbour works so as to avoid silting. Experimental work in Britain is still in its preliminary stages, and relies on the National Physical Laboratory and the Imperial College of Science and Technology. Nor does the report indicate whether or not there has been further delay in letting the contract for the erection of the new Water Pollution Research Station at Stevenage or acquiring a site for a new Road Research Laboratory. Design work on the project for the new tank and water-tunnel which was stopped in October 1951 has, however, been resumed; but it appears that, since the project is still "subject to review in the light of the current economic situation", the importance of an up-to-date 'tank' and ancillary equipment for studying the design of ships' hulls is not fully appreciated, although Britain still constructs one-third of the world's shipping.

Some attention is given in the present report to the remaining two matters in the building programme which were stressed last year as specially urgent—the Radio Research Station and the Building Research Station. The hope is expressed that the construction of the permanent buildings on the site at Slough, referred to in the previous report, will be commenced in 1953, but meanwhile the work has to continue partly in huts and partly at the National Physical Laboratory. Apart from a small amount of fundamental research in progress at two universities, with support from the Department of Scientific and Industrial Research, the Radio Research Station is the only establishment in Great Britain doing fundamental work in this field.

The Radio Research Station was one of the three establishments specially visited by the Advisory Council during the past year, and it was noted that at present about half the staff of the organization is engaged in work on propagation and about one-third on research on properties of materials used in radio construction. The Council was impressed by the unanimous opinion which it encountered that, while increased facilities are urgently needed, so that more effort can be directed to problems of importance to the manufacturing side of the industry, this effort should not be obtained by curtailing research on propagation. It was also regarded as essential, in the present stage of the development of radio forecasting, that those engaged in it and in organizing ionospheric observations should continue to work in close conjunction with those carrying out research on propagation. Nevertheless, the Summary of Expenditure appended to the report shows that expenditure on radio research was reduced by some 20 per cent during 1951–52.

We refer later to two features of the Department's work which are well illustrated by the position of the Radio Research Station, and pass to the work of the Building Research Station. The Advisory Council was also impressed by the work of this Station and its practical value to the building and contracting industries. It stresses particularly the investigation of the causes of defects in buildings; the work on thermal and acoustical insulation of buildings and on heating systems; and the work on alternative methods of construction, which has saved the industry much wasted effort. The Station has evolved a cheaper and better mortar, now in general use, and has shown how substantial economy in cement can be achieved in concrete and in external rendering. Current work on the causes of heavy maintenance costs of buildings and on eliminating unnecessary handling of materials during construction is also noted, and an experimental study of the planning of dwellings conducted in co-operation with housewives has led to modifications in the planning and equipping of kitchens which should result in economy in cost and increased satisfaction to the housewife.

It appears that the industry is taking more notice of the results of this work, which are being applied more widely. The Advisory Council is satisfied that, to meet the increasing needs of the industry and to economize in man-power, it is essential that the various branches of the work of the Station should be brought together on a single site with as little delay as possible. The report gives, however, no indication as to the progress made in the reconstruction and extension of the Building Research Station, of which the previous report had stated: "far more remains to be done, including the acquisition of additional land".

In view of this, it is surprising to find in the report of the Committee of the Privy Council that the resources available for building research are to be curtailed. There may be some substance in the view that the staff employed in building research in October 1951 represented an excessive proportion of the restricted total staff available for the Department, and the Committee of the Privy Council points out that when the reduction has been made the non-industrial staff for building research is more than one-seventh of the total for all the Department's research establishments and more than one-and-a-half times as large as that of any other establishment except the National Physical Laboratory. In the estimates for 1953–54, the actual reduction in staff is given as 39 on the 1952–53 figure of 577, and the expenditure as £366,790, compared with £378,904 for 1952–53. Even more surprising is the contrast between this decision and the firmness with which the Government holds to its programme of building three hundred thousand houses a year.

Even if the belief that at the present time this housing programme represents too large a proportion of the country's economic resources is unfounded, it is scarcely consistent with the Government's programme of eliminating waste to hold up investigations into how to build houses more efficiently and cheaply. Doubts as to the wisdom of the economies which the Committee of the Privy Council or the Advisory Council proposes are further suggested by the reference in the latter's report to the Geological Survey. The Survey furnishes reliable advice to industry and to government departments on such matters as mineral deposits, water supplies and the planning of mining operations, and in connexion with the execution of many civil engineering projects. Such advice is usually based on the geological map, on which the geologist records the results of his work; present-day demands for geological information require the compilation of such maps on a scale of six inches to the mile for most areas of Great Britain. When the Department of Scientific and Industrial Research prepared its post-war plans, it was estimated that some 33,000 square miles of Great Britain had not been surveyed on this scale, and the plan of expansion for the Geological Survey then approved provided for the completion of the mapping programme in about thirty years. At the present rate of progress it will take more than one hundred years to complete, and the Advisory Council's plea for additional staff for field-work, and its reference to the delay in dealing with inquiries caused by this slow progress, should be viewed also against the disparity between the expenditure on the Geological Survey and that, for example, on the corresponding surveys of the U.S.S.R. or the U.S.A. Nor would the increase in the estimated expenditure on the Survey to £176,706 in the 1953–54 Estimates, compared with £164,817, appear likely either to increase appreciably the rate of progress or diminish that disparity; expenditure in the United States before the Second World War was already £1 million compared with £70,000 in Great Britain.

Apart from expenditure on building research and on the National Physical Laboratory (reduced from £721,855 in 1952–53 to £666,785 in 1953–54), the 1953–54 estimates for the Department of Scientific and Industrial Research show slight increases over the estimates for 1952–53; only for radio research is there a significant increase—from £14,903 to £74,649, with an increase of 87 in the staff, to a total of 112. The impression derived from the estimates in the light of this report is of trifling and indecision, and a failure to grapple with the real issues. The resources of the Department appear to be spread too thinly over too wide a range of activities, and the Advisory Council appears to be reluctant to take the ruthless action which would really bring home to the nation and to the government the price which may be paid for niggardliness where research is concerned.

But it is not merely that proposals, such as the Committee of the Privy Council makes, for cancelling authorized vacancies in staff, are as likely to cause waste as economy: there is to be sensed something of a rift in outlook between the Committee of the Privy Council and the Advisory Council. It is hard to reconcile the former's decision, though reluctant, "that some contribution must be made by the Department in the general economies that are being made in the government service as a whole", with the "steadily deepening concern" of the Advisory Council. Nor does the effect of this decision "not to eliminate any major plan or activity, but to slow down some work and to arrest, for the time being, most of the planned expansions of activities" easily harmonize with the Advisory Council's firm view that "there is no alternative to the planned expansion of the Department of Scientific and Industrial Research that our predecessors recommended six years ago". Elsewhere, in concluding its report, the Advisory Council adds: "We are, however, becoming more and more convinced that science will never be adequately used in this country until many more scientists and technologists are employed throughout industry, not omitting the direction and management". Ostensibly the words are directed at industry and call for wider provision for higher technological education; but the Advisory Council could equally be aiming them higher.

That passage, however, concludes a discussion on technical information services and the measures being taken by the Advisory Council to stimulate the utilization of existing knowledge by industry. Reference is made here to the survey of technological resources and the requirements of industrial firms in the north-west of Britain now being conducted by the Manchester Joint Research Council; but the summary of expenditure this year does not disclose the expenditure on intelligence. With the Committee of the Privy Council's decision to seek its main economies, after building research, in the headquarters office, the omission may or may not be significant. The estimates for 1953–54 show a reduction of £14,292 in headquarters expenditure; but whether or not that has curtailed the activities of the intelligence division, the possibility of some degree of overlapping may merit examination; thus there is no clear justification in the report for the grant of £15,000 during the past three years to the Association of Special Libraries and Information Bureaux.

To suggest that major and minor activities of the Department should be rigorously scrutinized and ruthlessly pruned where their continuance on the existing scale cannot be justified in the national interest is not to advocate the reductions in the present effort which the Advisory Council regards as ill-founded. It may be the only way to overcome the obstacles hindering the development of the Department's plans to which the Advisory Council refers, for unless the resources at the disposal of the Department are very considerably expanded, only concentration of effort on carefully selected fields and objectives, and the elimination of some major activities, will permit the effective pursuit of the selected objectives and avoid increasing frustration, waste of effort and fruitless dissipation of resources. The Advisory Council appears to be aware of this danger, but it has failed so far to give such a lead, and the Committee of the Privy Council rejects the policy.

The dangers of the present situation are not confined to the Department. The Department has now an established and recognized place in the organization of research in Great Britain, and whatever criticism may from time to time have been made of the scale of its operations and the appropriateness of some of its research projects, there has been no suggestion that its activities should be seriously curtailed. Little has, in fact, been heard of late regarding the appropriateness of the research associations as a means for prosecuting industrial research compared with the research organization within industry. Indeed, it now seems to be accepted, even by those who lean to the adoption of the sponsored research institution of the Mellon Institute type as supplement or alternative, that they have a marked field of their own, not only in operational research but also in the dissemination of information and in technological training.

The general value of the Department's work is well attested by the present report alone; but so also is the extent to which its work is interlocked with the rest of the research effort of Great Britain and, to some extent, its provision for higher education. Proposals for expansion or curtailment or reorganization of the Department cannot be considered in isolation; this is well illustrated by the Department's relations with the universities. The Department makes very considerable grants over periods of years to the universities for special investigations. It also spends some £250,000 on grants to students and senior research awards at the universities; but it appears from the present report that the Department to some extent relies upon the universities to carry out investigations under contract which its existing establishments are unable to pursue. This is notable in radio research, for example, in hydraulics and in mechanical engineering, and in the present situation there would appear to be a distinct danger that the policy may be pushed too far. Sir John Stopford recently expressed concern that the large increase in the external public responsibilities of the universities since the Second World War might deflect university staffs from their primary duty of teaching and research. Sir John thought that the universities should reject the heavy responsibility of research enterprises too big for the limited resources of a university.

Others besides Sir John Stopford have expressed concern at the possible effect of sponsored research on university work; and the implications of this trend should be given more attention by the Advisory Council than appears from this present report. Allied to this question is that of the proper balance to be struck between fundamental research and *ad hoc* short-term investigations. That is never an easy decision, particularly when some of the *ad hoc* investigations and the testing work strengthen the contact between the Department's staff and industry. Nevertheless, it would appear from the Advisory Council's comments on radio research and some other activities that there is danger of testing work absorbing an undue proportion of the effort of some establishments. The possibility of transferring such testing work to a separate bureau or organization with no responsibilities for research appears to merit examination. If it could be effected, such a transfer would remove one factor which encourages an exaggerated view of the extent of the Department's true research effort.

That, and the relation of the Department's work to the general research effort of Great Britain and also to the universities, are matters to which the Lord President of the Council and his Committee should be addressing themselves with vision as well as urgency. On the disposition of the Department's own resources, the Advisory Council could do something more than reiterate its predecessor's recommendations for planned expansion. A more detailed and forceful exposition of the value of the Department's work to the nation seems also to be required.

Clearly, the Advisory Council cannot immediately survey the activities of all its establishments in the way that it has examined those of three of the research associations. It should not be impossible, however, to cover with reasonable speed and thoroughness in some such way those features of its work which in last year's report were singled out for special mention as in urgent need of expansion. If the case for such expansion were thus presented to the Lord President of the Council and to Parliament, backed by the Advisory Council to the extent of resignation or to the re-allocation of the present resources to other purposes where they could be more effectively used, it is hard to believe that the position would not be reconsidered by the government.

Last year's report raised the crucial issue of reasonable year-to-year financial flexibility for the Department, and the present report fully emphasizes its importance. That issue is, however, now completely over-shadowed by the fundamental one of the whole future of the Department. Whether its activities are to be expanded, reorganized or considerably curtailed can only be wisely determined in the light of a national policy for science and technology. It is to be hoped that the Advisory Council's present call for help will be noted by the Parliamentary and Scientific Committee and other bodies able to influence the government. The present unsatisfactory situation should be ended, and the future activities of the Department reviewed in the light of a policy taking full account of the nation's resources in materials and man-power. Only in the light of such a review and policy can wise decisions be made which will enable the Department to concentrate its resources on the approved objectives, in the confidence that those resources are adequate to the task, and that it can offer the conditions of service which will attract —and retain—scientists and technologists of the high calibre required.

# PREHISTORIC AMERICA AND POLYNESIA

## American Indians in the Pacific

The Theory behind the Kon-Tiki Expedition. By Thor Heyerdahl. Pp. xv+821+90 plates. (London: George Allen and Unwin, Ltd.; Stockholm: Bokförlaget Forum A.-B.; Oslo: Gyldendal Norsk Forlag, 1952.) 70*s.* net.

THOR HEYERDAHL is an enthusiast. His epic 'Kon-Tiki' raft-voyage across the eastern Pacific, enduring privation and risking death, was undertaken to support a theory. His latest book, massive and lavishly illustrated, presents the evidence for that theory, whole-heartedly, persuasively, and often uncritically.

The theory is ingenious. It is, briefly, that the evidence for the generally held idea of the Asiatic origin of the Polynesian people and Polynesian culture is quite inadequate, and that two streams from the American continent have been responsible. The first, Heyerdahl argues, went raft-borne from the Peruvian coast in pre-Inca times, approximately about A.D. 500. These were the people who provided the "Caucasian-like elements" of strongly-bearded, light-skinned, fair-haired folk mentioned in Polynesian tradition and by some early European voyagers. They were responsible, he holds, for introducing cotton, sweet potato, gourd and many other plants to Polynesia, and for many cultural items, notably the sculpture of huge anthropomorphic statues in stone, of which the best-known examples are on Easter Island. But, it is pointed out, the present-day Polynesians do not make much use of rafts—they are adept in the manufacture and use of canoes. Moreover, before Europeans came, they were ignorant of the loom, of pottery, of cereal cultivation and of other features characteristic of Central and South American cultures. Hence, Heyerdahl postulates a second stream of immigrants, a Kwakiutl-type of people arriving from Queen Charlotte Sound, British Columbia, where these items were lacking, about the beginning of the present millennium. It is these so-called "Maori-Polynesians" who are held to be responsible for the large canoe-hulls of Polynesia, and for many other cultural features, including adzes, rectangular plank houses, massive timber-carving, short striking-clubs, fire-walking and cannibalism.

The author builds up a case for Amerindian relationships and stimulus in Polynesia that is far stronger than any advanced hitherto. Among his most telling points are: the favouring effects of the major eastward movement of prevailing winds and currents; the sailing possibilities of the Peruvian balsa raft; the (so far) admitted American origin of the sweet potato and of the 'native' Polynesian cotton with its twenty-six haploid chromosomes; the lack of the *B* blood-group among Polynesians as against its prevalence in South-East Asia; and the striking superficial similarities and suggestive distribution of certain types of Polynesian and Amerindian sculpture. But much of what the author treats as proof will appear to many anthropologists, even to those with no axe of origins of their own to grind, as only surmise of more or less plausibility.

One difficulty is that much of the argument rests on seizing quite general similarities as significant of some kind of connexion. The division of the Indian society of the north-west Pacific coast into three separate social classes—aristocracy, commoners, slaves—is said to be "followed closely" by the Maori, the Society islanders and some other Polynesian groups, who "strictly adhered to the same division" (p. 141). As regards land tenure, it is stated that "the state was completely communistic among both the northwest Indians and the Maori-Polynesian tribes" (*ibid.*). This amateurish kind of expression is valueless in investigating relationships; it ignores basic elements in structure and organization. Moreover, comparisons which show differences are apt to be neglected. The Polynesians are stated to have had a system of patriarchal clan units, with marked analogy among the Kwakiutl, who "reckon descent usually in the father's sept, and *marry into some other*" (my ital., p. 141). Even granted the propriety of the "patriarchal clan" notion, which the complexities in both societies render dubious, it should be pointed out that on Heyerdahl's own quotation from Goddard, as well as according to data from Boas, the Kwakiutl are primarily exogamous, whereas the Polynesians are not.

Again, far too much reliance is placed on genealogies, myth and tradition in tracing connexions. Recent work in anthropology has shown that such memory material is to be interpreted primarily as a clue to contemporary social relationships; its value as a historical record is very limited. This caution is especially necessary if one attempts to use translations of Polynesian proper names. The many homophones to be found in Polynesian—and it does not appear that the author speaks any Polynesian dialect well—make it highly conjectural to assign a meaning to such a name unless one knows the circumstances in which the name was bestowed. The author translates, for example, *Tu-te-rangi-marama* as "Marama, the Sacred of the Heaven" (p. 722); *Mata-ki-te-rangi* as "Eyes Facing Paradise" (p. 756); and *Vaka-akau-uli* as "Steersman-of-log-craft" (p. 726). When we know that these could be also translated much more prosaically as "Tu of the bright sky", "Face to the sky", and "Canoe of dark wood", they lose their alleged importance as migration indicators. The various sun-god equations of the Polynesian Tangaroa with the Peruvian Kon, and of Tiki or Maui-tikitiki with Ticci are far-fetched. And to state that a connexion between a stone talisman, *mauri*, and the ocean-voyaging culture-hero Maui "cannot be proved, but is etymologically very possible" (p. 245), because early Polynesian voyagers are said to have taken such talismans with them in their canoes, is too casual.

In his anxiety to leave no loose ends, the author brushes negatives aside. The Polynesians had no pre-European cereals. Yet maize was a characteristic food-plant in the Peruvian area from which the author supposes them to have come. How did it escape them? By having been lost during the landing of the Amerindian craft through the surf on Polynesian reefs, or by having failed to give a successful crop after having been sown, he answers. But the question does not really interest him. The absence of pottery from Polynesia, too, attracts discussion only to demonstrate the lack of relation with South-East Asia, whereas no very cogent reasons are given to explain why pottery should not have been brought from Peru, where it had reached a high state of development by the time that the ancestors of the Polynesians are said to have left.

Finally, the author rather overdoes his argument about the virtual impossibility of the ancient Polynesians making headway against the trade winds and the prevailing currents—the "one-way ocean escalator from Peru westwards". Elsdon Best and S. Percy Smith have pointed out three factors which are relevant for voyages in the opposite direction. First, the prevailing winds do not prevail always. Winds, often of considerable strength, blow for significant periods from west-north-west or north-west or even south-west. Secondly, Polynesian canoes could beat to some extent against a contrary wind, helped by the long steering-oar. Thirdly, in a contrary wind that was not too strong the Polynesian often paddled his craft. Moreover, the effects of the equatorial counter-current, variable and weak as it often is, are not to be dismissed. Without decrying the author's magnificent achievement on his raft, it may be fairly said to have involved seamanship rather than sailing skill, and one receives the impression that he consistently undervalues what an oceanic sailing canoe can do.

Despite its huge amount of material, the book is ably written, with a lively style, and the argument is cleverly presented. Provided the reader is prepared for an all-out statement rather than the dispassionate examination of the case, he will be interested and even entertained. But also he should remember that the problems discussed are not those which most anthropologists regard as most important in the Pacific to-day.

RAYMOND FIRTH

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# SCIENTIFIC THOUGHT OF THE EARLY NINETEENTH CENTURY

## Genesis and Geology

A Study in the Relations of Scientific Thought, Natural Theology and Social Opinion in Great Britain, 1790–1850. By Charles Coulston Gillispie. (Harvard Historical Studies published from the income of the Henry Warren Torrey Fund, Vol. 58.) Pp. xv+315. (Cambridge, Mass.: Harvard University Press, 1951.) 30*s*. net.

THE author of the book under notice is not a geologist, or even a scientist, but is assistant professor of history at Harvard. "Genesis and Geology" is rather a forbidding title, reminiscent of a type of book published in considerable numbers and widely read during the first half of the nineteenth century. It recalls, for example, the Rev. John Pye Smith's "Relations between the Holy Scriptures and Some Parts of Geological Science", published in 1839, which attained five editions. In fact, Prof. Gillispie's book is an interesting, well-written, scholarly and at times even amusing study of the relations between scientific thought, natural theology and social opinion in Britain between the years 1790 and 1850.

Its publication arose out of the author's special interest, as a historian, in the nineteenth century, and his belief that issues stemming from the growth and dissemination of science may be approached by the historian as problems of intellectual history. Such studies he regards as desirable for the understanding of science as well as history. Because so much has been written about the period following the publication of Darwin's "Origin of Species", Prof. Gillispie concluded it would be more profitable to examine the preceding half-century, a period when the relation of science to religious beliefs was very much a matter of public concern. As a result, inevitably, he found himself forced to study the development of geology, rather than biology, for that was the golden age of geology. It was then the most popular science with the British public, with many followers on the Continent, and in the United States, too. Moreover, the period covered encompassed the publication of two outstanding geological classics, Hutton's "Theory of the Earth" (1795) and Lyell's "Principles of Geology" (1830–33). At about this time, however, some well-known geologists issued works the titles of which showed that they still had no difficulty in reconciling the new geology with the Mosaic account of Creation. A well-known example is Dean Buckland's "Reliquiæ Diluvianæ, or observations on the organic remains in caves . . ., and on other geological Phenomena attesting the action of the Universal Deluge" (1823). In addition, numerous works by naturalists with little or no claim to eminence appeared, with the definite object of reconciling the latest geological views with religious beliefs. An example is the book by the Rev. John Pye Smith, to which reference has been made above. Finally, the publication of Robert Cambers's "Vestiges of Creation" (1844) and Hugh Miller's counterblast, "Footsteps of the Creator" (1847), formed a link with the Darwinian period.

The excitement caused by the publication of the "Origin of Species" was not new in kind. Earlier discoveries, particularly in geology, had seriously challenged not only the literal interpretation of the Book of Genesis, but also the traditional and widely held belief that Providence controls the order of Nature to fulfil a divine purpose. The "Origin" added fuel to a fire already burning.

Here, then, is a book to be read especially by all who wish to appreciate the scientific and social background of the half-century or so preceding the publication of Darwin's "Origin of Species". It is carefully documented and includes, as well as upwards of six hundred text references, a bibliographical essay. It should also be consulted by geologists interested in the history of their subject, more especially because very many of the sources noted will not be found in standard histories of the subject.

V. A. EYLES

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# IMPACT OF MAN ON BRITISH WILD LIFE

## The Changing Wild Life of Britain

By H. L. Edlin. Pp. viii+184+36 plates. (London: B. T. Batsford, Ltd., 1952.) 21*s*. net.

THE wild life of Britain has been subjected to constant changes from the earliest times through the influence of man, who has introduced new plants and animals, driven others away, and altered the environment of those that have survived his interference. The dominating factor in the life of any wild animal in Britain to-day is its relations to man; "running parallel with the social, agricultural and industrial revolution of our human society, there has been a gradual change in the wild life of the country-side, which is still far from ended. Every change in methods of husbandry, sporting customs, or even the ownership of land, has aided certain organisms and upset others". This book deals with some of the more obvious changes that have taken place in the British flora and vertebrate fauna.

About two-thirds of the book is devoted to the fauna, mainly the mammals and birds, and the rest to the flora. Four chapters are given to mammals: the deer, the carnivores, the rodents, and the semi-domesticated cattle, sheep, goats and ponies that have free range over some of the moors and mountains in Britain—the last a chapter of much interest. The probable origin of these animals, and of some of the domestic breeds, is discussed, and the enormous influence that sheep-grazing has had on the character of the British flora and fauna is emphasized. "The implications to the naturalist are obvious—he will seek in vain for 'natural' vegetation over most of the British Isles; what he will find will be sheep induced, or at least sheep influenced, vegetation."

The section on birds points out that, although several species have been unable to withstand changed conditions and are no longer British breeding birds, only one, the great auk, has become extinct. On the other hand, many introduced species, especially among the waterfowl, have now become naturalized and are established members of the fauna.

The story of the flora is one of continual enrichment; only a few rarities have been lost, but scores of ornamental plants, weeds, and even forest trees have been introduced deliberately or by accident. The account of the introduced trees is particularly well done, as would be expected from the author's professional connexion with forestry.

The book admirably succeeds in its purpose of giving a survey of the endless changes wrought by man upon his surroundings. It is full of information presented in an attractive form; it is well written, and illustrated with many good photographs. The text is also embellished with numerous figures, but many of the reproductions of Bewick's wood engravings have, unfortunately, been enlarged and printed on paper too coarse to do justice to the delicacy of the originals. The more open woodcuts taken from "Matthiolus" to illustrate the plants are much more successful.

In a book of this nature that covers so wide a field in such detail there are bound to be some points on which a carping critic might check the author. But they are minor matters; the book can be warmly recommended to all naturalists.

L. HARRISON MATTHEWS

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# CONFORMAL REPRESENTATION

## Conformal Mapping

By Prof. Zeev Nehari. (International Series in Pure and Applied Mathematics.) Pp. viii+396. (London: McGraw-Hill Publishing Co., Ltd., 1952.) 64*s*.

## Conformal Representation

By C. Carathéodory. (Cambridge Tracts in Mathematics and Mathematical Physics, No. 28.) Second edition. Pp. ix+115. (Cambridge: At the University Press, 1952.) 12*s*. 6*d*. net.

CONFORMAL representation is a many-sided subject, of interest to geographers, physicists, mathematicians and engineers. It started with problems of mapping, but developed into the theory of functions of a complex variable. Valuable contributions were made by Riemann, who stated the fundamental theorem that any simply connected domain can be conformably mapped on a circle. His proof was based on Dirichlet's Principle and used intuition to infer the existence of a function with certain properties. Another proof is based on boundary-value problems and the Green's function. Modern writers prefer a third method, using only the theory of functions. It is a great merit of Prof. Z. Nehari that in his book, "Conformal Mapping", he has combined an account of modern methods with a return to the spirit of Riemann, and has written for the physicist and engineer as well as for the mathematician. To make the book self-contained except for a knowledge of calculus, the first four chapters give an account of harmonic functions, analytic functions, the complex integral calculus, and families of analytical functions. The chapters are stated (not quite convincingly) to be suitable for those with no previous knowledge of these subjects. The preliminary informal discussion of Montel's normal families in Chapter 4, showing why the investigation is necessary, is admirable. These introductory chapters occupy about one-third of the book. Chapter 5 starts with the mapping properties of analytical functions, the 'linear' (or bilinear) transformation, and Schwarz's lemma, and then proves the fundamental theorem. Chapter 6 gives the mapping of certain special functions, including elliptic and elliptic modular functions. Chapter 7 deals with the conformal mapping of multiply-connected domains, including a careful treatment of the Green's function and Dirichlet's Principle, of which a preliminary account was given in Chapter 1. The book concludes with an index, but no bibliography or references to original papers. There are many problems and exercises in each chapter.

A few points for criticism can be made. The statement (p. 32) that the results in the previous sections concerning harmonic functions "are true regardless of whether the domains in question are simply-connected or multiply-connected" is open to doubt. The conditions for which Cauchy's integral theorem are applied (p. 183) do not seem to be included in those for which it is proved (pp. 84–8). The treatment of the Schwarz–Christoffel formula (pp. 189–198) and of the Joukowsky aerofoil profile (p. 271) might be improved by the addition of references from which the reader could obtain further details. However, as a whole, the book is very good.

The first edition of Prof. C. Carathéodory's excellent tract on "Conformal Representation" appeared in 1932. The first three chapters gave a simple account, suitable for beginners, of the 'Möbius' (or bilinear) transformation, non-Euclidean geometry and elementary transformations. The remaining four chapters were much more advanced and dealt with the fundamental theorem and related topics by the most refined modern methods, eliminating all traces of the early approaches and, in particular, of the physical ideas by which Riemann was so much influenced. To a beginner such a treatment may appear artificial, but the advanced student can realize its merits.

The present second edition, of which the manuscript was completed by the author before his death in 1950, contains an excellent extra chapter on the general theory of uniformization, which uses the method of van der Waerden to prove the celebrated theorem of Poincaré and Koebe. The bibliography and notes have been rewritten and form a valuable guide to further reading.

H. T. H. PIAGGIO

# DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH

## REPORT FOR THE YEAR 1951–52

THE report of the Department of Scientific and Industrial Research for the year 1951–52* includes a brief covering report from the Committee of the Privy Council, over Lord Salisbury's signature, and the thirty-seventh annual report of the Advisory Council, signed by Sir Ian Heilbron, together with the usual summary of work carried out by the various research stations and boards and research associations. The appendixes include a classified list of departmental publications issued during the year, besides lists of assessors to the Advisory Council and of members of the research boards of the Department, of research associations and of grants for special investigations in progress during the year. While the report is an indispensable work of reference on the activities of the Department and is a very readable account of what Britain is getting for the £6 millions provided for these activities in the 1953–54 estimates, with its rising price the report is less than ever a popular account but rather one addressed strictly to the scientific and industrial world.

The gross expenditure of the Department for the year ended March 31, 1952, was £5,452,165, as against £5,007,822 in the previous year; this was reduced by receipts from various sources to £4,956,819, the net increase on 1950–51 being £402,397, and on 1949–50, £1,033,037. The staff of all grades employed in the Department on October 1, 1952, was 4,035 (including 149 part-time), a decrease of 53 compared with the previous year. The largest single item of expenditure was, as usual, the annual grants to research associations, totalling £1,334,863, besides special grants of £52,624. Gross expenditure on the National Physical Laboratory was £840,439, reduced by receipts to £559,335 net. Grants for special researches amounted to £313,693, a decrease of £74,209; and the list of grants for special researches in progress during the year ending September 30, 1952, is of interest in connexion with the recent argument in favour of giving the Department at least the right to carry over unspent money from year to year, if not to extend to the Department the principle of quinquennial grants so as to stabilize its budgetary expectations on a longer-term basis. The majority of the grants listed are spread over a period of years, the largest five being £487,500 to the University of Liverpool for the construction of a 400-MeV. proton synchrocyclotron for nuclear research, £317,700 to the University of Glasgow for the construction of a 300-MeV. electron synchrotron for nuclear research, £231,500 to the University of Birmingham for the construction of a 1,000-MeV. proton synchrotron for nuclear physics research, £191,000 to the University of Oxford for construction of a 140-MeV. proton synchrotron for nuclear physics, and £168,000 to the University of Manchester for radio-astronomy covering from four to six years.

Grants to students amounted to £251,241 net, an increase of £14,529. Net expenditure on mechanical engineering was £267,434, an increase of £129,868; on the Geological Survey and Museum £196,552, an increase of £38,351; on road research £273,259, an increase of £29,277; on the Chemical Research Laboratory £96,523, an increase of £22,346; on hydraulics £53,082, an increase of £27,084; and on fuel research £219,154, an increase of £15,223. Net expenditure of £498,123 on building research, £22,805 on fire research, £185,949 on food investigation, £97,288 on forest products research, £51,632 on pest infestation, and £55,842 on water pollution was of the same order but slightly higher than during 1950–51, while expenditure on radio research was £23,016, a decrease of £6,590. Net expenditure on headquarters administration, etc., was £208,029, and on overseas liaison £66,086, while research contracts again decreased to £34,310 compared with £70,606 during 1950–51. Expenditure on the Provision of Technical Equipment under American Aid increased from £498 to £97,433.

The number of students-in-training was 923, compared with 910 during 1950–51, and, of these, 384 were new. The senior research awards were thirteen in number, of which nine were new, compared with ten in 1950–51, and thirty-eight new grants for special investigations brought the total of such grants to ninety-one, compared with ninety-five in 1950–51. The preponderance in chemistry and physics continued: of senior research awards, five were in chemistry, six in physics and two in engineering; and of the grants for special investigations, twenty-six were in chemistry, forty-one in physics and fourteen in engineering. Of the grants to students, 390 were in chemistry, 276 in physics, 73 in biology, 71 in engineering, 48 in mathematics and astronomy, 38 in geology and mineralogy, and 27 in metallurgy.

The note of anxiety which characterized the report for last year recurs, both in the report of the Committee of the Privy Council and in that of the Advisory Council itself. The reasons for this anxiety and the implications of the measures adopted to meet the financial situation are discussed elsewhere (see p. 709). Apart from this, the most important feature of the former report is the intimation of the decision, in conjunction with the Committee of the Privy Council for Medical Research, and with the subsequent approval of the Lord President of the Council, to appoint two joint committees to study human problems in industry (see *Nature*, April 18, p. 684). The first, the Committee on Individual Efficiency in Industry, will be asked to keep under review the progress of knowledge bearing on the technical efficiency of the individual in industry, advise on general policy in research in this field, direct attention to gaps, make recommendations for filling them, and to consider and report from time to time on the requirements for the training of research workers and technologists in this field. The second, the Committee on Human Relations in Industry, will examine current activities concerning the study of human relations in industry and direct attention to problems of special timeliness and promise on which research might be undertaken or supported by the Department of Scientific and Industrial Research and the Medical Research Council, or other bodies.

The membership of these Committees was announced in the House of Commons on March 24, and the reasons for the decision to appoint the Committees are briefly indicated in a section of the Advisory Council's report. Fundamentally, they arise out of the recognition that the successful introduction of new methods and new equipment depends largely on human factors and that, while the responsibilities of the Medical Research Council and the Department of Scientific and Industrial Research in such matters as affect individual efficiency can be quite clearly defined, a joint approach to the whole field offers real advantage. Human relations are less tangible and more difficult to handle, and both Councils believe that a joint committee, with the first task of reviewing what is being done in this field in Britain and abroad, offers the best means of selecting the most promising lines of work for support by either Council.

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* Department of Scientific and Industrial Research. Report for the Year 1951–52. (Cmd. 8778.) Pp. 203. (London: H.M. Stationery Office, 1953.) 8*s*. net.

Apart from this, and from the financial situation of the Department, the chief features of the Advisory Council's report are the comments on the increasing interest of the research associations in operational research, on the recommendations of the Cremer report regarding research in chemical engineering, on technical information services, and on the Advisory Council's visits during the year to establishments of the Department. These included the Geological Survey and Museum of Practical Geology at South Kensington, the Building Research Station and the Radio Research Station; and the Advisory Council once again expressed itself as being well satisfied with what it saw and with the manner in which the directors are endeavouring to meet the demands on their restricted resources. In regard to operational research, the report comments on the value of such work in showing where laboratory research can be most profitably directed, and in the experience which it gives the man of science of working with all kinds of people in an industry. The pioneer work of the Cotton Research Association and the Boot and Shoe Research Association in this field is well known, and the Wool Industries Research Association has now made a close study of faults and irregularities in wool cloth, showing in which of the various stages from preparation to finishing they originate. Since the industry, until recently, employed about one mender for every two weavers, this investigation bears on the use of man-power, as well as on quality. An analysis has now been made of the time required for mending each type of fault and the frequency of its occurrence, thus enabling priority in planning research to be given to the investigation of those faults which are economically the most important, and the industry has shown great eagerness to apply the results of these studies in the mills.

An operational research team set up by the Joint Iron Council and the Cast Iron Research Association has visited more than two hundred foundries during the past two years, and the information gained is leading to the wider adoption of sound and economical practices throughout the industry. A statistical survey of children's feet carried out by the Boot and Shoe Research Association has led to the development of a new series of lasts for children's shoes, which, besides greatly increasing the ability of the industry to make children's shoes fit accurately and comfortably, is of importance for the export market. The Iron and Steel Research Association is making a survey to assess the optimum size of ships that can be handled at the principal ports from which iron ore is dispatched to Britain, and is also studying unloading methods to discover the reasons for the rapid discharge of ships at certain foreign ports and the applicability in Britain of the techniques employed.

In regard to the Cremer report, the Advisory Council agrees that the national interest demands a central organization working in collaboration with manufacturers so as to ensure correlation between basic research and actual operation, but the Association of British Chemical Manufacturers and the British Chemical Plant Manufacturers' Association have already arranged to make a more detailed study of information that is available in industrial research establishments and of the resources of these establishments for carrying out further investigations. The survey is expected to take a further six to twelve months and to lead to the establishment of a properly staffed documentation unit. In view of the emphasis laid by the Cremer Committee on improved documentation, arrangements have been made by the Department of Scientific and Industrial Research to prepare bibliographies of selected topics; one on drying has been completed, and another, on crushing and grinding, has been initiated in co-operation with the Institution of Chemical Engineers.

A feature of the summary of work is the increased proportion of space given to the work of the research associations. This is in accordance with the trends of recent reports; it now occupies some 115 pages, as against 72 pages for the work of the research establishments of the Department. The work of the Chemical Research Laboratory and of the National Physical Laboratory has recently been reviewed in these columns, and, from the accounts of the work of the other establishments and the research associations, only a selection can be here made to illustrate the range and extent of the contribution which they make to the national welfare and economy. That of the Joint Fire Research Organization, for example, is preventive rather than of direct value in relation to increased productivity, and is planned mainly in relation to the needs of the various government departments which have responsibilities in connexion with fire protection, and to assist the Fire Offices' Committee and local authorities in framing their requirements. Annual losses from fires usually amount to about £24 millions, approximately half of which is from large fires involving more than £10,000 damage each, and against such figures the significance of the work on smouldering, on the study, with the use of models, of the growth of fire, on the use of water and foam in fire extinction and on dust explosions can be appreciated. Analysis of fire statistics indicates that, while the rate of incidence of fire in television receivers continued to decrease, the hazard is still three times as much as that with radio sets.

Under the Food Investigation Organization, in view of the importance of the problems of storage of home-produced beef, work is being concentrated on improving the quality of frozen meat through the controllable factors prior to slaughter and during storage. Two members of the staff of the Low Temperature Research Station, Cambridge, are working during 1952–53 in the Abattoir Laboratories at Brisbane of the Australian Commonwealth Scientific and Industrial Research Organization and will apply to beef animals on a commercial scale the techniques which have shown promise on the laboratory scale at Cambridge. Preliminary experimental shipments indicate that the better the initial quality of the meat, the less the damage suffered as a result of freezing. Surveys have continued of the wastage and deterioration which occur during the distribution of lettuce, plums, strawberries and Cornish broccoli to the home market, and also experiments on the best storage conditions for certain new varieties of apples and pears. Work on the production of heat by potatoes stored in bulk has permitted general recommendations regarding the height of stacking and the need for ventilation, and progress has been made in identifying some of the many compounds shown by chromatographic methods to be present in apples. Basic investigations have related to the recovery of ascorbic acid from aqueous extracts of lucerne, and a study of the mechanism of action of phenolases on the naturally occurring phenols present in many plant and animal substances has shown that ascorbic acid is a useful inhibitor of enzymatic browning. The demonstration that *iso*citric and malic acids can be oxidized by enzymes isolated from peas by successive transference of hydrogen from *iso*citric and malic acids through coenzyme II to glutathione, thence to ascorbic acid and finally to oxygen, allocates possible functions to the important plant constituents—ascorbic acid and glutathione. Other investigations on the respiration of plant organs promise to illuminate the balance between carbohydrate and acid constituents which accompanies the ripening of fruits, and may lead to control or prediction of the losses of ascorbic acid during storage of plant organs; they have indicated that sterilizing foods with intense beams of high-velocity electrons is a promising process.

Some basic research has been maintained in all sections of the Forest Products Research Laboratory, but much time has been given to the testing of Colonial and other imported timbers, in order to keep pace with the increasing demand for information on their properties and uses. Measurements on adsorption and desorption within the hysteresis loop have been concluded and confirm earlier findings, and work is now in progress on the effect of temperature on the hysteresis loop. A new system of loading has been developed for testing stresses and similar structural units, and research on the physiology of fungi has included the study of the metabolic products of wood-inhabiting fungi. Much time has been devoted to the development of a new technique for observing the collapse of wood during pressure treatment which will facilitate the accurate determination of the relation between temperature and pressure, while work on the treatment of timber in stick, for the prevention of attack by *Lyctus* powder-post beetles, has aimed at finding improved methods of applying DDT and benzene hexachloride to stacks of timber. Fuel research has included investigations on the nature of the processes of maturing of coal, which are believed to change when the coal acquires a minimum density, and on the mode of occurrence of certain minor constituents in coal. The development of a pilot plant for the generation of water-gas from small-sized non-coking coals in a fluidized bed at about 900° C. is proceeding, and in work on the Fischer–Tropsch process it has been found that the activity of an iron catalyst prepared from magnetic iron oxide and alkali is greatly increased by reduction with hydrogen at 300° C. instead of 450° C. and by removing surface alkali by leaching with water. Investigations on the formation and prevention of external deposits on boiler heating surfaces, on the removal of sulphur compounds from flue gas and on the development of combustion chambers to enable solid fuels to be used in industrial gas-turbines has continued, while many new designs of domestic appliance have been tested and much attention given to atmospheric pollution and its prevention.

The development of the new Hydraulics Research Station continued, and considerable progress is reported in building a second wave-basin in the open in which it will be possible to reproduce tidal currents and the rise and fall of the tide at the same time as waves. Tidal studies have concentrated attention on the problem of siltation in the tidal basin at Tilbury, while a report on the approach channel to Heysham harbour has been submitted and an investigation is being carried out on behalf of Lyttleton Harbour Board, New Zealand, into designs for new extensions to the existing harbour. In the field of coast protection a team of five men, led by an experienced hydrographic surveyor, is making a survey on the south coast of England with the object of recording data for comparison with future surveys, so that an accurate estimate can be made of the gain or loss of beach material; and the team will also attempt to find explanations of how these changes occur.

In the Division of Mechanical Engineering, construction of the Hydraulic Machinery Laboratory, though not of the Heat Transfer and Creep Laboratories, has begun, but most of the work on the properties of materials at high temperatures and the work on the metrology of machine tools and screw threads has to be carried out at the National Physical Laboratory. Fundamental work on grease lubrication has recently begun, and a tentative theory of bearing has been developed to take account of the rheological properties of grease. Experiments on fretting corrosion have confirmed the resistance of phosphated steel surfaces: on surfaces so treated it could be virtually eliminated by suitable lubrication. The performance of precision ball-bearings is being studied with special reference to the dimensional accuracy and finish of the ball and track surfaces, and equipment for investigating high-speed gears has been designed and built by a firm of gear manufacturers. The relation between stress and plastic strain in a polycrystalline aggregate has been used to provide a physical basis for the use of the principle of maximum work in macroscopic theory, tests are being made to establish basic principles governing the plastic deformation of metals in press- and drop-forging, and a micro-technique has been developed for measuring tool-wear so that the machining of large quantities of metal is avoided.

The Pest Infestation Laboratory, which works in close collaboration with the Infestation Control Division of the Ministry of Agriculture and Fisheries and with the corresponding division in the Department of Agriculture for Scotland, is becoming increasingly concerned with Colonial problems relating to the storage of foodstuffs, especially of cereals, where the most immediate needs are for the dissemination of existing knowledge and the assessment of problems on which further research is required. Respiration measurements on wheat grain at different humidities at 25° C., in the presence and absence of micro-organisms, indicate a sharp increase in the rate of respiration of normal grain as the moisture content rises above 16 per cent, accompanied by the development of visible external mould, especially at moisture contents of 18 per cent or more. Subepidermal mycelium appears to have no effect on the respiration of damp grain. The protection against infestation afforded by impregnating jute sacking with pyrethrins or piperonyl butoxide, or a mixture of the two, has been investigated, and all treatments with pyrethrin or the mixtures greatly reduced the likelihood of infestation. Tests have also been made on the relative efficiency of vacuum fumigation techniques and straightforward fumigation at atmospheric pressure. Among the problems investigated at the Road Research Laboratory are the effect of striped pedestrian crossings on road casualties, the braking performance of commercial vehicles, the rear lighting of vehicles in relation to accidents, the behaviour of soils in relation to road construction, the possibilities of prestressing concrete for roads, and the improvement of road tar. Further aspects of the treatment of sewage by alternating double filtration are being studied by the Water Pollution Research Organization, as well as the relative importance of factors affecting the toxicity of poisons to fish, while an increasing proportion of the resources of the Laboratory is being devoted to the study of conditions in the Thames Estuary.

New terms of grant were offered to nine research associations for the next five-year period. The British Boot, Shoe and Allied Trades Research Association receives a block grant of £8,000 a year, conditional on £15,000 from the industry, and an additional £100 for each £100 from industry up to a maximum of £10,000. Reference has already been made to the Association's work on children's shoes, but its day-to-day work on shoe-making materials and components is reflected in all categories of footwear. For the British Cotton Industry Research Association, a block grant of £50,000 a year was made, conditional on £220,000 from the industry, and an additional £100 for each £100 from industry up to a maximum of £40,000 for the period April 1, 1954–March 31, 1957. New developments in the textile industry during the year include the registration of Shirley Developments, Ltd., to take over under formal agreements the many commercialized results already in existence. By this means it is hoped to secure that the practical results of research are more quickly, effectively and fully adopted by the industry. Work on the newer fibres is expected to increase, but cotton still occupies the major part of the research programme. The Association's work on sizing warps is estimated to offer savings in starch to the industry of about £200,000 on £1 million, and the radioactive static eliminator, which has been on trial for two years, is now commercially available.

The new block grant for the British Hat and Allied Feltmakers' Research Association for 1952–54 will be £7,000 a year, conditional on £10,000 from the industry, with up to £5,000 on the £100 for £100 basis. The Association reports advances in the knowledge of mercuric carrotting of rabbit fur, which are leading to a better understanding of the process, and an investigation has been started on the effect of different types of dyeing machine on the quality of felt produced. For the two years 1952–53, the British Food Manufacturing Industries Research Association will receive a block grant of £9,000 a year, conditional on £20,000 from industry, with up to a further £6,000 on the customary basis. Besides studies of analytical methods, the keeping qualities of different types of margarine, and the incidence of mould infection, particularly on strawberries and blackberries, the Association is investigating the graining and rheological behaviour of chocolate, which are important in controlling the physical character of the chocolate and in preventing 'bloom'. For the British Non-Ferrous Metals Research Association the block grant for 1954–56 will be £28,000 a year, conditional on £65,000 from industry, with up to a further £15,000 on the usual basis; more than thirty investigations are at present in hand. A novel method of recovering zinc from galvanizer ash has been developed, the general adoption of which would save the galvanizing industry sums covering its entire subscription to the Association for many years. The Association has also developed an anodic test for a naturally occurring inhibitor of the cold-water pitting of copper pipes, which enables the corrosiveness of a water to be assessed in seven days.

A block grant of £10,000 a year has been made to the British Paper and Board Industry Research Association for the period October 1, 1952–September 30, 1957, conditional on £30,000 from the industry, with up to a further £12,000 on the usual basis. Work on effluent problems continued, and as a first step in a long-term study of fibre structure and properties as they affect paper manufacture and, in particular, of the fundamental effects produced by the beating process, a literature survey has been made and new techniques have been developed in preparing fibres for study under the electron microscope. The possibility of incorporating fungicides in the packaging material during manufacture so as to prevent attack of paper and board by bacteria and moulds is being investigated. Besides a block grant of £40,000 a year conditional on £50,000 from the industry, and up to a further £40,000 on the usual basis for the two years 1952–53, the Production Engineering Research Association has been promised £100,000 towards the cost of a new research building at Melton Mowbray, contingent on at least the same amount from the industry. Research in progress has included investigations to enable the accurate calculation of punch loads for a wide range of ferrous and non-ferrous materials, on the performance of experimental aqueous cutting fluids containing various additives and rust inhibitors, and on the effect of tool surface finish on tool life. For the period April 1, 1952–March 31, 1957, the Coil Spring Federation Research Organization will receive a block grant of £5,000 a year, conditional on £6,000 from industry, with up to a further £10,000 on the £100 for £100 basis, and plans have been made for the establishment of a central headquarters in the Midlands; further work on decarburization and its relation to type of steel, spring manufacture and performance has revealed some important features of the manufacture of springs from black rolled bar, and a study on avoiding hydrogen embrittlement has shown that a variety of oxidizing agents, including chromic sulphuric acid, are effective. The Wool Industries Research Association will receive a block grant of £40,000 a year for the period October 1, 1953–September 30, 1956, conditional on £100,000 from industry, with up to a further £30,000 on the usual basis. General recommendations have been made for the use of synthetic detergents in scouring, and work has been started on the effect of chlorination on the dyed strength and shade of nylon, in the presence and absence of wool, while it has been shown that the frictional forces between clean nylon and keratin surfaces are determined by the elastic indentation of the surfaces and the shear strength of the materials.

Other interesting features of the work of the research associations which may be noticed here are the studies on consumer preference carried out by the British Baking Industries Research Association in collaboration with the School of Bakery, Royal Technical College, Glasgow, which have indicated a marked ability to differentiate between shortbreads containing butter and cake margarine, respectively, and between cake products containing margarine with dried egg and butter with fresh eggs, respectively.

There was no evidence that smokers and persons with artificial dentures were appreciably inferior in their ability to taste. The British Electrical and Allied Industries Research Association's preliminary trials of the 100-kW. wind-driven generator in Orkney are being followed by full performance tests prior to permanent commission; preliminary trials of electric weed-killers have given promising results, and work has started on the flash illumination of laying poultry to increase egg production. The British Iron and Steel Research Association's work on graphite electrodes has led to two types of resistivity tests, the adoption of which in some works has offered savings of four to five shillings per ton of steel. The Lace Research Association has developed a new lubricant for lace machines which is as effective as graphite and offers a minor social revolution in the elimination of the saturation of the workers' clothes with graphite which characterized the old conditions. The designs of the Parsons and Marine Engineering Turbine Research and Development Association for turbine machinery in merchant ships have proved so successful overseas that applications are being received for licence agreements from countries outside the United Kingdom, and six licences have been granted. Interest in the use of oonophor oil as a drying oil is rapidly developing, and the Nigerian Government, the Colonial Office and the Paint Research Station are co-operating in exploiting the discovery and establishing a oonophor-growing industry. The Printing, Packaging and Allied Trades Research Association has patented a new design of book-binding which allows a book to open flat without major strain to the back; 'Patracrat', its light-sensitive material for making photo-lithographic plates, has been widely adopted, and much interest has been displayed in its journey shock recorder. The British Rayon Research Association has obtained very promising results with methods it has devised using ultrasonics for the removal of oil stains.

These examples should sufficiently demonstrate how varied is the contribution which the Department of Scientific and Industrial Research is making, alike through its own research stations and organizations and through the industrial research associations, to industrial efficiency and productivity and to almost every side of national welfare. The report shows, too, the extent to which contact and co-operation with industry and with other organizations and government bodies enables the Department to keep in touch with practical needs. Manifestly the wisdom with which the work of the Department is conducted in different fields, and the soundness of the selection of its objectives cannot be judged from an annual report of this order. Confidence in that respect is inspired by the three surveys of the work of the Leather, the Cast Iron and the Ceramics Research Associations which have already been made at the request of the Advisory Council, particularly that of the Leather Research Association. As the Advisory Council points out, however, while such surveys are of considerable value in reviewing progress and assessing priorities, they take time to complete and make considerable demands on the time of all concerned. To conduct such surveys every five years, even for the research associations alone, would be too big a task with existing resources, and the Advisory Council's proposal to arrange for such surveys only when special circumstances indicate the desirability seems reasonable, particularly as it also proposes to require a much more detailed review of the work of each research association before the renewal of grants.

# REFRACTOMETRY OF LIVING CELLS

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SURPRISINGLY little attention has been devoted in the past to the determination of the refractive index of living protoplasm. Earlier workers who investigated the subject were apparently content simply to record values without interpreting their meaning, and the methods employed were rather crude or subject to considerable error. Vlès[1] pointed out that the refractive index of a spherical or cylindrical cell could be determined by treating it as a lens and measuring its focal length. This method only gave average values for the whole cell, that is, nucleus, cytoplasm and inclusions. Even less-precise methods were sometimes used. Thus, the frequently quoted figures of von Angerer[2] for the refractive indices of bacteria were estimated by comparing the subjective brightness (under the conventional microscope) of bacteria with that of oil emulsions. Other techniques have been reviewed in the literature[3].

## Methods

The method which we have developed[4] originated in a chance observation. During the course of a survey carried out with the phase-contrast microscope on a wide variety of living cells, it was noticed that the cytoplasm of the amœbocytes of earthworm blood appeared bright instead of dark when viewed by positive phase-contrast (and dark when viewed by negative phase-contrast). This was the reverse of the appearance of all other living cells examined in this laboratory, and could only mean that the refractive index of these cells was less than that of the mounting medium. It was then realized that the latter was not physiological saline or serum, as generally employed, but earthworm blood, which contains a considerable amount of dissolved hæmoglobin, so that the refractive index is appreciably raised. When the blood was washed out with saline, the cytoplasm of the same cells became dark, as usual. In order to determine the refractive index of the cytoplasm, it was only necessary to dilute the blood until the cytoplasm virtually disappeared, and then to measure the refractive index of the diluted blood. As it was inconvenient to use blood or hæmoglobin solutions, a search was carried out for other suitable colourless proteins. After several trials, the material now being used as an immersion medium is a plasma albumin preparation which is available as a dried powder. It is soluble in water or dilute saline up to at least 45 per cent w/v, and its salt content and *p*H can be adjusted to suit the particular cells being examined.

This method is, of course, the well-known 'immersion method' of refractometry which has long been used in mineralogy. It has not hitherto been successfully employed in biology because most of the common non-aqueous immersion media damage living cells. Any substance to be used for the refractometry of living cells must fulfil the following requirements: (1) it must be non-toxic and must not affect the structure or function of living cells; (2) it must not penetrate the cell; (3) it must exert a low osmotic pressure, that is, it must be of high

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molecular weight; (4) it must be freely soluble in water so that the refractive index of the solution can equal or exceed that of the part of the cell to be measured. These requirements are met by the albumin preparation actually used. Numerous experiments have shown that motile cells, such as various protozoa, bacteria, spermatozoa and ciliated epithelial cells, remain active and apparently in good condition for at least thirty minutes (and often for several hours) even in highly concentrated solutions. Cell-division and germination of spores have also been observed. The tonicity of the medium has been checked by plotting distribution curves of cell diameter for spherical cells such as spermatocytes. These experiments and full details of the technique will be described elsewhere.

It seems curious that so simple a method could not have been evolved much earlier. On reflexion, however, its success evidently depends on two fairly recent developments. In the first place, moderately pure preparations of suitable proteins have only been available on a large scale within the past few years. True, some early workers attempted to use gelatin as an immersion medium, but as this sets to a jelly in low concentrations, it is of no practical value. The second factor is the development of phase-contrast microscopy by Zernike[5]. This is an extremely sensitive method for observing local variations of refractive index (or strictly, optical path, that is, the product of refractive index and thickness) and thus enables the match between immersion medium and object to be judged with considerable accuracy. Two-beam interference microscopy[6] has also been used in this work, for which it possesses certain advantages over phase-contrast.

## Meaning of Refractive Index: Solid and Water Content of Living Cells

The refractive index of parts of living cells can be measured by this method to an accuracy of the order of 0·001–0·005. Even greater accuracy is possible in some cases, but in general the range of individual variation among cells of one type is greater than the experimental error of a single measurement. The bare figures are, however, of very little interest, and it is only when we consider what they mean that the full significance and possibilities of the method become clear. As a first rough approximation we can regard the living cell as an aqueous solution of protein. If we immerse such a solution in a medium containing the same protein, the refractive index difference between the cell and the medium will vanish when the concentration of protein in the external medium is equal to that inside the cell. Thus, if we were able to use the cell protoplasm as the immersion medium, we could determine its concentration inside the cell. Can we do the same by using a different protein? It is a remarkable fact that equal concentrations of aqueous solutions of different proteins all have approximately the same refractive index. The refractive index varies almost linearly with concentration, and the increase per 1 per cent increase in concentration is known as the specific refractive increment, α. The values of α for nearly all proteins so far studied do not differ by more than about ± 5 per cent from a mean figure of 0·0018. The extreme cases are the lipoproteins, and pigmented proteins such as hæmoglobin, but even here the variation from the mean is only slight. (The figures in the accompanying table were kindly provided by Dr. G. S. Adair.) Thus, if the cell were composed of protein alone, we could determine its concentration by using almost any protein as the immersion medium. Of course, there are other substances present besides proteins. These might be expected to introduce large errors; but, in fact, the refractive increments of nearly all organic substances in solution (and certainly of those likely to be present in living cells) are very nearly the same. Anomalies may occur with pigments (in the region of absorption bands), and with substances containing conjugated double bonds. Materials of special biological interest are the carbohydrates, lipoids and nucleic acid compounds. The first two usually have low values of α, in the region of 0·0014–0·0015. For nucleic acids, α has been variously given as 0·0016[7] and 0·0020[8]. For solutions of tobacco mosaic virus the value is 0·0017[9], that is, about the same as for much simpler proteins. Hence the error in assuming an average value for α for substances present in appreciable amounts in living cells is small, and only in exceptional cases, as perhaps in cells heavily loaded with pigments, glycogen or lipoids, is any considerable error likely to occur. Thus, in brief, the concentration of protein in the external medium, which makes a certain part of a cell vanish, is also the concentration of total solids in that part of the cell. In many cases the proportion of protein is so great relative to other substances that little error is introduced by regarding this figure as a measure of protein concentration. Clearly, if the total solid concentration is $x$ per cent, then the concentration of water is $(100 - x)$ per cent. A simple observation under the microscope thus gives us accurate information about two very important quantities, the estimation of which has always been a matter of difficulty. Measurements of the water content of living cells involving wet and dry weight determinations lack precision because one can never be sure of removing all extraneous surface water. Indeed, any attempt to dry thoroughly the surface of cells or tissues would almost certainly result in changes of cell permeability, perhaps with further loss of water from inside the cell. The great advantage of the new method is that it can be carried out on the living, and as far as can be judged, undamaged cell, and the results apply to individual cells or parts of cells, instead of being average figures based on large numbers of possibly different cells. In other words, the range of variation of water and solid concentration can be estimated in a given type of cell under different physiological conditions.

| Protein | |
|---|---|
| Total serum (human) | 0·00179 |
| Euglobulin | 0·00183 |
| Pseudoglobulin | 0·00181 |
| Total albumin | 0·00181 |
| Recrystallized albumin | 0·00181 |
| Lipoprotein | 0·00170–0·00171 |
| Hæmocyanin *Helix* | 0·00179 |
| *Octopus* | 0·00184 |
| *Carcinus* | 0·00187 |
| Egg albumin | 0·001813 |
| Sheep CO hæmoglobin | 0·001945 |
| Globin (ox) | 0·00178 |
| CO hæmoglobin (ox) | 0·00193–0·00195 |

Specific refractive increments (α) for various proteins (figures provided by Dr. G. S. Adair)

## Applications and Results

It is only possible in the present article to mention briefly a few of the different types of problem which have so far been studied by the technique and to indicate the trend of work now in progress.

(1) *General cytology and biology.* In general, the refractive index of the cytoplasm of most types of living animal cell has been found to lie between

1·350 and 1·367, corresponding to between 10–20 per cent concentration of solids. The degree of variation may be quite small in any given species. For example, the cytoplasm of snail spermatocytes and that of snail amœbocytes each has a refractive index corresponding to about 14 per cent of solids, even though the former are compact spherical cells, whereas the latter are very flat and irregular with extremely thin pseudopodial processes. As is to be expected, there is usually some degree of variation between individual cells of the same type from the same animal. As a rule, however, the extreme values rarely differ by more than ± 10 per cent from the mean value, and often the degree of scatter is very much less. Insufficient work has been done to make any statement about the possible correlation between the age or developmental state of an individual and the solid content of its cells; but such an investigation may provide useful clues to the mechanism of ageing. Even in normal human oral epithelial cells there appears to be a progressive decrease in the water content from the inner layers outwards, probably connected with the degree of cornification. The outermost layers may contain more than 30 per cent of solids, the innermost only about 11 per cent. It would be surprising if changes in the distribution of tissue water did not occur with advancing age.

The study of motile organisms is of particular interest both because of the evidence it provides for the absence of serious damage produced by the immersion technique, and because of the light it may throw on the mechanism of locomotion. Many species of protozoa have been observed, and special attention has been paid to some types of amœbæ. These organisms retain their normal motility for at least thirty minutes, even in high concentrations of protein, in which they appear with strongly reversed contrast. In general, the clear ectoplasmic layer of a resting region contains about 8–10 per cent of solids. In active movement, however, the tip of a pseudopodium may contain less than 2½ per cent of solids. This represents a considerable redistribution of water, such as has been postulated in some theories of amœboid movement. One forms an impression that water is squeezed forward into the pseudopodium from the less active 'hind regions' of the organism and that a sudden liquefaction accompanied by streaming of granules takes place.

The human spermatozoon often contains a collar of cytoplasm just behind the head. This contains about 14 per cent solids, as in the cytoplasm of many other cells. The heads, however, are very much denser and contain about 45 per cent of solids. It is difficult to obtain precise values for the tails; but they appear to contain approximately 50 per cent solids. The flagella and cilia of other types of cells are generally also very dense and their solid content cannot always be estimated by this method. In *Euglena*, however, the solid content of the flagella is only about 20 per cent, a value not very much higher than that for the cytoplasm itself.

It seems to be a general rule that many types of cellular activity are accompanied by an increase in water content. Thus in spermatogenesis the appearance of chromosomes may be heralded by a reversal of cytoplasmic contrast. The metaphase chromosomes, in particular, are surrounded by a bright zone of low solid content.

(2) *Microbiology*. Some of the most useful applications of microrefractometry may well occur in the study of bacteria, fungi and yeasts. Many of these organisms show considerable tolerance to *p*H and tonicity, so that the preparation of the immersion medium is greatly simplified. Fully grown bacterial cultures show surprisingly little variation in the individual cells and rather precise end-points are often obtained. In general, there is little difference in the solid content of the same species grown on solid or in liquid medium, provided that the medium contains all the necessary growth factors. Thus, *Sarcina lutea* gave the same value, 35 per cent, in each medium. *Proteus vulgaris* gave values of 28·5 per cent in liquid and 29 per cent on solid media. On the other hand, *Streptococcus hæmolyticus* had a higher solid content (43 per cent) in liquid medium than on solid (34 per cent). Most bacteria so far examined have a rather higher solid content (of the order of 25–40 per cent) than have tissue cells or protozoa. The values for a given strain vary very little, once the culture is fully grown, and the reproducibility of the results, even after many months, is quite astonishing. A study of the variations of solid concentration and mass of bacteria at different stages of the growth cycle and in response to diverse metabolic conditions, including the action of antibiotics, is being undertaken. There is every indication that this technique may be a useful and novel aid in the investigation of bacterial metabolism.

Work on fungi has suggested a variety of interesting problems. The solid content of fungal mycelia varies along their length, and only measurements of the young, actively growing tips are used as a basis of comparison. Nearly twenty species of *Penicillium* have been measured, and the solid content of the active regions is remarkably constant, the extreme values being 24–28 per cent. In *Rhizopus* and *Absidia*, two zygomycetes, however, the value is only about 15 per cent. Such differences may perhaps have some taxonomic bearing.

The behaviour of fungal spores is particularly striking. When a group of spores is examined in certain concentrations of protein some appear bright while others remain dark, in positive phase-contrast. Such spores were actually grown on the slide in the immersion medium. The bright spores invariably germinated and a bright mycelium grew out. The complete growth-cycle to the formation of new spores could be observed. The dark spores remained dormant, or if they germinated, always passed through a stage of reversal of contrast. Here again it appears that cellular activity is accompanied by an increased water content. So far as is known, this is the first time that it has been possible to distinguish spores which are about to become active from dormant ones. Another observation may throw some light on the sexual differentiation of fungi. In *Absidia glauca* the two progametangia which come into contact from different hyphæ show a distinct difference in refractive index. Thus, in 7·5 per cent protein one appears dark and the other bright. Again, this is perhaps the first indication of a structural or chemical difference which could not be revealed by classical methods.

The economic importance of yeasts makes their study particularly desirable. Both brewer's and baker's yeasts have been found to have an exceptionally high solid content (40 per cent) in the cytoplasm of resting cells. The vacuoles give very low values, and the water content of the cytoplasm rises sharply during active budding. As will be indicated below (section 5), the immersion method greatly assists the cytological study of yeast cells by phase-contrast microscopy.

(3) *Studies on cell permeability and death.* An investigation has been carried out in this laboratory into the action of fixatives on living cells[9]. For this reason an attempt was made to study the changes in refractive index produced by different fixatives. The immersion method failed completely, however, and it was never possible to make a fixed cell appear with reversed contrast. The reason for this is presumably that the dead cell becomes permeable to external protein, so that the external concentration never exceeds the internal one. This suggests a new and simple test for cell death or increased permeability, and there is much evidence to support this hypothesis. It may prove possible to detect earlier stages of damage by using solutions of substances of lower molecular weight, and experiments of this type are now in progress. Among the substances we have tried are preparations of peptone and of polyvinyl-pyrrolidone. These are apparently toxic in high concentrations (exceeding about 15 per cent), but amœbæ, for example, can tolerate them for reasonable periods in concentrations of about 12 per cent, and the values for refractive index obtained with protein have been confirmed with both substances. Although most bacteria and fungi so far studied do not show reversal of contrast in concentrated peptone or polyvinyl-pyrrolidone, yeast cells can be reversed by dialysed peptone. This behaviour may possibly be related to differences in the nature of the membranes of these micro-organisms. If some cells, for example, snail spermatocytes, are immersed in high concentrations of polyvinyl-pyrrolidone, both nuclei and cytoplasm may be reversed at first. In a few minutes, however, the cytoplasm becomes dark, but the nucleus remains bright. This suggests that the cell membrane becomes permeable to the material, but the nuclear membrane remains impermeable. The advantages of a simple visual method for studying changes in cell permeability are obvious.

(4) *Hæmatology.* The mammalian red cell can be regarded as a membrane containing a concentrated solution of hæmoglobin. The latter is the major constituent of the cell, and accounts for more than 97 per cent of the total solids, including stroma[11]. Thus, refractometry of red cells is essentially a new method of hæmoglobinometry and one, moreover, which determines a very fundamental quantity in clinical hæmatology, namely, the corpuscular hæmoglobin concentration. Again, this quantity can be determined on individual cells and not, as hitherto, as an average figure for millions of cells. The actual range of concentrations in the cells of any individual can be determined, and work has begun on the task of plotting actual distribution curves showing the relative number of cells containing a given hæmoglobin concentration. Such curves are reminiscent of the familiar Price-Jones distribution curves of red-cell diameter, and despite the considerable labour involved, they must be computed and subjected to statistical analysis in order to understand the nature of normal and pathological variations of the red-cell population.

A survey of various types of blood diseases is being carried out with the collaboration of the Department of Clinical Pathology of the Radcliffe Infirmary, Oxford, and full details will be reported elsewhere with Dr. J. B. Howie. It may be mentioned that the picture in iron-deficiency anæmia is a very clear-cut one. The scatter is usually greater than normal, but the highest members of the population rarely reach the concentration of the normal median. Even quite mild cases of iron deficiency with blood hæmoglobin as high as 80 per cent can be rapidly detected by this method. In pernicious anæmia, on the other hand, the range seems to be shifted in the opposite direction with a median slightly higher than normal, and many members of the population contain concentrations considerably higher than normal. Thus, contrary to current opinion, our results suggest that pernicious anæmia is, in fact, an example of a true hyperchromic anæmia with a raised corpuscular hæmoglobin concentration in some cells, and not simply a normal hæmoglobin concentration with larger cells.

Another hæmatological application which may be of practical value is the recognition of 'dead' cells or functionally abnormal red cells. In section (3) above we stressed that reversal of contrast could only be obtained with living cells. With the present technique we have never found any normal cells which were not reversed in 38 per cent protein solution. If a preparation of normal cells is left to stand over-night in this strength of protein, a proportion of the 'bright' cells becomes dark. Similarly, if a suspension of 'bright' cells is damaged, for example, by narcotics or by sub-hæmolytic concentrations of lytic agents, a number of cells, depending on the degree of damage, become dark. Presumably these cells are 'leaky' and allow the protein to penetrate into their interiors. Blood stored in a refrigerator begins to show a gradually increasing proportion of 'leaky' cells after some time, and this proportion is rapidly increased by keeping the blood at room temperature. It is hoped to devise a simple and rapid test for determining whether a given specimen of stored blood from a blood bank is suitable for transfusion.

Many hæmatological problems remain to be investigated. Apart from the determination of normal and abnormal distribution curves, there are questions associated with the change-over from the fœtal type of hæmoglobin to the adult type, the nature of hæmolytic anæmias, the changes which occur during treatment of anæmias, the possible alterations which blood cells undergo in the spleen, the effect of various anticoagulants, and the influence of different substances on the survival of stored blood.

(5) *Contrast variation in phase-contrast microscopy.* In order to obtain the maximum information from the phase-contrast method, it is essential to vary the refractive index of the mounting medium[12]. This has not hitherto been possible in the case of living cells, and some of these have been regarded as unsuitable for phase-contrast work. Thus, many spherical cells are very refractile and are surrounded by intense and disturbing haloes when examined in saline or plasma media, so that little or no internal structure can be made out. Such haloes can be greatly reduced by immersion in suitable protein solutions, and cytological details can then be readily studied. The method is particularly useful with refractile structures such as yeasts, spores, and some plant cells. The immersion method can also be used for the measurement of birefringence of living cells as already foreshadowed[13].

(6) *Spectrophotometry of cell suspensions.* Suspensions of cells mounted in saline or nutrient media are very cloudy and scatter light. If, however, the refractive index of the cells is determined and they are then suspended in a medium of about the same refractive index, light scattering is greatly reduced and the suspension becomes virtually transparent. Concentrated suspensions of blood cells, for example, can be clarified in this way[14]. It now becomes possible

to carry out spectrophotometry on such material much more accurately and with much more concentrated suspensions than hitherto, and the state of pigments, enzymes, etc., in living animal and plant cells and micro-organisms can be investigated. Results obtained by this method will be reported in detail by one of us (R. B.).

(7) *Combination of refractometry and mass determination.* By means of interference microscopy it is possible to determine the product of refractive index and thickness, and hence the dry mass of a living cell[15,9]. Although refractometry and mass determination are closely related, the information given by the former, that is, the concentration of solids, is generally more fundamental. Thus the knowledge of the actual mass of a structure like an amœbal pseudopodium is of no great interest, because it depends on the size of the pseudopodium, which may be varying rapidly. The local concentration of solids is of much greater value. When the two methods are combined, however, it is possible in principle to obtain a considerable amount of useful information about living cells. If the product of refractive index difference and thickness and the refractive index itself are measured, the thickness can be calculated. The integrated product of thickness and projected cell area then gives the cell volume. Thus, from two optical measurements it is possible to derive (1) the dry mass of part or the whole of a cell, (2) the concentration of solids in different parts of the cell, (3) the cell thickness, (4) the cell volume, (5) the concentration of water in different regions, (6) the total mass of water. Such facts provide a useful basis for much quantitative work on living cells.

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# FLAVOUR ASSESSMENT

A SYMPOSIUM on flavour assessment, in which the Food Group of the Society of Chemical Industry, the Biological Methods Group of the Society of Public Analysts and the Biometric Society joined, was held on the afternoon and evening of Wednesday, March 11, at the Wellcome Research Foundation, Euston Road, London. The chairman of the Food Group, Prof. H. D. Kay, took the chair at the afternoon session, and Dr. H. O. J. Collier, of the Society of Public Analysts, and Dr. Katherine Coward, of the Biometric Society, at the after-tea and evening sessions. Some two hundred and thirty people were present.

The first speaker was Dr. E. D. Adrian, who discussed the physiological background of flavour assessment. He pointed out that while the strict physiology of the sense-organs tells us little about the sensations experienced by the individual, which are elaborate constructions of the central nervous system, the physiologist can tell us a good deal about the kind of information which comes in when the end organs are stimulated. The concept presented to consciousness is an edited synthesis of this information; in the case of our appreciation of food and drink, it depends both on the signals coming from the eyes as well as the nose and mouth, and also on the idiosyncratic likes and dislikes acquired during our upbringing and past experience. The physiologist deals with the stage where the environmental change is analysed by the sense organs; he can measure the size, number, grouping and spacing of the brief impulses travelling up the sensory nerve fibres.

The flavour of food is signalled by the taste buds in the tongue and the back of the mouth and the large olfactory organ at the back of the nose. In man, the olfactory organ, which has an area of about 2 sq. cm. on either side, contains several million long, sensory cells, each ending in a hair-like process which projects into the surface layer of mucous and water on the surface of the organ.

With smells, there has always been the difficulty of making any classification or analysis of the qualitative aspects, or of producing a scale of smells. Recent research has left the sensation out of account and recorded the signals which the sense organ sends to the brain. Experiments have been carried out with the rabbit, which has a large olfactory organ, to determine the character of the impulses—changes in electrical potential—passing along the olfactory nerve after a measured stimulus, consisting of a definite quantity of the vapour of a chemical substance of known composition, has been brought to the olfactory surface within a definite and fairly short time. Dr. Adrian showed a number of slides recording those impulses.

With a similar stimulus, the time course of the discharge of impulses is characteristic, and may help the animal to distinguish one smell from another. The esters and substances soluble in water seem to act more rapidly than those only soluble in lipoids. It is possible that there may be different types of reception, perhaps depending on the distance of the cell nucleus in the long sensory cell from the receptor hairs. Thus air which has passed over coffee gives a group of potential spikes on the record of the discharge differing from that given by air which has passed over tea. When pure chemical substances are tried, there seems to be at least four classes of substances of which the discharge patterns can be distinguished. This is most obvious when the stimulus is not too far from the threshold, that is, when only a few conducting units are in action.

How the stimulating molecules of the odoriferous substances excite the end organs is a different problem; but at least we know that the olfactory organ sends the same sort of messages into the brain as the other sense organs, and that judgments of flavour are based on a central editing and synthesis of signals arriving via a fairly large number of afferent channels.

Mr. H. G. Harvey (British Food Manufacturing Industries Research Association) dealt with certain basic considerations in regard to flavour assessment from a somewhat different angle. In the well-fed human, the reaction to flavour is still primitive and largely confined to like or dislike, or preference of one food to another, though many separate sensory messages associated with colour, temperature, texture, taste, odour, obviously enter into any such judgment. Mr. Harvey emphasized the importance of visual appearance, quoting Moir's experiment where table jellies with colours not conforming to the flavours customarily associated with these colours were tasted by a large group of people, most of whom failed to allocate the flavours correctly. When food intended for sale to persons of normal vision is being tested for flavour, the normal association of colour and flavour should be allowed to operate.

Nearly every type of tasting test, Mr. Harvey pointed out, falls into one of two categories: (1) consumer preference and (2) grading, though the way in which particular assessments are made varies widely. A sound statistical planning is necessary, whatever method is used. Mr. Harvey compared, with examples, the 'paired comparison' method and the 'triangular' test, where three samples, of which two are identical, are presented to each assessor. He considered that assessors should, where possible, be given the simplest possible judgment to make. Assessors vary greatly in their discrimination for reasons that are usually obscure, though non-smokers do not seem to show any significant difference in tasting ability from smokers.

Mr. A. S. C. Ehrenberg (Institute of Psychiatry, Maudsley Hospital, London) and Dr. J. M. Shewan (Torry Research Station, Aberdeen), in a paper on the objective approach to sensory tests, illustrated their conclusions from a study of present-day methods of preserving fish in palatable form, using carefully trained taste panels for the assessment of qualities which go a little beyond simple flavour. They endeavour to measure 'eating quality', grading this variable on a ten-point scale, each point of which is given a detailed description. The panel is trained to agree on the association of the descriptive terms and the place on the scale. A major difficulty is to decide whether or not the level of assessment remains reasonably constant over a period of time; quick-frozen fish stored at low temperatures show little change over months of storage and have some value as standards; also, objective chemical measurements (total volatile bases) seem to agree fairly consistently with the position on the 'eating quality' scale given by the organoleptic assessments.

Mr. J. M. Harries (Ministry of Food) also spoke on specialist grading tests and consumer acceptance trials. The consumer acceptance or preference tests, the results of which vary with standards of living, have usually a wide scatter of individual results about an average. When attempting to forecast consumer preference, the scatter is as important as the average. The relation of this variation to the economic concept of elasticity of demand was discussed. In consumer preference tests, the food should be presented in the form in which it is normally used. One method employed is to offer five samples, three (identical) of one kind, two (identical) of another—a method useful in assessing the effect of alternative treatments on the flavour of a given food.

For specialist grading tests, a limited panel of individuals of trained acuity is used; such tests are not concerned primarily with likes and dislikes but are meant to effect a sensory analysis of flavour or other food characteristics, previously formulated in as precise a way as possible, and discussed beforehand by the panel. By such means, it is often possible to place different samples in a consistent order, or on a numerical scale. Mr. Harries reviewed some of the statistical methods of dealing with the test data.

Dr. J. O. Irwin (London School of Hygiene and Tropical Medicine) gave an interesting statement of the biometrician's point of view. There has been in the past a good deal of doubt as to the legitimacy of speaking of the measurement of sensation, and whether the only measurable quantities are the stimuli that evoke the sensation. His view is that the attempt to provide and classify such measurements has, nevertheless, to be made. He referred to the classification proposed by Chambers into (1) nominal, (2) ordinal, (3) interval and (4) ratio scales, and briefly described the use and limitations of each of these scales. The pragmatic approach to ordinal scales, not infrequently used in flavour assessment, is often better than a too pedantic use of a precise form of metric—an example was given of this from results on bacterial plate counts of milk. The biometric assessment of the properties of food, such as odour or flavour, is a type of assay not too dissimilar from, say, the biological assay of the amount of insulin in a given preparation.

Dr. Irwin directed attention to a valuable publication by the U.S. Department of Agriculture, namely, Bulletin No. 34 of the Bureau of Human Nutrition and Home Economics, 1950, in which a thorough examination of many aspects of the 'specialist grading' type of test is given. He ended his talk by scrutinizing from the biometric point of view some of the findings mentioned by the previous speakers.

A short discussion followed the conclusion of each of the five papers presented.

# OBITUARY

## Dr. Marc Daniels

Dr. Marc Daniels, a member of the Tuberculosis Research Unit of the Medical Research Council, died in London on March 3 at the age of forty-six. Educated in Manchester and Paris, he took his British medical qualification in 1937 and, a few years later, entered the public health field. After two years in Lincolnshire, however, he gained a scholarship at the Royal College of Physicians, a committee of which was directing a survey on the epidemiology and prevention of tuberculosis in young adults, under the Prophit Trust. From this point Daniels concentrated upon tuberculosis, and, after outstanding work in this survey during 1942–45, and in the preparation of its important report, which among other beneficial effects led to the official recognition of tuberculosis in nurses, laboratory workers and certain other categories as an industrial disease, he joined UNRRA as a consultant in post-war Europe. Some of his observations in this sphere were recorded in his Milroy Lectures to the Royal College of Physicians in 1949.

In 1946 Daniels joined the staff of the Medical Research Council, and thereafter was responsible for the practical co-ordination of two important lines of inquiry undertaken by the Tuberculosis Research Unit under the direction of special committees of the Council. One of these was the controlled trials of BCG and vole bacillus vaccines in the prevention of tuberculosis in school-leavers, now being conducted in Birmingham, Manchester and the Home Counties; the other was the nation-wide trials of the newer chemotherapeutic agents in human tuberculosis (streptomycin, *p*-aminosalicylic acid and isoniazid, the latter being still under test). Although Daniels's most abiding interest lay in epidemiology, his reputation was most enhanced by these—the first strictly controlled—chemotherapeutic trials in tuberculosis; the reports, prepared by him for the committee, received highly favourable comments in many countries, as much for their methods as for their content. Indeed, one of his main scientific contributions was the successful application of statistical methods to group studies in clinical tuberculosis. With the services of Prof. Bradford Hill as statistical designer, and of Daniels as organizer, these trials constituted an advance in the evaluation of new drugs in acute and chronic disease. While occupied with this work, Daniels served on many missions concerned with tuberculosis, for the Foreign Office, the British Council, and the World Health Organization; he was a member of the Streptomycin Sub-committee of W.H.O.'s Expert Tuberculosis Committee.

Daniels brought enthusiasm, precision and modesty to all his work, and he developed many friendships at home and abroad. Having a world outlook on health problems, he was very conscious of the moral and social responsibilities of medical men and scientists in a world needing peaceful development, but subjected to increasing strains and the threat of destructive uses of medical and scientific skill; and he was interested in the Medical Association for the Prevention of War from its formation. He had for many years been a member of the Association of Scientific Workers. He had many other interests, showing discriminating appreciation of art and drama, in both of which he took personal part. Daniels had two daughters by his first marriage, to Anne Burgess. In 1949 he married Kay Graw.

P. D'Arcy Hart

## NEWS and VIEWS

### Geography at Oxford:

#### Prof. K. Mason

Prof. K. Mason retires from the chair of geography in the University of Oxford at the end of this academic year, after twenty-one years service. He went to Oxford from the Survey of India, at a time when the last of many proposals for an Honour School in Geography was receiving favourable consideration from the University, and thus became heir to the Oxford tradition in geography. He wisely accepted the proposals without serious change and concentrated his efforts on making the new School work smoothly, on collecting a well-qualified staff, and, most successfully, on securing a building which could adequately house the growing number of students reading geography. The splendid lecture theatre, in the design of which he took an active part, is a fitting memorial to this side of his activities. Not least of his services was to induce the Drapers Company to provide three travelling scholarships. Under his administration the numbers have grown continuously from a mere handful in 1932 to about 180 in the present year. He leaves the Honour School of Geography at Oxford firmly established and well fitted for further expansion.

#### Mr. E. W. Gilbert

Mr. E. W. Gilbert, who succeeds Prof. Mason, is the first Oxford man since the days of Sir Halford Mackinder to direct the Oxford School of Geography. Like Mackinder, he began by taking the Honour School of Modern History—in 1922. He then gained all the distinctions possible at Oxford before the days of an Honour School of Geography, including the degree of B.Litt., for a thesis on the exploration of Western America, afterwards published by the Cambridge University Press (1933). Mr. Gilbert's first teaching post was at Bedford College, London. He next became joint head of the newly established Honour School of Geography in the University of Reading. He returned to Oxford in 1936 as Rockefeller research lecturer in human geography, and seven years later became reader in human geography. Most of his very large number of contributions to geography deal with the human and regional aspects of the subject, and this fact alone is some guarantee that the traditions of Oxford geography will be maintained. Moreover, Mr. Gilbert begins his career as professor with a full knowledge and experience of the Oxford School of Geography. Oxford is fortunate in retaining the services of one of her most devoted sons; the School of Geography has now an experienced and very competent staff; and Mr. Gilbert is fully qualified to maintain the high standards set by his predecessors.

### Meldola Medal, 1952

The Meldola Medal is the gift of the Society of Maccabæans and is awarded each year to the chemist who, being a British subject and less than thirty years of age on December 31 in that year, is considered to have shown the greatest promise as indicated by his or her published work. On the recommendation of the Council of the Royal Institute of Chemistry, two candidates have been adjudged equal, and therefore two Medals have been awarded for 1952 to T. L. Cottrell and Dr. B. C. L. Weedon, respectively.

#### Mr. T. L. Cottrell

Mr. Cottrell graduated in 1943 from the University of Edinburgh and joined the Research Department of the Nobel (then Explosives) Division of Imperial Chemical Industries, Ltd. There he worked in the Organic Research Section until 1946, when he was sent to study in the Physical Chemistry Laboratory in Oxford and investigated the thermo-chemistry of the ionization of some organic acids and also some theoretical problems connected with molecular structure. On his return in 1948 to the Nobel Division, where he is now in charge of the Physical Chemistry Research Section, Mr. Cottrell became interested in the properties of gases at high temperatures and pressures, and in aspects of chemical kinetics. Using a simple quantum mechanical model, he investigated the effect of density on molecular energy and, in collaboration with Dr. S. Paterson, used the results to derive an equation of state which could be applied in the calculation of the velocity of detonation of condensed explosives. In the course of this work an investigation was made of the conditions under which the virial theorem holds in such calculations. In chemical kinetics he has made a study of the pyrolysis of nitrocompounds, distinguishing between bond breaking and unimolecular mechanisms and, in addition, is at present doing theoretical work on rates of energy transfer in gases.

### Dr. B. C. L. Weedon

Dr. Weedon was educated at Wandsworth School and at the Imperial College of Science and Technology, London, and, after graduating in 1942, worked at the Imperial College on the reactions of acetylenic alcohols. He later joined Imperial Chemical Industries, Ltd. (Dyestuffs Division), and spent two years in the research laboratories at Blackley. In 1947 he was appointed to his present position as lecturer in organic chemistry at the Imperial College, and, with Sir Ian Heilbron, until the latter relinquished his chair, and then independently, he worked on compounds of the vitamin A type; as a result, several features in the relationship between biological (growth-promoting) activity and molecular structure were elucidated. Dr. Weedon has been working in the carotenoid field and has developed routes to the synthesis of methylbixin and some related compounds. Another of his current interests is in fatty acids, and he is also associated with Prof. R. P. Linstead in developing anodic reactions of preparative value in organic chemistry. Such methods have, for example, been found to provide convenient routes to a wide variety of straight- and branched-chain, saturated and unsaturated, fatty acids. During this research a novel route to some vinyl*cyclo*propanes was encountered.

## New Zealand Department of Scientific and Industrial Research

Mr. F. R. Callaghan has recently retired from his post as secretary to the council and permanent head of the New Zealand Department of Scientific and Industrial Research, and has been succeeded by Dr. W. M. Hamilton, assistant secretary in control of the agriculture and biology branches of the Department. Mr. Callaghan is a graduate of Canterbury University College, Christchurch, and after a period of teaching in the South Island he was appointed in 1916 as instructor in agriculture to the Auckland Education Board. In 1926 he was in charge of the New Zealand Government Court at the Wembley Exhibition, London. Then, in 1927, he joined the newly formed Department of Scientific and Industrial Research, and from the first took a major part in the establishment of the Department on sound lines, helping the secretary in the formidable task of establishing, equipping and staffing the many new units of the Department. In 1936 he also became chief executive officer of the Plant Research Bureau, which comprised the Plant Diseases Division, the Grasslands Division, the Crop Research Division, the Entomological Research Station, and the Botany Division, and he was largely responsible for the development of agricultural research in the Department. Mr. Callaghan was officially appointed assistant secretary in 1935, deputy secretary in 1939, and finally secretary and permanent head in 1947 in succession to Dr. E. Marsden. During his service with the Department he has seen it grow from a small beginning to a large organization of great importance to New Zealand science, and the success of this expansion is in no small way due to his efforts. His successor, Dr. Hamilton, was educated at Auckland University College and Massey Agriculture College, gaining the degree of D.Sc. for his survey of the dairy industry. He joined the Department in 1936 and in 1941 deputized for Mr. Callaghan as chief executive officer of the Plant Research Bureau. He was appointed assistant secretary in charge of the agricultural and biological branches in 1948.

## Research Expenditure in the United States

Federal expenditure in the United States on scientific research and development during 1952 was 1,839 million dollars, according to the National Science Foundation, and is estimated as 2,189 million dollars for this year and 2,327 million in 1954. Of this expenditure, the Department of Defence accounted for about 72 per cent in 1952, the Atomic Energy Commission for 14 per cent, and the National Advisory Committee for Aeronautics and the Federal Security Agency for 4 per cent each, with a little more than 3 per cent for the Department of Agriculture. The distribution ratios for the 1953–54 estimates are similar. These figures may be compared with those given for industrial research and development in a preliminary report issued by the Research and Development Board, Department of Defense (Washington 25, D.C.). Based on a survey made during the middle of 1952 of about two thousand companies that are estimated to handle 85 per cent of all industrial research and development in the United States, this report indicates that the co-operating companies spent nearly two thousand million dollars on research and development in 1951, half of which was financed by the Federal Government, and 97 per cent of this government programme was sponsored by the Department of Defense and the Atomic Energy Commission. The survey covered some ninety-four thousand scientific workers and engineers and a hundred and forty thousand supporting workers; of all these, more than half were employed in the electrical machinery, aircraft and chemical industries. Nearly 90 per cent of the scientific workers and engineers were working in manufacturing industries, and 55 per cent in the electrical machinery, aircraft and chemical industries; more than a third were employed by less than twenty companies which have research staffs of a thousand or more, and less than 2 per cent were employed by six hundred companies with staffs of less than five professional workers. The electrical machinery, aircraft and chemical industries account for 55 per cent of research expenditure, but the chemical industry, which ranks third in respect of expenditure on research, received only 7 per cent of its expenditure from Federal funds. The report refers to a greatly increased rate of turnover of scientific workers and engineers and to the vulnerability of industry engaged on defence research programmes to demands of military service.

## Royal Scottish Forestry Society: Centenary Endowment Fund

In February 1954 there will be an important forestry centenary, for, a hundred years previously, the Royal Scottish Forestry Society, the senior forestry society in the British Commonwealth, was founded. Particularly from the beginning of the eighteenth century, many Scottish landowners had pioneered in planting, and, in the middle of the nineteenth century, interest had been quickened by the introduction of conifers from the Pacific slope of what was to become the north-west States of the United States and British Columbia. From its foundation, the Society has stimulated and co-ordinated interest and the development of forestry in Scotland; but its influence has been felt far beyond the bounds of that country. It helped to promote the establishment of chairs in forestry in the Universities of Edinburgh and Aberdeen, and it continues to strive to extend education in forestry. The Society has taken a leading part in advocating the need for a national forest policy and a State forestry department, and in the latest post-war period it has helped directly and indirectly to mould government policy in relation to private forestry. Like many societies in these days, its income is proving inadequate for its necessary activities; a Centenary Endowment Fund of £10,000 is therefore being started. Donations should be sent to the Treasurer, Royal Scottish Forestry Society, 7 Albyn Place, Edinburgh, 2.

## Nuclear Research in Yugoslavia

The growth and development of nuclear research in Yugoslavia, and of the Institut de Recherches sur la structure de la Matière at Vincha, near Belgrade, is mainly due to the efforts of Prof. P. Savich, the present head of the Chemistry Laboratory. When, late in 1948, the building of the Institute was commenced, Prof. Savich was one of the only two men of science in Yugoslavia who could claim any previous experience of nuclear physics. Since then, however, about a hundred young physicists, chemists, mathematicians and engineers, many of whom have been trained in Yugoslav universities, have been gathered together to form the physics, chemistry, applied mathematics, electronics and biological sections of the Institute. The present director is S. Dedijer, and Dr. R. J. Walen is in charge of the physics section. The Institute possesses a Cockcroft–Walton type of accelerator, giving 1·5 MeV., and preliminary studies for the construction of a nuclear reactor are being undertaken. The progress made and the standard achieved may be judged from the collection of the first sixteen scientific articles published by members of the Institute, which has recently been issued (*Recueil de Travaux de l'Institut*, 1; 1952. Pp. 120; from the Institute, Belgrade). Six of the articles are in English, nine in French and one in German (with English summary). They deal mainly with instruments and techniques useful in nuclear energy research, and include articles on impulse amplifiers, a large-window rectangular β-particle Geiger–Müller counter, the fluorimetric determination of uranium in ores, the determination of feeble concentrations of heavy water, the uses of mass spectrometers, glass-to-metal seals, the structure of electrolytically deposited copper, measurements of β-ray spectra, the retardation of neutrons, and particle track lengths in photographic emulsions.

## Presentation of Technical Information

Subsequent to Prof. R. O. Kapp's lectures on "The Presentation of Technical Information", given at University College, London, in 1947, an informal discussion group was formed which, in October 1948, entered on a formal existence under the title, Presentation of Technical Information Discussion Group (Secretary: B. C. Brookes, University College, Gower Street, London, W.C.1). The objects of the Group are to interchange ideas and experience of the art of exposition, and to encourage the development of any methods of presenting technical information which promise to raise the general standard of exposition. A paper read at a meeting of the Group on November 19, 1952, by J. W. Godfrey, deals with the preparation and production of technical instruction manuals and has been issued as Group Paper D.G. No. 1. It discusses the qualifications of a technical writer, the considerations which may lead an organization to set up a technical publications unit and the problems of co-ordination which may arise in such a writing unit. Some notes are also included on difficulties, such as formulæ, in the preparation of typescript for letterpress, and on methods of production, including the production of illustrations.

## Health Education in Rumania

In the summer of 1952 Dr. S. Leff, medical officer of health to the County Borough of Willesden, visited Rumania, and he has recorded some of his impressions of health activities in that country (*Health Educ. J.*, 11, No. 1; January 1953). Before the War most Rumanian babies were born in home conditions of great ignorance and poverty; doctors and midwives were almost unknown in rural areas. During recent years the Rumanian Ministry of Health has built more than one thousand maternity hostels throughout the country, each with a doctor and midwife in attendance. These hostels are small; but, within a period of about two years, the number of mothers delivered under aseptic conditions in them rose to almost 100 per cent. The combination of measures for health education and the raising of the standard of the health services has resulted in a large reduction in the maternity mortality-rates and in the halving of the infant mortality-rates within four years. Another example of the results that can be achieved by health education is the Rumanian experience in combating typhus. Up to the end of the War, 72,000 people suffered from typhus annually, largely owing to dirt, lack of washing facilities and illiteracy. In 1952 the number had fallen to a few hundred. This was accomplished as the result of an extensive health education campaign throughout the country. The success of this campaign has been repeated with malaria, where the number of cases has been reduced from 50,000 annually to 5,000.

## Embryology of the Orobanchaceæ

*Cistanche tubulosa*, like other members of the Orobanchaceæ (Personales), is a leafless total parasite, growing on the roots of *Acacia* and other trees. In an investigation of its embryology, B. Tiagi (*Lloydia*, 15, 3, 129; 1952) has found that the embryo sac is not characterized by any unusual features, but after fertilization the embryo remains small and relatively undeveloped. In the small mature seed the embryo is an ovoid structure with tissue differentiation but without differentiation of plumule, cotyledons or radicle. The cellular endosperm forms a rather feeble chalazal haustorium but a very aggressive micropylar haustorium, with intercellular hyphal-like branches which penetrate the integument. These endosperm developments, however, are general in the autotrophic Scrophulariaceæ and are not correlated with the parasitic habit in *Cistanche*.

## Nutrition Society Conference on Scurvy

THE Nutrition Society is holding a two-day conference in Edinburgh during May 22–23, in honour of the bicentenary of the publication of James Lind's "Treatise of the Scurvy". After an opening ceremony in the University Upper Library, Surgeon Vice-Admiral Sir Sheldon Dudley will give an address on Lind, and Sir Edward Mellanby will then take the chair at the first session; the chairmen at other sessions will be Vice-Admiral Sir Alexander Ingleby-Mackenzie, Prof. R. C. Garry and Dr. L. J. Harris. Thirteen papers will be read dealing with various aspects of scurvy and vitamin C, of which six will be by authors from the United States and one each from Belgium, France and Holland. Further information can be obtained from Dr. C. P. Stewart, Department of Clinical Chemistry, Clinical Laboratory, Royal Infirmary, Edinburgh.

## The Night Sky in May

NEW moon occurs on May 13d. 05h. 06m., U.T., and full moon on May 28d. 17h. 03m. The following conjunctions with the moon take place: May 10d. 19h., Venus 4° S.; May 14d. 11h., Mars 4° S.; May 25d. 09h., Saturn 8° N. Mercury is a morning star, rising at 4h. 15m. on May 1 and at 4h. on May 15, and is in superior conjunction on May 24, after which it becomes an evening star but is too close to the sun for the remainder of the month to be favourably seen. Venus, a morning star, rises at 3h. 30m., 2h. 55m. and 2h. 20m. on May 1, 15 and 31, respectively; its stellar magnitude is about – 4·2 during the month, and the visible portion of the illuminated disk varies from 0·1 to 0·36. Mars sets at about 21h. during the month, which is an hour after the sun at the end of the month and it will then be difficult to observe. Jupiter sets at 20h. 50m. and 20h. 15m. on May 1 and 15, respectively, and is in conjunction with the sun on May 25, after which it becomes a morning star but cannot be observed during the remainder of the month. Saturn rises in the afternoon, and some time after sunset remains visible until the early morning hours; it is easily recognized by its proximity to Spica, and its stellar magnitude averages about 0·6. The $\eta$ Aquarid meteor shower is active in the early part of May and is visible in the early-morning hours. For many years it has been believed that this shower was associated with the debris of Halley's Comet, but recent work carried out by Prof. A. C. B. Lovell and his team at Jodrell Bank, University of Manchester, has thrown some doubt on this connexion, although further research is necessary before a definite pronouncement can be made. The velocities of these meteors obtained by radar methods at Jodrell Bank are less than would have been expected from the debris of Halley's Comet, but the results are not yet conclusive.

## Announcements

IN the Department of Nuclear Physics of the Australian National University, Canberra, Dr. B. D. McDaniel, associate professor of physics in Cornell University, has taken up his duties as a visiting Fulbright Fellow, and Dr. J. H. Carver, formerly of the Cavendish Laboratory, Cambridge, has been appointed a research Fellow in the Department, working with Prof. E. W. Titterton on photo-disintegration problems.

THE Royal Dutch-Shell Group of oil companies is offering a research studentship in geophysics, of value £400 a year and tenable for two to three years at the University of Cambridge, which is open to men of any nationality less than twenty-seven years old. Further information can be obtained from Mr. B. C. Browne, Department of Geodesy and Geophysics, Downing Place, Cambridge. Applications must be completed by July 1.

THE Development Commission is offering a few grants to British honours graduates for training in research problems in marine or freshwater science, which is designed to fit them for employment either in the Fishery Research Services of the Ministry of Agriculture and Fisheries and the Scottish Home Department or in a marine or freshwater biological research institute. The grants are worth £250-£350 a year, with extra university fees paid, and are tenable initially for one year, but renewable up to a maximum of three years. Application forms, to be returned by May 20, can be obtained from the Secretary, Development Commission, 6a Dean's Yard, Westminster, London, S.W.1.

THE annual Cornell University summer laboratory course in techniques and applications of the electron microscope will be given in the Laboratory of Electron Microscopy of the Department of Engineering Physics during June 15–27, under the direction of Dr. Benjamin M. Siegel. The course is designed for research workers, both in academic institutions and in industry, who have recently entered the field of electron microscopy or who are planning to undertake research problems involving applications of the instrument. Further inquiries should be addressed to Dr. Benjamin M. Siegel, Department of Engineering Physics, Rockefeller Hall, Cornell University, Ithaca, N.Y.

A SPECIAL summer course in the thermodynamics of equilibrium and non-equilibrium states will be given at the Massachusetts Institute of Technology during June 29–July 10. The course, which is designed especially for teachers, research workers and development engineers, will provide an exposition of classical thermodynamics and explore the newer extensions of the subject into the kinetics of processes in which non-equilibrium states play an essential part. Besides the general lectures, a number of special topics will be discussed, including a biography of Count Rumford (the bicentenary of whose birth at Woburn, Mass., has been celebrated this year), the thermodynamics of irreversible processes, the third law of thermodynamics, the thermodynamics of compressible fluids, and critical points and transitions of the second kind and other related subjects. Further information can be obtained from the Director of the Summer Session, Room 3–107, Massachusetts Institute of Technology, Cambridge 39, Mass.

A BIBLIOGRAPHY on cholinesterases and the anti-cholinesterase drugs is being prepared by Dr. K.-B. Augustinsson, of the Biochemical Institute, University of Stockholm (Odengatan 63, Stockholm 6), covering all published (official and unofficial) reports and patents, etc., in this field. In order to facilitate the compilation of this bibliography, Dr. Augustinsson requests that complete sets of relevant reprints be sent to him at the above address. If this is not possible, he would be very grateful for bibliographical details, and also any further information such as possible future publications and the names and addresses of librarians who might be prepared to co-operate in gathering together material.

# DEVELOPMENTS IN METHODS OF MICROSCOPY

A WELL-ATTENDED symposium and exhibition, organized by the Royal Microscopical Society (Industrial Section) in collaboration with the Spectroscopy Group of the Institute of Physics, the Optical Group of the Physical Society and the Physical Methods Group of the Society of Public Analysts and Other Analytical Chemists, was opened at King's College, London, on March 20 by Prof. J. T. Randall. Prof. Randall welcomed the co-operation of the four societies concerned, which he said is a recognition that to-day microscopy is not the servant mainly of only one discipline, but of many.

The meeting consisted of three sessions of papers in the anatomy lecture theatre, while an exhibition of apparatus was staged in the Physics Laboratories at King's College. In the first session, Dr. A. E. J. Vickers surveyed the use of the polarizing microscope in organic chemical research. Optical measurements such as refractive index, birefringence, can be made, which characterize and identify materials. He showed a number of microscopes of different design, as well as accessories such as universal stages, for meticulously orienting crystals. Polarization was also the subject of two of the five short papers of the second session. Mr. E. G. Steward showed how X-ray analysis, together with examination of birefringence, can identify components of mixed minerals. He also exhibited a simple hot stage for studying polarizing microscope interference figures of crystals at raised temperatures: 200°–300° C. could easily be obtained with negligible heat loss, cooling arrangements being unnecessary. Dr. R. Barer discussed polarization of the fluorescent light emitted by certain crystals, and suggested this might be used for determining the orientation of molecular planes.

Mr. M. G. L. Curties discussed the testing of microscope objectives with the Baker–Smith interferometer, in which shear is obtained by birefringent elements. He showed interferograms of aberrant objectives and the effect of unsuitable cover glasses and immersion oils. Dr. H. H. Hopkins spoke on the influence of the illuminating aperture on optical images. The partial coherence of the light in the object plane depends on the aperture of the illuminating system. Some results obtained by a generalization of the diffraction theory of image formation were given, including the influence of aberration and condenser aperture on images of periodic structures, of lines of negligible width and of straight edges. Dr. M. H. F. Wilkins described a solid fused-quartz ultra-violet microscope water-immersion objective of N.A. 0·90, constructed with spherical surfaces. The quartz/aluminium reflecting interfaces are internal, so that atmospheric deterioration is prevented. Photomicrographs as examples of the performance of the objective were exhibited: the same field taken in infra-red and in ultra-violet showed the relative quantities and distribution of hæmoglobin and nucleic acid in developing red cells.

Among other exhibits was a double-refracting interference microscope with variable phase, shown by Mr. F. H. Smith. The optically matched condenser and objective pairs with double-refracting components each exert a double-focus effect. The condenser illuminates axially separated planes of the specimen with the same portion of the luminous source, while the objective brings the two separated planes into coincidence in the image plane. The interference of the images is controlled by a double-refracting phase-shifting system. Prof. S. Tolansky exhibited a device for showing the profile of a surface. The shadow of a thin opaque line thrown at an angle on to a flat surface under the microscope appears straight, but if the surface is corrugated the line faithfully contours the corrugations. An infra-red reflecting microscope of N.A. 0·8 and focal length 13·5 mm. was demonstrated by Dr. W. C. Price; it is constructed with large mirrors to give a long working distance and to match the optics of an infra-red spectrometer. The focal length permits the objective to be used at the low magnifications necessary for infra-red work. Dr. P. M. B. Walker showed a densitometer for recording the density in photomicrographs by a double-beam system incorporating a circular density wedge, and he and Dr. H. G. Davies showed a photomultiplier attachment for photometric microscopy. Dr. W. E. Seeds exhibited an ultra-violet monochromator for use with a microscope of low aperture and high dispersion. It is a reflecting system involving two passages of light through a 60° quartz prism: with a line source, large field areas can be illuminated monochromatically.

In Mr. J. R. King's apparatus for examining opaque objects by fluorescence microscopy, ultra-violet radiation suitably filtered from a high-pressure compact source mercury vapour lamp is reflected on to the specimen from above by a Chapman and Aldridge illuminator with aluminized surfaces, as modified in the Beck–Chapman illuminator. A new technique for examining fine particles of such materials as coal, which is only translucent when thin, was demonstrated by Dr. R. G. H. Boddy. The particles are collected by the 'delta' technique, the deposition of the dust on a slide being watched under the microscope to obtain an adequately sized and distributed sample. The particles are then crushed by a specially designed condenser while the process is under observation, the measurements of the particles and the manner and results of crushing affording new information about them. A two-circle goniometer of unconventional design to provide a robust and simple apparatus for measuring crystal angles was exhibited by Mr. W. T. Moore and Mr. L. W. Codd. Dr. R. Barer and Dr. W. Weinstien demonstrated a microscope lamp designed to fulfil the two conflicting requirements for Kohler illumination: for high-power objectives a large aperture has to be filled, but the field of view is small, while for low-power work the field is large and the aperture small. The new lamp uses one fixed lens and two interchangeable lenses to provide combinations suited to objectives and condensers commonly used.

A historical note was struck by Mr. F. C. Grigg, who illustrated, from the Royal Microscopical Society's collections, the development of the microscope slide. Leeuwenhoek made special microscopes for individual objects: the rotating object holder later became popular, with talc windows enclosing a variety of objects. The ivory slide held the field for more than a century, and early glass slides, also with a number of objects, were long and narrow. The first 3 in. × 1 in. glass slides were covered with ornate paper covers: the present uncovered slide has now been used exclusively for upwards of fifty years.

Finally, among the exhibits was a small electron microscope shown by Mr. R. H. Horne.

The third session, a paper on cinemicrography, was given by Mr. R. McV. Weston. He discussed the apparatus and general technique of filming through the microscope and the difficulties that arise when cinecamera and microscope are harnessed together, mentioning vibration, weight, size of film and apparent changes of speed with magnification. He showed lantern slides of a number of famous pieces of apparatus and finished with a fascinating film he had made, the only one so far to have been taken at 3,000 exposures per sec. through the compound microscope: it showed what happened to the mercury at the constriction in a clinical thermometer immersed in warm water.

MARY DEMPSEY

# BRITISH NON-FERROUS METALS RESEARCH ASSOCIATION

## OPEN DAYS

During the week beginning March 23 the British Non-Ferrous Metals Research Association held open days during which, representatives of members and other industrial companies, university staffs and government scientific workers were invited to visit the laboratories at Euston Street, London, N.W.1. A total of more than eight hundred persons went during the week, and, at a press conference held on the first day, some fifty newspapers and periodicals were represented. The equipment of the laboratories was demonstrated, and the Association's present researches with some of those recently concluded were illustrated by exhibits.

The work of the Association covers every aspect of metallurgy, including extraction, melting and casting, working, mechanical and physical testing, corrosion, analysis and metal finishing. Major research projects, of which there are forty-two in hand at the moment, are selected from those problems which are of interest to groups of the Association's members and which can be more satisfactorily handled on a co-operative basis than in an individual works laboratory. Members co-operate with the Association's staff, which exceeds one hundred and fifty in number, by making available through a number of advisory committees knowledge within the industry on the problem in question; in some cases, members carry out in their own laboratories specific items in a research for which they have special facilities and try out some of the Association's investigations on a production scale for the benefit of other members.

The exhibits at the open days naturally referred mainly to the work actually carried out in the laboratories in Euston Street and were too numerous for comprehensive description. The following notes select a few items for special mention.

*Pressing of aluminium alloys.* One of the difficulties in the production of sheet-metal pressings in the aluminium–magnesium alloys, which are otherwise the most suitable for this purpose, is the appearance of markings in the less severely worked parts of the sheet due to uneven yielding. These are called stretcher/strain markings and are similar in appearance to those occurring in steels. The true nature of these markings has been investigated and the causes of their formation ascertained in the laboratories. From this basic knowledge practical recommendations for their avoidance have been made, and the effectiveness of the measures suggested has been established by works trials carried out with the collaboration of several members. The industry is now in a position to supply aluminium–magnesium alloy sheets which are not liable to these markings.

*Improvements in bronze foundry practice.* Over many years the Association's work in this field has established the principles governing the avoidance of gas and shrinkage unsoundness, and the present work is largely concerned with the application of this knowledge in industrial production. A special investigation is also being made in the use of insulated feeder-heads which not only improve the feeding of a casting but also greatly reduce both the weight of metal melted for a good casting and the labour involved in fettling.

*Titanium.* Although some exaggerated statements have been made about titanium, there is no doubt that its remarkable strength and corrosion resistance, coupled with its relatively light weight (intermediate between aluminium and steel), make it an extremely promising material for many engineering applications. The present high cost restricts very much its potential uses, but the prospects for the future are such as to make it important for Great Britain to play its share in the development of titanium alloys. The Association has investigations in this field in hand on behalf of the Ministry of Supply, and is provided with special equipment and experience in the techniques necessary for the handling of this highly reactive element.

*Prevention of corrosion.* Many of the applications of non-ferrous metals in engineering practice depend on their intrinsically high corrosion resistance, and the urge to develop better materials for particular applications is very pressing. In the field of condenser-tube alloys, the Association is pre-eminent. Aluminium brass, which is now very widely used in marine and land installations, was developed in the Association's laboratories, and the beneficial effect of iron additions in the 70/30 cupro-nickel alloy, which is widely accepted as the best all-round material for marine use, was fully established by the Association's work. This was followed by the development of copper–nickel–iron alloys of low nickel content, which are easily worked by the coppersmith and are resistant to corrosion by moving sea-water.

Similar work has been carried out on materials for the conveyance of fresh waters. For example, the occasional pitting to which copper water-pipes are subject has been traced in part to a film of carbon formed during the annealing operation which, when recognized, can easily be avoided, and in part to the absence from some waters of a naturally occurring corrosion inhibitor. Attempts are at present in hand to isolate and identify this inhibitor.

*Metal economy.* Researches designed to improve the efficiency of the manufacturing operations or to lengthen the service life in a particular application all promote the economical use of metals, and most of the Association's work comes in this category. Some researches have, however, been specifically aimed at problems in this field, such as the recovery of copper from pickle liquors, reduced consumption of zinc in galvanizing and more effective use of nickel in electroplating.

*Metal finishing.* One of the main investigations in the relatively newly formed Metal Finishing Laboratory at Euston Street is on the use of nickel in electroplating. Other researches in that field, designed to improve technique, are those on the electroplating of aluminium and on chromium deposition. The plating of aluminium is difficult, due to a tendency of the basis metal to form a film which prevents proper adhesion of the deposit. This is overcome by the initial formation of a thin zinc coating in one of two ways: chemical replacement, or electrodeposition. The conditions necessary to secure the optimum results in both these methods have been worked out, with marked improvement in industrial practice as a result.

*Analysis.* In the analytical field, the Association is responsible, apart from a vast amount of analysis required in its own investigations, for the development of new methods and apparatus. The exhibits during the open days covered an extremely wide variety of analytical methods, including the determination of gases in metals. In the chemical field great use is made of the polarograph (including derivative polarography) and of the spectrophotometer. In the field of spectrographic analysis, the Association has been responsible for a great deal of work aimed at improving the range and accuracy of the method. A direct-reading spectrograph (Quantometer) has recently been acquired, designed for the examination of copper alloys. The accuracy and field of use of this instrument are being explored in the light of its known success in the aluminium and steel industries.

# DEODAR AS PENCIL WOOD

UNTIL recently the so-called East African cedar (***Juniperus procera***) from Kenya has held sway in Britain, the United States and elsewhere as providing the highest class of pencil. Formerly the eastern red cedar of America (***Juniperus virginiana***) was widely used for pencil-making in the United States; but supplies gave out and the Kenya cedar held pride of place for the best-class and highest-priced pencil. Another tree used for this purpose in the United States is the incense cedar (***Libocedrus decurrens***), which grows in California. The use of the beautiful Indian deodar wood (***Cedrus deodara***) for pencil slats is a new idea, due to the research work undertaken at the Research Institute at Dehra Dun, and Indian Forest Bulletin No. 149 (New Series) gives a brief account of this new application*. The deodar has been extensively used in the past for other purposes: after the Sikh Wars in the Punjab (1849), the province was taken over and the British made acquaintance with the deodar, practically the only wood used by the local people, in the building of stations and cantonments; later, in the early 1860's, with the coming of the railways, the wood was in even greater demand for making sleepers.

The habitat of the deodar is the north-west Himalaya at approximately 6,500–8,000 ft. It has a strong timber, of good grain and easy to work, and is free from warpage. The trees are felled on contracts by the mountain people, converted ***in situ*** as required for logs or sleepers and floated down the mountain rivers to the part of the hills where they are collected in depots and built into rafts for the rest of the journey. The forests and work are mostly under the supervision of the government forest department. From the work done at the Institute, it is claimed that the wood makes first-class pencils. Unfortunately, its colour is light yellow; it is thought the public would be suspicious of the unusual colour, so the deodar slats are stained with a dye to a more popular colour. If the deodar pencil can be put on the market at a paying price, the results should be satisfactory, for the consumption in India to-day is about half a million gross of pencils, of which the deodar will supply the demand for higher quality pencils and save imports.

In supplies of material it is hoped to make use of part of the millions of cubic feet of sawn timber extracted every year as shipur; but perhaps more particularly to exploit the huge amount of off-cuts and small pieces left in the forest after the shipur conversion. The bulletin is silent as to the methods by which this material can be collected on the mountain-side in forests where chain-felling is not practical, and it also gives no indication as to the costs of such collection.

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[*] Indian Forest Bulletin (New Series). No. 149 (Wood Seasoning): Deodar as Pencil Wood. By M. A. Rehman and Jai Kishen. Pp. iv+7 (Delhi: Manager of Publications, 1951.) 5 annas; 6*d.*

# EARTHQUAKES DURING 1952

DURING 1952 there were eighty-nine earthquakes each having a magnitude 6 or greater than 6 on the Richter logarithmic scale. The greatest two had magnitudes 8¼ and about 8¼, these being rather less than the greatest the world has known. One of the two occurred on March 4 from an epicentre near the east coast of Hokkaido, Japan. Fissures in the earth were caused, and a section of the cliff sank into the sea. Several bridges were damaged, railway lines were buckled and two trains were derailed. When buildings collapsed, fires were started. There was probably some geological fault displacement in the sea-bed also, as a tsunami with waves up to eight feet high swept the coast and swamped a fishing fleet of twenty boats at Urumai village. At least 31 people were killed and 169 injured, and there was extensive damage to property.

The other earthquake occurred on November 4 from an epicentre near the east coast of Kamchatka (see *Nature*, 170, 914; 1952). The epicentre, as calculated from observations at eighty-one observatories by the workers at the International Seismological Association Central Station at Strasbourg, was situated at lat. 52·9° N., long. 160·1° E., and the initial time was 10 hr. 58 min. 23 sec. G.M.T. The macroseismic effects in Kamchatka are not yet known, but the earthquake started a great tsunami which spread across the Pacific Ocean and reached as far as the shores of New Zealand, the Hawaiian Islands and South America.

During the past year five earthquakes were reported with a focal depth equal to, or greater than, 400 km., the one with the greatest focal depth (700 km.) being on February 11 with its epicentre in the Java Sea.

There were a number of earthquakes in or near Europe, and these included the following. On January 3 an earthquake occurred with epicentre near Hasankale in Turkey, Erzurum being affected; the shock caused damage to some 1,570 houses, and at least 94 persons were killed and 262 injured. On February 7 an earthquake at Arette in the Low Pyrenees, and on February 24 another near Worms and Ludwigshafen in the lower Rhine valley, were both felt with intensity 7 on the Modified Mercalli scale. On February 22 an earthquake took place with epicentre near Winster in Derbyshire. Chimney-stacks collapsed and walls of buildings, chiefly in the main street, collapsed; some slight damage was done in the surrounding district, and it is likely that movement took place along the Crich–Cromford–Bonsall fault. The shock was accompanied by a sound like a double explosion. On March 9 an earthquake was felt with intensity 8 at Etna in Sicily, and on the same day a strong one occurred in north-west Turkey. An earthquake with intensity 7 was felt on May 20 at El Palmar in Spain. Shocks with intensity 8 occurred on June 8 at Pierre Longue (France), on June 13 at Perivola (Peloponnese Islands) and on June 26 at Riberra Quente, Azores. On September 29 an earthquake was felt with intensity 7 at Munchhausen and Soufflenheim in the lower Rhine valley, and on October 8 there was a shock in lower Alsace with the same intensity. Twelve people were killed and a hundred injured on October 22 in an earthquake in the Adana district in Turkey.

Other earthquakes causing property damage and casualties occurred as follows. On July 21 in the Tulare Valley in southern California an earthquake caused extensive damage and several people were killed. The town most seriously affected was Tehachapi, some hundred miles north of Los Angeles. Permanent vertical ground movement at Bear Mountain fault was as much as one metre. On October 14 an earthquake from an epicentre at lat. 8·5° N., long. 83° W., near the south coast of Costa Rica, resulted in casualties and property damage, as did one on October 28 in Haiti (epicentre at lat. 18 5° N., long. 73·5° W.). On November 22 an earthquake caused slight property damage in San Luis Obispo County, California.

Reports have been received from the United States Coast and Geodetic Survey in co-operation with Science Service and the Jesuit Seismological Association, the International Seismological Association at Strasbourg, and from observatories at Aberdeen, Arkansas, Beograd, Cleveland (Ohio), De Bilt (Netherlands), Durham, Fayetteville (U.S.A.), Karlsruhe, Kew, Pasadena, Perth (Western Australia). Stuttgart, Toledo, Wellington and the New Zealand stations (including Fiji), and Zurich and the Swiss stations.

ERNEST TILLOTSON

# EDUCATION IN INDIA

THE first elections in free India under universal suffrage showed that a large proportion of voters had voted not for any particular cause, or person, but for the sacred bull (*Science and Culture*, 18, No. 1; July 1952). Congress, which now holds power, had long been mindful of the importance of educational reforms. So far back as the Karachi session of the Indian National Congress of 1931, a resolution was passed defining the fundamental rights of citizens and stating in its preamble that to enable the masses to appreciate what Swaraj would mean to them, Congress should provide for free and compulsory education.

Since independence, the National Government has been seriously tackling this problem. A large number of committees was appointed to consider general educational matters. Among them was the Kher Committee, which recommended that: (1) a fixed percentage of central and provincial revenues—about 10 per cent of the central and 20 per cent of the provincial—should be earmarked for education by the respective Governments; (2) about 70 per cent of the expenditure on education should be borne by Provincial Governments, including local bodies, and the remaining 30 per cent by the Central Government; (3) all contributions for education approved by the Provincial and Central Governments should be exempted from income tax.

The percentages recommended by the Kher Committee were not large. In certain States of the United States of America, nearly 30 per cent is spent on education, and in one State nearly 40 per cent. Apart from Mysore, which was already spending a larger percentage on education, no other major State, excepting a few like Bombay and Madras, have given serious attention to the Kher Committee's recommendations.

A comparison of State finances for 1951–52 shows that the total educational budget of all the States amounted to Rs. 65 crores, which is about 14·8 per cent of the total budgets of the various States against the Kher Committee's recommendation of 20 per cent. From these figures it is clear that the attempts to remove 'illiteracy' in the Indian Union has fallen short of the objective of Congress.

When Shri B. G. Kher's Committee recommended that 10 per cent of the central budget should be spent on education, it was implied that the bulk of it should be spent on higher and professional education. Ten per cent of the central budget comes to 30–40 crores of rupees, while the actual expenditure by the Central Government has varied between 3 and 6 crores.

The University Commission, appointed by Government on November 4, 1948, supported the National Planning Committee and Kher Committee's recommendation that democracy depends for its very life on a high standard of general, vocational and professional education. The academic problem has assumed new shapes. India now has a wider conception of the duties and responsibilities of universities. "They have to provide leadership in politics, administration, the professions, industry and commerce. They have to meet the increasing demand for every type of higher education, literary and scientific, technical and professional. It is for the universities to create knowledge and train minds who would bring together material resources and human energies."

The Commission found that the universities were unable to carry out these responsibilities because their finances were totally inadequate.

Like the Kher Committee, it recommended that the Central Government should make large grants for higher education through a properly constituted agency.

The Commission is aware that the Central Government has taken the responsibility of maintaining the Universities of Banaras, Aligarh and Delhi (and now, the Visva Bharati), and that a large amount of money has been given as grants to meet the needs of these universities. While welcoming and appreciating the grants that have so far been given, the Commission has suggested that, even though grants to other universities are mainly provincial responsibilities, they should also be the concern of the Central Government at least so far as postgraduate education and research are concerned. The Commission noted with appreciation that grants to universities have been given by the Government of India in recent years, but hoped that there would be a more systematized method of giving these grants on the advice of a responsible body.

# MICROSOMAL PARTICLES OF NORMAL COW'S MILK

By Dr. R. K. MORTON

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HITHERTO, cow's milk has been considered to contain particulate components belonging to three categories, namely: (1) blood cells, leucocytes, bacteria and other readily sedimentable 'foreign' material; (2) butterfat globules; and (3) particles of the casein – calcium phosphate complex. However, it has recently been shown that lipoprotein particles, with which the alkaline phosphatase is firmly associated, also occur in milk[1,2]. Disruption of the lipid-protein bonds by treatment with *n*-butanol releases the alkaline phosphatase into true solution[1,3].

In order to obtain the lipoprotein particles, whole milk was centrifuged (2,500 *g*, 45 min.) and the cream layer removed and repeatedly washed with distilled water. After churning, the buttermilk so obtained was centrifuged at high speed (14,000 *g*, 45 min.). The red-brown lipoprotein precipitate was then dispersed in distilled water.

The separated milk was also centrifuged under similar conditions to obtain a pure white precipitate of casein. In this way both the lipoprotein and casein complexes were isolated by methods expected to produce only a minimum of denaturation or other modification, although the recovery was by no means quantitative.

The properties of the two materials are compared in the accompanying table.

COMPARATIVE PROPERTIES OF CASEIN AND LIPOPROTEIN PARTICLES OF NORMAL COW'S MILK

| | Casein particles | Lipoprotein particles |
|---|---|---|
| Lipid (per cent) | 3 | 22 |
| Nucleic acid | Not determined | Present |
| Cytochrome *c* | Absent | Present |
| Enzymic activities: | | |
| Alkaline phosphatase | 0·6 | 57·2 |
| Diaphorase | Absent | 2·5 |
| Coenzyme I–cytochrome *c* reductase | Absent | 0·1 |
| Xanthine oxidase | Absent | 37·7 |
| Succinic dehydrogenase | Absent | Absent |
| Cytochrome oxidase | Absent | Absent |

Units for enzymic activities: alkaline phosphatase expressed as µmole phosphorus liberated from β-glycerophosphate/hr./mgm. nitrogen (at 37° C.), dehydrogenases expressed as µmole 2 : 6-dichlorophenol indophenol (diaphorase and xanthine oxidase) or of cytochrome *c* (coenzyme I–cytochrome *c* reductase) reduced/hr /mgm. nitrogen (at 18° C.)

The difference between the two protein complexes is immediately apparent. The relatively high lipid content (most of which is phospholipid) and the considerable enzymic activity of the lipoprotein preparation suggests that this was obtained relatively free of contaminant casein. Moreover, the very low enzymic activity of the casein precipitate indicates that it was only slightly contaminated with lipoprotein particles.

Partial separation of the casein from the lipoprotein particles has also been obtained by removing the former as paracasein by the action of crystalline rennin. However, other methods of separation, such as by precipitation of casein at the isoelectric point, with salts or with organic solvents, result in co-precipitation of the lipoprotein particles. Hence casein prepared by these methods will always contain this lipoprotein impurity, which may account for some of the heterogeneity ascribed to so-called 'purified' casein[4].

The chemical and enzymic characteristics of the lipoprotein complex as shown in the table are very similar to those of the microsomal particles from animal tissues[5]. Therefore, it is considered that these lipoprotein particles of normal cow's milk should be called 'milk microsomes'. Furthermore, since the alkaline phosphatases of milk and of mammary gland are identical, it appears that the microsomes are released into the milk from the secretory cells of the gland. The isolation of microsomes from an animal secretion without prior homogenization or other disruptive treatment indicates that these particles occur as such in the cells.

Microsomes have been considered to be derived by fragmentation of mitochondria[5,6]. However, it is clear that the milk microsomes could not have been obtained in this way. The failure to demonstrate either succinic dehydrogenase or cytochrome oxidase in any of the precipitates from milk indicates that mitochondria (with which these enzymes are firmly associated) are virtually absent. They apparently are not released into milk during normal secretion. The significance of the presence of microsomes and absence of mitochondria is the subject of further investigation.

The factors which influence the release of microsomes into milk from the secretory cells of the mammary gland have not yet been studied. It seems likely, however, that more microsomes will be released during disturbance of normal functioning of the gland, as, for example, during mastitis infection, or towards the end of lactation. The alkaline phosphatase activity of milk rises under both these influences[7,8]. Thiouracil treatment also increases the phosphatase activity of milk[9,10], in contrast to thyroxine[11]. It seems very probable that these compounds affect the release of the milk microsomes, rather than the phosphatase activity of the microsomes themselves. Therefore, caution is urged against concluding that the change in activity of milk is an indication of similar changes in the enzymic activity of the mammary gland itself[9,10].

The association of xanthine oxidase activity with microsomal particles has not previously been demonstrated. It is therefore of interest that microsomes from liver have also been found to have high activity. It now seems important to determine whether the properties of the particle-bound xanthine oxidases differ from those of the flavoprotein obtained in solution either by proteolytic or lipolytic action[12] or by butanol treatment[1].

Electron micrographs of the casein particles and the milk microsomes have shown that both are spheroidal in shape. The microsomes, however, do not show the same tendency to clump in regular forms as do the casein particles; they are much less dense and they often appear somewhat flattened. Both types of particles vary in size, from a maximum of about 250 mµ diameter, diminishing beyond the limits of resolution with the equipment available (less than 30 mµ).

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In endeavouring to obtain an active preparation of the 'virus' responsible for transmissible carcinoma in mice, different workers have employed centrifuging, either of untreated milk[13,14], or of milk after coagulation of casein with chymotrypsin[15]. The precipitates so obtained would certainly contain both casein and microsomal particles, the latter predominating where chymotrypsin treatment was used. Comparison of the electron micrographs obtained in the present work with those of particles separated from milk of mice having mammary carcinoma[13-15] confirms this view. Consequently, the claim that virus particles have been demonstrated in the sedimented material from infective milk cannot be considered as established. Moreover, the apparent relationship between the occurrence of human breast carcinoma and the number of particles found in milk[16] might well be explained by the release of a greater number of microsomes into milk from diseased cells. This would become particularly apparent in human milk, since the casein content (0·5 per cent) is so very much lower than that of cow's milk (3 per cent). The possibility that the milk microsomes themselves may carry the infective agent which is concerned in inducing carcinoma in susceptible mice is at present being investigated.

I wish to thank Mr. R. W. Horne, formerly of the Cavendish Laboratory, Cambridge, for taking the electron micrographs. I am grateful to Dr. M. Dixon for his continued interest and advice in this work, and to the Gowrie Scholarship Trust Fund of Australia and the Agricultural Research Council of Great Britain for financial support.

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# MEASUREMENT OF WIND CURRENTS IN THE SEA BY THE METHOD OF TOWED ELECTRODES

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It was first pointed out by Faraday that when a stream of water flows through the earth's magnetic field an electromotive force should be induced in it. Experiments made by Faraday himself, by suspending electrodes in the River Thames from Waterloo Bridge, failed to detect this e.m.f., owing to polarization of the electrodes and other experimental difficulties. Since then, measurements made on various submarine cables showed voltages related to the velocities of the tidal streams in their vicinity. In 1918, Young, Gerrard and Jevons[1] carried out experiments in the English Channel, using both fixed electrodes and electrodes towed in tandem behind a vessel. Their experiments showed clearly the existence of the induced e.m.f.'s due to tidal currents. In 1946, Longuet-Higgins[2] made measurements of the potential differences across pairs of fixed electrodes in the English Channel and gave a theoretical treatment of the potential gradients generated by water flow in a shallow channel. Since 1946 a form of equipment using towed electrodes, and known as the geomagnetic electro-kinetograph (G.E.K.), has been developed in the United States and used in a number of U.S. oceanographic and survey vessels to determine surface currents in the ocean (Von Arx[3]). The method of towed electrodes has also been used during recent cruises of the R.R.S. *Discovery II*, using quite simple equipment.

If a stream of water is moving horizontally with a velocity of $V$ cm./sec. and the vertical component of the earth's magnetic intensity is $Z$ gauss, then the e.m.f. induced in a filament of water of length $l$ cm., transverse to the direction of flow, is given by

$$E = VZl \times 10^{-8} \text{ volt.} \qquad (1)$$

Its direction is from right to left, in the northern magnetic hemisphere, as one faces downstream. If there is a conducting return path below the moving water, a current will flow, the current density $i$ being given by

$$i = E/(\rho + \rho')l,$$

where $\rho$ is the specific resistance of the moving water, and $\rho'$ may be termed the effective specific resistance of the return path. Then the potential difference measured by a voltmeter connected across a pair of fixed electrodes, distant $l$ apart, would be

$$e_1 = E - \rho li = E[1 - \rho/(\rho + \rho')]. \qquad (2)$$

If, however, the electrodes and the voltmeter are attached to a vessel drifting with the water, an e.m.f. $E$ will also be induced directly in the connecting wires, and the potential difference actually measured, $e_2$, will be the difference between this and the potential difference in the water, that is :

$$e_2 = e_1 - E = -\rho li = -\rho E/(\rho + \rho'). \qquad (3)$$

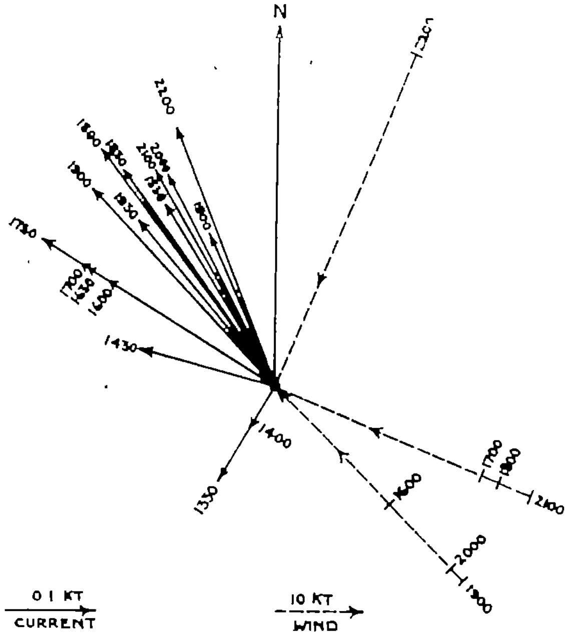
It is seen that the method of drifting electrodes is most sensitive when $\rho' \ll \rho$. This is the case when the flow extends only to a depth which is small compared with the total depth of water, so that the lower layer of water acts as a low-resistance return path for the electric current.

In the towed-electrode equipment used in *Discovery II*, the electrodes are of the non-polarizing silver/silver-chloride type, packed in glass wool in a cylindrical 'Tufnol' casing, which contains a number of holes to allow access to the water. A two-core rubber-covered cable serves for making electrical connexion to the electrodes and for towing them. The distance between the electrodes is usually 100 yd. and, with this separation, the sensitivity is approximately 2 millivolts per knot when $Z$ is about 0·4 gauss. On board, the two conductors are connected to the input of a D.C. amplifier, the output of which operates a pen recorder. A resistance-capacitance filter, with a time constant of approximately 30 sec., may be connected across the input to the amplifier, to reduce signals due to the component of particle velocity of the waves.

When the electrodes are being towed, the potential difference measured depends on the component of drift of the ship and electrode system at right-angles to the direction of towing, the forward speed of the ship being immaterial. By making observations on two courses at right-angles, the drift of the surface water may be determined in magnitude and direction. It is also necessary that a change of course of 180° should be made periodically to determine the 'zero point' of the potential difference and eliminate slow changes in the electro-chemical potentials of the electrodes. One way of fulfilling these conditions is by steaming in squares, that is, changing course by 90° at regular intervals.

The towed-electrodes method is well suited to the measurement of wind drift in deep water, since the drift is unlikely to extend to a depth greater than about 50 fathoms. An example of its use for this purpose, showing the development of a drift current following a change in the wind, was obtained during a recent cruise of *Discovery II*. At noon on October 12, 1952, *Discovery II* was in position 47° 50′ N., 12° 30′ W., in a depth of about 2,400 fm. After blowing from west-north-west during the morning, the wind had dropped to 'light airs' by noon. Soon afterwards, it started to blow from the south-east and freshened, reaching an average speed of 18 knots by 1600 hr., $25\frac{3}{4}$ knots at 1700 hr. and 30 knots at 1900 hr. A series of towed-electrode measurements was started at 1230 hr., the vessel steaming in squares, changing course by 90° every half-hour.

The accompanying diagram shows, in vector form, the drift currents as computed from these measurements. Each full-line arrow shows the direction and speed of drift, as computed from measurements on the four legs of a square, obtained during the period of 2 hr. centred on the time marked against the arrow. The corresponding wind vectors are shown by the broken-line arrows.



*Discovery II*, October 12, 1952. Current vectors, derived from towed electrode observations, and corresponding wind vectors. The time of observation is marked against each vector. At 1200 hr. the wind was reported as "light airs" and at 2130 hr. as "variable, 10 to 25 kt."

The 1330-hr. vector shows the drift as 0·12 knot, setting approximately towards south-south-west, and at 1400 hr. the drift had decreased to 0·05 knot in the same direction. The 1430-hr. vector, however, shows a drift of 0·16 knot in direction west by north. Subsequent vectors show the drift to be turning farther towards north-west and increasing in magnitude. By 1730 hr. the speed was 0·30 knot, bearing 301° (true). Afterwards the speed did not increase appreciably, although the direction continued to veer. Between 1800 and 2200 hr., the direction varied between 316° and 338°; but the variations are probably within the experimental error. Taking the mean of the determinations from 1800 to 2200 hr., the drift was 0·29 knot in direction 326°. The mean of the wind determinations from 1700 to 2100 hr. was 28 knots, blowing towards direction 308°. Thus the magnitude of the drift was about 1·0 per cent of the wind speed and its direction 18° to the right of the wind. After 2100 hr. the wind dropped, and at 2130 hr. was 10–25 knots, variable in direction. By 2200 hr. it had backed to north-north-east and increased to 40 knots. It appears from the meteorological charts that the centre of a small, but intense, depression passed slightly to the south of the ship's position at 2100 hr. The 2200-hr. drift vector (based on measurements taken between 2100 and 2300 hr.) shows no response to the change in wind direction, and could scarcely be expected to do so.

It is of interest to compare these observations with the classical theory of wind drift, due to Ekman[4]. According to the theory, the surface drift, after the steady state has been reached, should be 45° to the right of the wind (in the northern hemisphere) and its magnitude $v_s$ should be given by

$$v_s = 0{\cdot}0127\, W (\sin\varphi)^{-1/2},$$

where $W$ is the wind speed and $\varphi$ the latitude. Taking $\varphi = 48°$, gives $v_s = 0{\cdot}0148\, W$. If the water is initially at rest and a wind suddenly starts to blow and then remains steady, the surface current should reach a speed comparable with the steady-state value after about $2\frac{1}{2}$ hr., in this latitude. The direction of the surface current should approach its final value more slowly, and after $2\frac{1}{2}$ hr. should be approximately 18° to the right of the wind.

The observed drift had a speed only about two-thirds of that predicted by theory for a current generated by the local wind. The discrepancy may be due, in part, to the presence of another current constituent which is independent of, or less readily affected by, the local wind. Current charts indicate that, in this part of the north-east Atlantic, there is a general drift towards the south-east, which would be almost directly opposed to the wind drift observed on October 12, and would thus reduce its magnitude.

These observations illustrate the rapid response of the surface drift to a change in wind and show that such changes in drift may readily be determined by the towed-electrodes method, using simple recording apparatus.

Acknowledgment is made to Dr. J. T. Crennell, of the Admiralty Chemical Laboratory, for advice on the design and construction of the electrodes, to Mr. M. J. Tucker, who was responsible for the electronic equipment, and to Dr. G. E. R. Deacon and the captain and officers of R.R.S. *Discovery II* for their part in making the observations.

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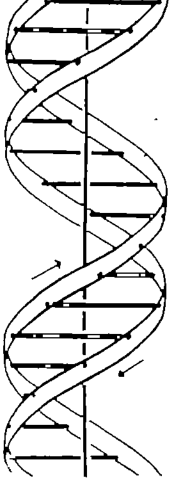
# MOLECULAR STRUCTURE OF NUCLEIC ACIDS

## A Structure for Deoxyribose Nucleic Acid

WE wish to suggest a structure for the salt of deoxyribose nucleic acid (D.N.A.). This structure has novel features which are of considerable biological interest.

A structure for nucleic acid has already been proposed by Pauling and Corey[1]. They kindly made their manuscript available to us in advance of publication. Their model consists of three intertwined chains, with the phosphates near the fibre axis, and the bases on the outside. In our opinion, this structure is unsatisfactory for two reasons: (1) We believe that the material which gives the X-ray diagrams is the salt, not the free acid. Without the acidic hydrogen atoms it is not clear what forces would hold the structure together, especially as the negatively charged phosphates near the axis will repel each other. (2) Some of the van der Waals distances appear to be too small.

Another three-chain structure has also been suggested by Fraser (in the press). In his model the phosphates are on the outside and the bases on the inside, linked together by hydrogen bonds. This structure as described is rather ill-defined, and for this reason we shall not comment on it.



This figure is purely diagrammatic. The two ribbons symbolize the two phosphate—sugar chains, and the horizontal rods the pairs of bases holding the chains together. The vertical line marks the fibre axis

We wish to put forward a radically different structure for the salt of deoxyribose nucleic acid. This structure has two helical chains each coiled round the same axis (see diagram). We have made the usual chemical assumptions, namely, that each chain consists of phosphate diester groups joining β-D-deoxyribofuranose residues with 3′,5′ linkages. The two chains (but not their bases) are related by a dyad perpendicular to the fibre axis. Both chains follow right-handed helices, but owing to the dyad the sequences of the atoms in the two chains run in opposite directions. Each chain loosely resembles Furberg's[2] model No. 1; that is, the bases are on the inside of the helix and the phosphates on the outside. The configuration of the sugar and the atoms near it is close to Furberg's 'standard configuration', the sugar being roughly perpendicular to the attached base. There is a residue on each chain every 3·4 A. in the $z$-direction. We have assumed an angle of 36° between adjacent residues in the same chain, so that the structure repeats after 10 residues on each chain, that is, after 34 A. The distance of a phosphorus atom from the fibre axis is 10 A. As the phosphates are on the outside, cations have easy access to them.

The structure is an open one, and its water content is rather high. At lower water contents we would expect the bases to tilt so that the structure could become more compact.

The novel feature of the structure is the manner in which the two chains are held together by the purine and pyrimidine bases. The planes of the bases are perpendicular to the fibre axis. They are joined together in pairs, a single base from one chain being hydrogen-bonded to a single base from the other chain, so that the two lie side by side with identical $z$-co-ordinates. One of the pair must be a purine and the other a pyrimidine for bonding to occur. The hydrogen bonds are made as follows: purine position 1 to pyrimidine position 1; purine position 6 to pyrimidine position 6.

If it is assumed that the bases only occur in the structure in the most plausible tautomeric forms (that is, with the keto rather than the enol configurations) it is found that only specific pairs of bases can bond together. These pairs are: adenine (purine) with thymine (pyrimidine), and guanine (purine) with cytosine (pyrimidine).

In other words, if an adenine forms one member of a pair, on either chain, then on these assumptions the other member must be thymine; similarly for guanine and cytosine. The sequence of bases on a single chain does not appear to be restricted in any way. However, if only specific pairs of bases can be formed, it follows that if the sequence of bases on one chain is given, then the sequence on the other chain is automatically determined.

It has been found experimentally[3,4] that the ratio of the amounts of adenine to thymine, and the ratio of guanine to cytosine, are always very close to unity for deoxyribose nucleic acid.

It is probably impossible to build this structure with a ribose sugar in place of the deoxyribose, as the extra oxygen atom would make too close a van der Waals contact.

The previously published X-ray data[5,6] on deoxyribose nucleic acid are insufficient for a rigorous test of our structure. So far as we can tell, it is roughly compatible with the experimental data, but it must be regarded as unproved until it has been checked against more exact results. Some of these are given in the following communications. We were not aware of the details of the results presented there when we devised our structure, which rests mainly though not entirely on published experimental data and stereochemical arguments.

It has not escaped our notice that the specific pairing we have postulated immediately suggests a possible copying mechanism for the genetic material.

Full details of the structure, including the conditions assumed in building it, together with a set of co-ordinates for the atoms, will be published elsewhere.

We are much indebted to Dr. Jerry Donohue for constant advice and criticism, especially on interatomic distances. We have also been stimulated by a knowledge of the general nature of the unpublished experimental results and ideas of Dr. M. H. F. Wilkins, Dr. R. E. Franklin and their co-workers at

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April 2.

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# Molecular Structure of Deoxypentose Nucleic Acids

While the biological properties of deoxypentose nucleic acid suggest a molecular structure containing great complexity, X-ray diffraction studies described here (cf. Astbury[1]) show the basic molecular configuration has great simplicity. The purpose of this communication is to describe, in a preliminary way, some of the experimental evidence for the polynucleotide chain configuration being helical, and existing in this form when in the natural state. A fuller account of the work will be published shortly.

The structure of deoxypentose nucleic acid is the same in all species (although the nitrogen base ratios alter considerably) in nucleoprotein, extracted or in cells, and in purified nucleate. The same linear group of polynucleotide chains may pack together parallel in different ways to give crystalline[1-3], semi-crystalline or paracrystalline material. In all cases the X-ray diffraction photograph consists of two regions, one determined largely by the regular spacing of nucleotides along the chain, and the other by the longer spacings of the chain configuration. The sequence of different nitrogen bases along the chain is not made visible.

Oriented paracrystalline deoxypentose nucleic acid ('structure *B*' in the following communication by Franklin and Gosling) gives a fibre diagram as shown in Fig. 1 (cf. ref. 4). Astbury suggested that the strong 3·4-A. reflexion corresponded to the internucleotide repeat along the fibre axis. The ~ 34 A. layer lines, however, are not due to a repeat of a polynucleotide composition, but to the chain configuration repeat, which causes strong diffraction as the nucleotide chains have higher density than the interstitial water. The absence of reflexions on or near the meridian immediately suggests a helical structure with axis parallel to fibre length.

## Diffraction by Helices

It may be shown[5] (also Stokes, unpublished) that the intensity distribution in the diffraction pattern of a series of points equally spaced along a helix is given by the squares of Bessel functions. A uniform continuous helix gives a series of layer lines of spacing corresponding to the helix pitch, the intensity distribution along the *n*th layer line being proportional to the square of $J_n$, the *n*th order Bessel function. A straight line may be drawn approximately through the innermost maxima of each Bessel function and the origin. The angle this line makes with the equator is roughly equal to the angle between an element of the helix and the helix axis. If a unit repeats *n* times along the helix there will be a meridional reflexion ($J_0^2$) on the *n*th layer line. The helical configuration produces side-bands on this fundamental frequency, the effect[5] being to reproduce the intensity distribution about the origin around the new origin, on the *n*th layer line, corresponding to *C* in Fig. 2.

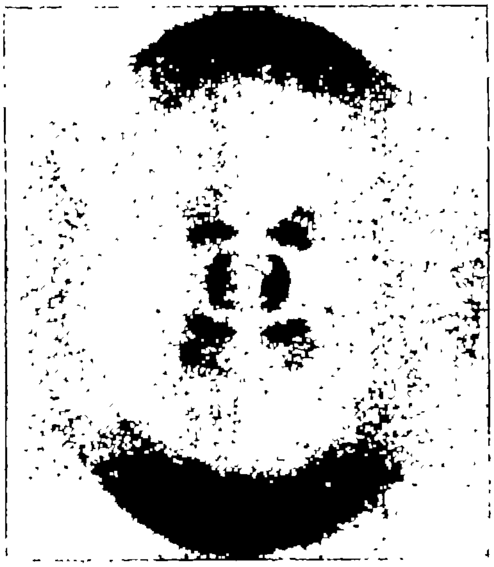

Fig. 1. Fibre diagram of deoxypentose nucleic acid from *B. coli*. Fibre axis vertical

We will now briefly analyse in physical terms some of the effects of the shape and size of the repeat unit or nucleotide on the diffraction pattern. First, if the nucleotide consists of a unit having circular symmetry about an axis parallel to the helix axis, the whole diffraction pattern is modified by the form factor of the nucleotide. Second, if the nucleotide consists of a series of points on a radius at right-angles to the helix axis, the phases of radiation scattered by the helices of different diameter passing through each point are the same. Summation of the corresponding Bessel functions gives reinforcement for the inner-

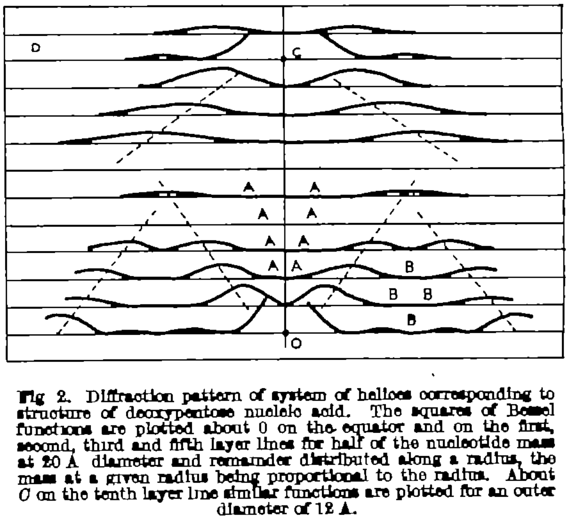

Fig. 2. Diffraction pattern of system of helices corresponding to structure of deoxypentose nucleic acid. The squares of Bessel functions are plotted about 0 on the equator and on the first, second, third and fifth layer lines for half of the nucleotide mass at 20 A. diameter and remainder distributed along a radius, the mass at a given radius being proportional to the radius. About *C* on the tenth layer line similar functions are plotted for an outer diameter of 12 A.

most maxima and, in general, owing to phase difference, cancellation of all other maxima. Such a system of helices (corresponding to a spiral staircase with the core removed) diffracts mainly over a limited angular range, behaving, in fact, like a periodic arrangement of flat plates inclined at a fixed angle to the axis. Third, if the nucleotide is extended as an arc of a circle in a plane at right-angles to the helix axis, and with centre at the axis, the intensity of the system of Bessel function layer-line streaks emanating from the origin is modified owing to the phase differences of radiation from the helices drawn through each point on the nucleotide. The form factor is that of the series of points in which the helices intersect a plane drawn through the helix axis. This part of the diffraction pattern is then repeated as a whole with origin at *C* (Fig. 2). Hence this aspect of nucleotide shape affects the central and peripheral regions of each layer line differently.

## Interpretation of the X-Ray Photograph

It must first be decided whether the structure consists of essentially one helix giving an intensity distribution along the layer lines corresponding to $J_1, J_2, J_3 \ldots$, or two similar co-axial helices of twice the above size and relatively displaced along the axis a distance equal to half the pitch giving $J_2, J_4, J_6 \ldots$, or three helices, etc. Examination of the width of the layer-line streaks suggests the intensities correspond more closely to $J_1^2, J_2^2, J_3^2$ than to $J_2^2, J_4^2, J_6^2 \ldots$ Hence the dominant helix has a pitch of ~ 34 A., and, from the angle of the helix, its diameter is found to be ~ 20 A. The strong equatorial reflexion at ~ 17 A. suggests that the helices have a maximum diameter of ~ 20 A. and are hexagonally packed with little interpenetration. Apart from the width of the Bessel function streaks, the possibility of the helices having twice the above dimensions is also made unlikely by the absence of an equatorial reflexion at ~ 34 A. To obtain a reasonable number of nucleotides per unit volume in the fibre, two or three intertwined coaxial helices are required, there being ten nucleotides on one turn of each helix.

The absence of reflexions on or near the meridian (an empty region *AAA* on Fig. 2) is a direct consequence of the helical structure. On the photograph there is also a relatively empty region on and near the equator, corresponding to region *BBB* on Fig. 2. As discussed above, this absence of secondary Bessel function maxima can be produced by a radial distribution of the nucleotide shape. To make the layer-line streaks sufficiently narrow, it is necessary to place a large fraction of the nucleotide mass at ~ 20 A. diameter. In Fig. 2 the squares of Bessel functions are plotted for half the mass at 20 A. diameter, and the rest distributed along a radius, the mass at a given radius being proportional to the radius.

On the zero layer line there appears to be a marked $J_{10}^2$, and on the first, second and third layer lines, $J_9^2 + J_{11}^2$, $J_8^2 + J_{12}^2$, etc., respectively. This means that, in projection on a plane at right-angles to the fibre axis, the outer part of the nucleotide is relatively concentrated, giving rise to high-density regions spaced *c.* 6 A. apart around the circumference of a circle of 20 A. diameter. On the fifth layer line two $J_5$ functions overlap and produce a strong reflexion. On the sixth, seventh and eighth layer lines the maxima correspond to a helix of diameter ~ 12 A. Apparently it is only the central region of the helix structure which is well divided by the 3·4-A. spacing, the outer parts of the nucleotide overlapping to form a continuous helix. This suggests the presence of nitrogen bases arranged like a pile of pennies[1] in the central regions of the helical system.

There is a marked absence of reflexions on layer lines beyond the tenth. Disorientation in the specimen will cause more extension along the layer lines of the Bessel function streaks on the eleventh, twelfth and thirteenth layer lines than on the ninth, eighth and seventh. For this reason the reflexions on the higher-order layer lines will be less readily visible. The form factor of the nucleotide is also probably causing diminution of intensity in this region. Tilting of the nitrogen bases could have such an effect.

Reflexions on the equator are rather inadequate for determination of the radial distribution of density in the helical system. There are, however, indications that a high-density shell, as suggested above, occurs at diameter ~ 20 A.

The material is apparently not completely paracrystalline, as sharp spots appear in the central region of the second layer line, indicating a partial degree of order of the helical units relative to one another in the direction of the helix axis. Photographs similar to Fig. 1 have been obtained from sodium nucleate from calf and pig thymus, wheat germ, herring sperm, human tissue and $T_2$ bacteriophage. The most marked correspondence with Fig. 2 is shown by the exceptional photograph obtained by our colleagues, R. E. Franklin and R. G. Gosling, from calf thymus deoxypentose nucleate (see following communication).

It must be stressed that some of the above discussion is not without ambiguity, but in general there appears to be reasonable agreement between the experimental data and the kind of model described by Watson and Crick (see also preceding communication).

It is interesting to note that if there are ten phosphate groups arranged on each helix of diameter 20 A. and pitch 34 A., the phosphate ester backbone chain is in an almost fully extended state. Hence, when sodium nucleate fibres are stretched[3], the helix is evidently extended in length like a spiral spring in tension.

## Structure *in vivo*

The biological significance of a two-chain nucleic acid unit has been noted (see preceding communication). The evidence that the helical structure discussed above does, in fact, exist in intact biological systems is briefly as follows:

*Sperm heads.* It may be shown that the intensity of the X-ray spectra from crystalline sperm heads is determined by the helical form-function in Fig. 2. Centrifuged trout semen give the same pattern as the dried and rehydrated or washed sperm heads used previously[4]. The sperm head fibre diagram is also given by extracted or synthetic[1] nucleoprotamine or extracted calf thymus nucleohistone.

*Bacteriophage.* Centrifuged wet pellets of $T_2$ phage photographed with X-rays while sealed in a cell with mica windows give a diffraction pattern containing the main features of paracrystalline sodium nucleate as distinct from that of crystalline nucleoprotein. This confirms current ideas of phage structure.

*Transforming principle* (in collaboration with H. Ephrussi-Taylor). Active deoxypentose nucleate allowed to dry at ~ 60 per cent humidity has the same crystalline structure as certain samples[5] of sodium thymonucleate.

We wish to thank Prof. J. T. Randall for encouragement; Profs. E. Chargaff, R. Signer, J. A. V. Butler and Drs. J. D. Watson, J. D. Smith, L. Hamilton, J. C. White and G. R. Wyatt for supplying material without which this work would have been impossible; also Drs. J. D. Watson and Mr. F. H. C. Crick for stimulation, and our colleagues R. E. Franklin, R. G. Gosling, G. L. Brown and W. E. Seeds for discussion. One of us (H. R. W.) wishes to acknowledge the award of a University of Wales Fellowship.

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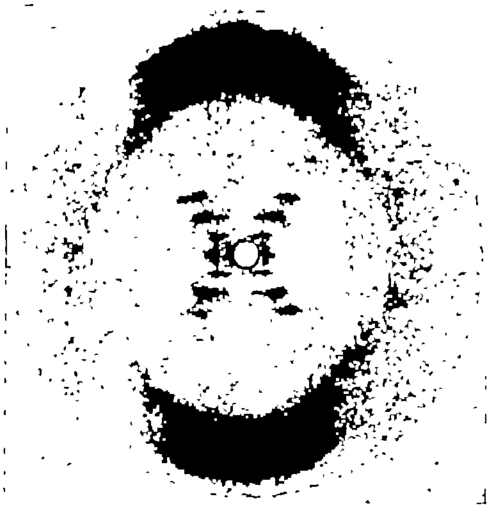
# Molecular Configuration in Sodium Thymonucleate

Sodium thymonucleate fibres give two distinct types of X-ray diagram. The first corresponds to a crystalline form, structure *A*, obtained at about 75 per cent relative humidity; a study of this is described in detail elsewhere[1]. At higher humidities a different structure, structure *B*, showing a lower degree of order, appears and persists over a wide range of ambient humidity. The change from *A* to *B* is reversible. The water content of structure *B* fibres which undergo this reversible change may vary from 40–50 per cent to several hundred per cent of the dry weight. Moreover, some fibres never show structure *A*, and in these structure *B* can be obtained with an even lower water content.

The X-ray diagram of structure *B* (see photograph) shows in striking manner the features characteristic of helical structures, first worked out in this laboratory by Stokes (unpublished) and by Crick, Cochran and Vand[2]. Stokes and Wilkins were the first to propose such structures for nucleic acid as a result of direct studies of nucleic acid fibres, although a helical structure had been previously suggested by Furberg (thesis, London, 1949) on the basis of X-ray studies of nucleosides and nucleotides.

While the X-ray evidence cannot, at present, be taken as direct proof that the structure is helical, other considerations discussed below make the existence of a helical structure highly probable.



Sodium deoxyribose nucleate from calf thymus. Structure *B*

Structure *B* is derived from the crystalline structure *A* when the sodium thymonucleate fibres take up quantities of water in excess of about 40 per cent of their weight. The change is accompanied by an increase of about 30 per cent in the length of the fibre, and by a substantial re-arrangement of the molecule. It therefore seems reasonable to suppose that in structure *B* the structural units of sodium thymonucleate (molecules on groups of molecules) are relatively free from the influence of neighbouring molecules, each unit being shielded by a sheath of water. Each unit is then free to take up its least-energy configuration independently of its neighbours and, in view of the nature of the long-chain molecules involved, it is highly likely that the general form will be helical[3]. If we adopt the hypothesis of a helical structure, it is immediately possible, from the X-ray diagram of structure *B*, to make certain deductions as to the nature and dimensions of the helix.

The innermost maxima on the first, second, third and fifth layer lines lie approximately on straight lines radiating from the origin. For a smooth single-strand helix the structure factor on the *n*th layer line is given by:

$$F_n = J_n(2\pi rR) \exp i\, n(\psi + \tfrac{1}{2}\pi),$$

where $J_n(u)$ is the *n*th-order Bessel function of $u$, $r$ is the radius of the helix, and $R$ and $\psi$ are the radial and azimuthal co-ordinates in reciprocal space[2]; this expression leads to an approximately linear array of intensity maxima of the type observed, corresponding to the first maxima in the functions $J_1$, $J_2$, $J_3$, etc.

If, instead of a smooth helix, we consider a series of residues equally spaced along the helix, the transform in the general case treated by Crick, Cochran and Vand is more complicated. But if there is a whole number, $m$, of residues per turn, the form of the transform is as for a smooth helix with the addition, only, of the same pattern repeated with its origin at heights $mc^*$, $2mc^*$ . . . etc. ($c$ is the fibre-axis period).

In the present case the fibre-axis period is 34 A. and the very strong reflexion at 3·4 A. lies on the tenth layer line. Moreover, lines of maxima radiating from the 3·4-A. reflexion as from the origin are visible on the fifth and lower layer lines, having a $J_5$ maximum coincident with that of the origin series on the fifth layer line. (The strong outer streaks which apparently radiate from the 3·4-A. maximum are not, however, so easily explained.) This suggests strongly that there are exactly 10 residues per turn of the helix. If this is so, then from a measurement of $R_n$ the position of the first maximum on the *n*th layer line (for $n$ 5<), the radius of the helix, can be obtained. In the present instance, measurements of $R_1$, $R_2$, $R_3$ and $R_5$ all lead to values of $r$ of about 10 A.

Since this linear array of maxima is one of the strongest features of the X-ray diagram, we must conclude that a crystallographically important part of the molecule lies on a helix of this diameter. This can only be the phosphate groups or phosphorus atoms.

If ten phosphorus atoms lie on one turn of a helix of radius 10 A., the distance between neighbouring phosphorus atoms in a molecule is 7·1 A. This corresponds to the P . . . P distance in a fully extended molecule, and therefore provides a further indication that the phosphates lie on the outside of the structural unit.

Thus, our conclusions differ from those of Pauling and Corey[4], who proposed for the nucleic acids a helical structure in which the phosphate groups form a dense core.

We must now consider briefly the equatorial reflexions. For a single helix the series of equatorial maxima should correspond to the maxima in $J_0(2\pi rR)$. The maxima on our photograph do not, however, fit this function for the value of $r$ deduced above. There is a very strong reflexion at about 24 A. and then only a faint sharp reflexion at 9·0 A. and two diffuse bands around 5·5 A. and 4·0 A. This lack of agreement is, however, to be expected, for we know that the helix so far considered can only be the most important member of a series of coaxial helices of different radii; the non-phosphate parts of the molecule will lie on inner co-axial helices, and it can be shown that, whereas these will not appreciably influence the innermost maxima on the layer lines, they may have the effect of destroying or shifting both the equatorial maxima and the outer maxima on other layer lines.

Thus, if the structure is helical, we find that the phosphate groups or phosphorus atoms lie on a helix of diameter about 20 A., and the sugar and base groups must accordingly be turned inwards towards the helical axis.

Considerations of density show, however, that a cylindrical repeat unit of height 34 A. and diameter 20 A. must contain many more than ten nucleotides.

Since structure $B$ often exists in fibres with low water content, it seems that the density of the helical unit cannot differ greatly from that of dry sodium thymonucleate, 1·63 gm./cm.$^3$ [1,5], the water in fibres of high water-content being situated outside the structural unit. On this basis we find that a cylinder of radius 10 A. and height 34 A. would contain thirty-two nucleotides. However, there might possibly be some slight inter-penetration of the cylindrical units in the dry state making their effective radius rather less. It is therefore difficult to decide, on the basis of density measurements alone, whether one repeating unit contains ten nucleotides on each of two or on each of three co-axial molecules. (If the effective radius were 8 A. the cylinder would contain twenty nucleotides.) Two other arguments, however, make it highly probable that there are only two co-axial molecules.

First, a study of the Patterson function of structure $A$, using superposition methods, has indicated[6] that there are only two chains passing through a primitive unit cell in this structure. Since the $A \rightleftharpoons B$ transformation is readily reversible, it seems very unlikely that the molecules would be grouped in threes in structure $B$. Secondly, from measurements on the X-ray diagram of structure $B$ it can readily be shown that, whether the number of chains per unit is two or three, the chains are not equally spaced along the fibre axis. For example, three equally spaced chains would mean that the $n$th layer line depended on $J_{3n}$, and would lead to a helix of diameter about 60 A. This is many times larger than the primitive unit cell in structure $A$, and absurdly large in relation to the dimensions of nucleotides. Three unequally spaced chains, on the other hand, would be crystallographically non-equivalent, and this, again, seems unlikely. It therefore seems probable that there are only two co-axial molecules and that these are unequally spaced along the fibre axis.

Thus, while we do not attempt to offer a complete interpretation of the fibre-diagram of structure $B$, we may state the following conclusions. The structure is probably helical. The phosphate groups lie on the outside of the structural unit, on a helix of diameter about 20 A. The structural unit probably consists of two co-axial molecules which are not equally spaced along the fibre axis, their mutual displacement being such as to account for the variation of observed intensities of the innermost maxima on the layer lines; if one molecule is displaced from the other by about three-eighths of the fibre-axis period, this would account for the absence of the fourth layer line maxima and the weakness of the sixth. Thus our general ideas are not inconsistent with the model proposed by Watson and Crick in the preceding communication.

The conclusion that the phosphate groups lie on the outside of the structural unit has been reached previously by quite other reasoning[1]. Two principal lines of argument were invoked. The first derives from the work of Gulland and his collaborators[7], who showed that even in aqueous solution the —CO and —NH$_2$ groups of the bases are inaccessible and cannot be titrated, whereas the phosphate groups are fully accessible. The second is based on our own observations[1] on the way in which the structural units in structures $A$ and $B$ are progressively separated by an excess of water, the process being a continuous one which leads to the formation first of a gel and ultimately to a solution. The hygroscopic part of the molecule may be presumed to lie in the phosphate groups ($(C_2H_5O)_2PO_2Na$ and $(C_3H_7O)_2PO_2Na$ are highly hygroscopic[8]), and the simplest explanation of the above process is that these groups lie on the outside of the structural units. Moreover, the ready availability of the phosphate groups for interaction with proteins can most easily be explained in this way.

We are grateful to Prof. J. T. Randall for his interest and to Drs. F. H. C. Crick, A. R. Stokes and M. H. F. Wilkins for discussion. One of us (R. E. F.) acknowledges the award of a Turner and Newall Fellowship.

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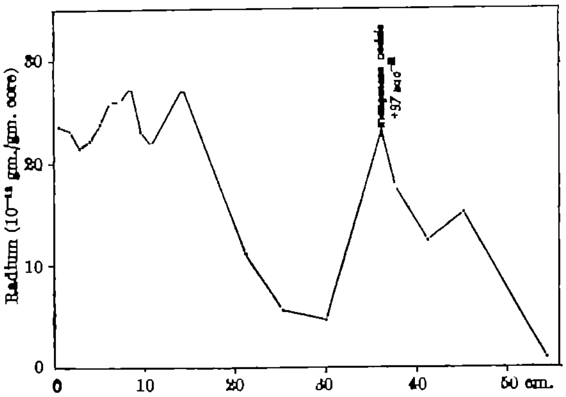
# LETTERS TO THE EDITORS

*The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications*

## Vertical Distribution of Radium in Deep-Sea Sediments

The surprisingly high content of radium in certain deep-sea sediments discovered nearly fifty years ago by J. Joly[1] remained unexplained until 1937, when H. Pettersson[2] suggested an ocean-wide precipitation of ionium from sea water on to the ocean bottom as its origin. Extensive radium measurements on deep-sea cores raised by the Swedish Deep-Sea Expedition carried out in this institute by Pettersson[3], T. Bernert[4] and me did not confirm the regular vertical distribution of radium reported by other workers[5]. An expected rise in radium content from moderate values in the uppermost surface layers to a maximum corresponding to a radioactive equilibrium between precipitated ionium and ionium-supported radium generally occurred; but the maximum was not followed by the theoretical exponential decline downwards governed by the rate of decay of ionium, to 50 per cent in 83,000 years, to 25 per cent in 166,000 years, etc. Instead, a number of secondary maxima of radium content separated by equally pronounced minima were observed (see graph), which could not well be explained as due to intervening changes in the rate of total sedimentation. Another explanation offered was that ionium and radium are not in radioactive equilibrium; that is, the assumption underlying the use of measurements of radium as indicating the concentration in the same layer of its mother element is unjustified.

Radium is well known for its migratory habits, leading to high concentrations of the element in manganese nodules. It was, therefore, decided to ask the assistance of a specialist on the photographic method—Dr. E. Picciotto, of the Centre for Nuclear Research in Brussels—to develop a method suitable for direct determinations of the content of ionium in the sediment. These attempts have met with success, as is seen from the following communication by Dr. E. Picciotto and Miss N. Isaac. So far, only a limited number of samples from Pacific red clay have been measured; but already the present results lend support to the conclusion that the greater part of the radium in the sediment is ionium-supported, and the migration of radium is proved.



Radium concentration in a red clay core from the Central Pacific Ocean at lat. N. 02° 23′, long. W. 173° 50′, depth of water 5,560 m. A manganese nodule with a concentration of 97·1 × $10^{-12}$ gm. radium/gm. sediment was found at a depth of 32 cm. in the sediment

However, interesting results can also be obtained from the radium measurements. Thus an integration of the total radium content in a sediment core down to levels ($L_0$) where practically all the ionium precipitated has had time to become disintegrated, so that generally only very small quantities of uranium-supported radium are present, permits a comparison between the excess radium in the upper sediment layers and the potential supply of radium derivable from the uranium in the superposed column of sea water. Although both figures are of the same order of magnitude, there appears to be a surplus of sediment radium over that to be expected from ionium precipitation by a factor of 1·5–3. This discrepancy, which evidently falls outside the limits of experimental error, may possibly be due to a considerably higher content of dissolved uranium in the ocean during late quaternary time than at present (namely, 1·3 × $10^{-6}$ gm. radium/litre[6]).

Having found through such an integration of the total radium content the corresponding value for the total ionium content in the sediment column, a theoretical value of the ionium content at $L_0$ can be calculated by assuming that the column $L_0$ is precipitated during a certain period of time (for example, 330,000 years = 4 half-periods of ionium). The time correlation is now varied until the calculated ionium content at $L_0$ is in correspondence with the measured radium content within limits of error. In this way we have found an average value for the rate of sedimentation during the period of time considered. The values thus found are of the order of 1 mm. in 1,000 years, in fair agreement with other methods of estimation. This method is, however, liable to errors, arising on one hand, as mentioned before, from a possible change in the rate of ionium sedimentation and, on the other, from the complication represented by the vertical migration of radium in the sediment.

A full report on these measurements and calculations will be published in the Reports of the Swedish Deep-Sea Expedition.

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Jan. 14.

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## Ionium Determination in Deep-Sea Sediments

Measurements carried out in the Oceanographical Institute, Göteborg, on the radium content in deep-sea cores by H. Pettersson, Traude Bernert, V. Kröll[1] *et al.* showed the vertical distribution of radium to be highly complicated. We were therefore asked to develop a method for direct measurement of the ionium content in samples of sediment from the Swedish Deep-Sea Expedition.

Uranium-$X_1$ (thorium-234) is added to a solution of the sample as radio-tracer for ionium (thorium-230).

The solution (0·5 $N$ hydrochloric acid) is passed through a column of ion exchanger ('Amberlite *IR*100'). Elution with 2 $N$ hydrochloric acid removes most of the cations, including uranium and radium. A second elution with 0·5 $M$ oxalic acid[2] releases the thorium isotopes together with polonium; the last-named element is removed by extraction with dithizone[3]. Oxalic acid is removed by calcination, and the nearly carrier-free thorium (ionium + uranium $X_1$) redissolved in the smallest possible volume of a complexing solution of citric buffer at $p$H 7[4]. The yield of ionium recovered is checked by counter-measurements of the β-activity of the uranium-$X_1$. The concentration of ionium is measured by the α-radiation detected with nuclear emulsion using the double-emulsion technique[5].

Assuming radioactive equilibrium between thorium and radio-thorium to prevail in the sample, the proportion of α-track 'stars' with five branches on the plates gives the concentration of thorium and permits the separation of thorium and ionium, since the latter gives only single α-tracks[6]. The method also permits the detection of possible residues of radium from the number of three- and four-branched stars. Measurements of the lengths of the tracks make it possible to detect impurities like uranium and polonium which give also single tracks.

The method was checked with a standard solution of ionium containing $10^{-11}$ gm. ionium/c.c., obtained by dissolving a sample of pitchblende and measuring the concentration of uranium in the solution. In this solution uranium was known to be in radioactive equilibrium with its descendants[7]. The concentration of ionium in this solution was of the same order as that in the uppermost layers of sediment examined.

The main difficulty lies in the preparation of uranium-$X_1$ of sufficient purity and in the elimination of radioactive contamination by the chemicals used and by the photographic emulsion.

The method enables us at present to measure a concentration of ionium between $10^{-9}$ and $10^{-10}$ gm./gm. to within 10 per cent, and to detect a concentration of $10^{-11}$ gm./gm. in a sample weighing 0·5 gm., a quantity which, by the use of microchemical methods, could be reduced to a few milligrams. An absolute quantity of ionium as low as $10^{-13}$ gm. contained in a volume of $10^{-3}$ c.c. can easily be measured by the photographic method.

Our main purpose has been to ascertain whether, in deep-sea sediments, there exists radioactive equilibrium between ionium and radium. For lack of a suitable method of determining ionium, it has hitherto not been possible to solve this problem. For this reason all conclusions regarding the vertical distribution in the sediment cores of ionium and subsequent inferences regarding the rate of sedimentation have so far had to be based on radium measurements and on the hypothesis that there is radioactive equilibrium between ionium and radium in the cores.

The samples we have worked on were taken from cores of deep-sea sediments raised in the Pacific Ocean by the Swedish Deep-Sea Expedition. Their radium content has been measured in Göteborg. The results so far obtained are too few to allow any general conclusions to be drawn, and the figures set out in the accompanying table should be considered as preliminary values, subject to revision after control measurements. With these reservations, they seem to lend support to the hypothesis of ionium precipitation, and they further indicate that the irregularities found in the radium curves may be due to a lack of radioactive equilibrium between ionium and radium.

| Sample No. | Core No. | Depth in sediment (cm.) | Radium ($10^{-12}$ gm./gm.) | Ionium ($10^{-10}$ gm./gm.) | $R = \frac{\lambda_{\text{Ra}} N_{\text{Ra}}}{\lambda_{\text{Io}} N_{\text{Io}}}$ |
|---|---|---|---|---|---|
| 4 | 83 | 3·5– 4·5 | 27·9 | 14 | 1 |
| 5 | 83 | 31·5–32·5 | 46·4 | 10 | 2·3 |
| 11 | 86*B* | 11·5–13 | 38 | 20 | 1 |
| 12 | 86*B* | 16·5–17·5 | 52 | 13 | 2 |
| 13 | 86*B* | 48 –49 | 19·1 | < 1 | > 1 |

We wish to thank the Oceanographical Institute of Göteborg, and in particular Prof. H. Pettersson, for support. We are indebted to Profs. F. G. Houtermans and G. P. S. Occhialini and to Dr. H. Rotschi for helpful suggestions, and to Mr. C. Waller (Ilford, Ltd.) for supplying specially purified emulsion.

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## An Interferometer Microscope for the Accurate Measurement of Optical Thickness

The methods developed by Barer[1] and Davies and Wilkins[2] for the measurement of the dry weights of cells involve the accurate measurement of the optical thickness of the cell at a number of points on its surface. In many cases, the optical thickness is quite a small fraction of a wave-length, so the measurement must be made with considerable accuracy; furthermore, in the case of a living cell, speed of measurement is essential.

In order to fulfil these conditions, a new type of interferometer microscope has been designed. The basic arrangement of the microscope is similar to that of Lebedeff[3], in which the specimen is enclosed between two birefringent plates together with a suitably oriented half-wave plate. Lebedeff's microscope, however, enabled only very thin plates to be used at high powers, resulting in a doubling of the image. To overcome this difficulty, a glass hemisphere is cemented to the upper plate to increase the working distance of the objective[4]. In this way, plates 5 mm. thick can be used with a 4-mm. objective, and the second image becomes so far out of focus that it disappears.

The system gives an image of the light source and an image of the source with the object superimposed, coincident and polarized mutually at right-angles. If viewed through an analyser at 45° to each plane of polarization, the two images interfere and the object is revealed by normal interference contrast. In order to effect the measurement, further modifications are introduced. A birefringent quarter-wave plate is placed above the objective, suitably oriented so that the image and reference beams are circularly polarized in opposite senses thereby. These two beams then combine to form a single plane-polarized beam, with an orientation of polarization depending on the phase differences between the two beams. The plane of polarization may then be rotated by a rotatable half-wave plate with suitable scale. The phase-difference may be measured by rotating the plane of polarization to a fixed position and reading off from the scale the angle through which it has been turned.

In order to determine accurately when the plane of polarization has a given direction, a half-wave plate consisting of a sheet of 'Cellophane' is placed in the focal plane of the eyepiece. A system of small squares, arranged in chequer-board formation, is cut out of the half-wave plate, and the analyser is fixed, making an angle of 45° with the principal directions of the half-wave plate. Under these conditions, there is an intensity contrast between the cut-out squares and the rest of the field unless the plane of polarization is parallel to one of the principal directions of the half-wave plate. Hence, an accurate setting for the orientation of the plane of polarization is possible by adjusting for disappearance of each small square in turn.

Using mercury green light, it has been found possible under good conditions to repeat settings within ± 0·25°, which corresponds to ± 0·003 wave-lengths, as a complete rotation corresponds to four wave-lengths. The chequer-board formation of the squares facilitates the averaging of optical thickness over the cell.

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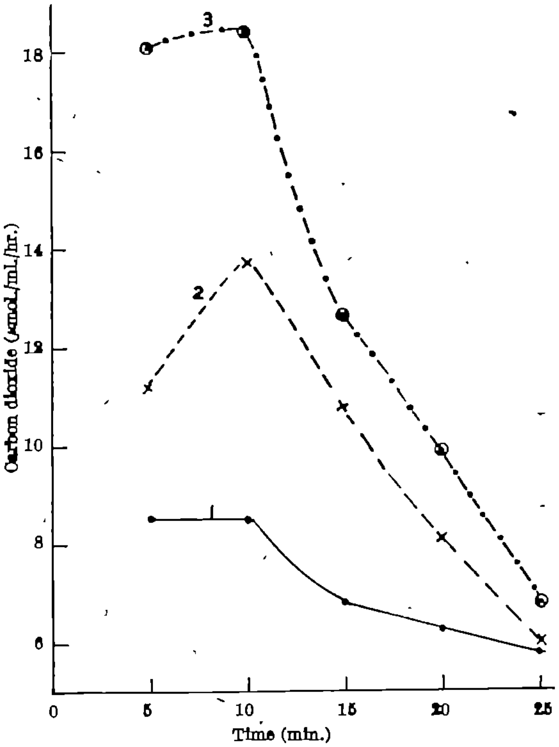
## Hydrolysis of Anhydrides by Esterases

IN recent investigations[1] the idea was expressed that tetraethyl pyrophosphate and related inhibitors of esterases are enzymatically split into a positive phosphonium ion and a negative residue, the former attaching itself to a nucleophilic group in the active surface of the enzyme. The irreversible combination of organic phosphates with esterases is thus analogous to the reaction of esters as substrates: here the acylinium ion is attached reversibly to the enzyme. The ease with which anhydride bonds are split was used for explaining the superiority of this type of inhibitor over trialkyl phosphates. However, since esters are the natural substrates of esterases, it can be expected that both types of compounds, esters as well as anhydrides, are attacked by the same enzyme, the latter at a faster rate. This was borne out by the following experiments.

(1) Carboxylic acid anhydrides are split both by acetylcholine esterase and by liver esterase. This cannot be demonstrated 'directly' by adding the substrate to the buffered enzyme solution, since spontaneous hydrolysis of such anhydrides in dilute aqueous media is very rapid. We have therefore developed a 'two-phase' technique by placing the substrate, dissolved in toluene, into the side bulb of a Warburg vessel. Upon adding the organic solution to the main vessel, an equilibrium between the two layers is established, thus supplying the aqueous phase continuously with small amounts of substrate. The accompanying graph shows that liver esterase increases the hydrolysis of propionic anhydride by about 100 per cent and the choline esterase by about 60 per cent.



Enzymatic hydrolysis of propionic anhydride. The anhydride was dissolved in toluene, 1 : 100 ; 0·2 ml. was added to the side bulb of each Warburg vessel. The main vessel contained 2·9 ml. of (1) bicarbonate buffer (control); (2) acetylcholine esterase, 1 : 2,500 (this preparation from electric organ, when diluted 1 : 40,000, hydrolysed 6 µmol./ml./hr., when acetylcholine, $3\cdot3 \times 10^{-3}$ *M*, was used as standard substrate); (3) liver esterase, 1 : 60 (this enzyme from dog's liver, at a dilution of 1 : 100, produced 5·2 µmol. carbon dioxide/ml./hr., when diacetin, $4\cdot1 \times 10^{-2}$ *M*, was used as standard substrate). Note that 2 mol. carbon dioxide is equivalent to 1 mol. propionic anhydride

(2) By using the dilution technique, we have been able to demonstrate that triethyl phosphate is an irreversible inhibitor of acetylcholine esterase, but the concentrations required for a given degree of inhibition are 100–200 times higher than with tetraethyl pyrophosphate (see table).

(3) On the basis of these results, it can be expected that a mixed phosphoric – carboxylic anhydride will also be split by esterases, but the direction of the

IRREVERSIBLE INHIBITION OF ACETYLCHOLINE ESTERASE BY TRIETHYL PHOSPHATE

The enzyme, 0·2 ml., was incubated with 1·0 ml. of a $7\cdot2 \times 10^{-4}$ *M* solution of the inhibitor in bicarbonate buffer (0·1 *M*). After 30 min. the mixture was diluted 250 times and its hydrolytic activity measured by the Warburg method. Final dilution of the enzyme 1 : 1,500 ; final concentration of the inhibitor $2\cdot4 \times 10^{-6}$ *M*. A control was run by diluting the inhibitor first and then incubating with the enzyme. The substrate was acetylcholine, $3\cdot3 \times 10^{-3}$ *M*

| | Activity (µmol hydrolysed/ml./hr.) | % Inhibition |
|---|---|---|
| 1. Enzyme alone, 1 : 1,500 | 5·5 | |
| 2. Enzyme + diluted inhibitor | 3·6 | 35 |
| 3. Enzyme + concentrated inhibitor | nil | 100 |

hydrolysis is not predictable. If the C—O bond is broken, the mixed anhydride will serve as substrate, whereas attack at the P—O bond will lead to inhibition. We have found that dibenzyl acetyl phosphate is an irreversible inhibitor of choline esterase. Since this anhydride is split by water very rapidly, the inhibitory effect was demonstrated by adding 0·01 ml. of the undiluted inhibitor to 0·1 ml. of the buffered enzyme. After 5 min. at room temperature, the mixture was diluted thirty times and the remaining activity of the enzyme compared with an untreated control. Under these conditions our derivative of acetyl phosphate produced complete inactivation of the esterase, whereas the control hydrolysed 6 µmol. of acetylcholine/ml./hr. Treatment of the enzyme with a 1 : 30 dilution of the anhydride in buffer gave no inhibition because of the rapid spontaneous hydrolysis of the inhibitor.

A detailed account of these experiments will be published elsewhere. We wish to thank Mr. J. Blank for the preparation of dibenzyl acetyl phosphate.

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## Enzymatic Transoximation

IT has been recently shown[1] that oximes are enzymatically converted into amino-compounds. I have now demonstrated an enzyme which catalyses the transoximation.

The enzyme was prepared from silkworms. 2 gm. of digestive organ-free tissues of fifth instar larvæ was ground and centrifuged twice after adding water. The residue was mixed with 3 ml. of 0·01 *M* pyruvic acid oxime, 3 ml. of 0·01 *M* acetaldehyde and 3 ml. of 0·01 *M* acetone and then diluted with water or 0·015 *M* buffer to 30 ml. The mixture was put in a 100-ml. Erlenmeyer flask, covered with toluol and kept at 35° C. for 15 hr. After reaction, the mixture was distilled *in vacuo*, and the total amount of acetaldoxime and acetoxime in the distillate was determined colorimetrically. In the control, the enzyme preparation was used after heating at 100° C. for 10 min.

Experiments indicated that the enzymatic activity was reduced to half by heating at 60° C. for 10 min. The optimum *p*H of enzyme action was about 5·6 and the optimum temperature 37° C. Under the experimental conditions described above, about 10 µgm. of oxime-nitrogen was transferred, and no free hydroxylamine or nitrous acid was detected in the reaction mixture. I suggest the name 'transoximase' for the enzyme.

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## Active Absorption of Glucose from the Intestine

GLUCOSE disappeared rapidly from the lumen of an isolated loop of rat intestine, immersed in tyrode at 37° C. and aerated by a mixture of oxygen and 5 per cent carbon dioxide. This occurred even when the solutions (tyrode containing 200–800 mgm. per cent glucose) within the loop and surrounding the loop were identical, so that no concentration gradient of glucose existed between the inner and outer solution. The rate of uptake of glucose, during the first 15–30 min., was of the same order of magnitude as that found during resorption *in vivo* from similar solutions. With other sugars, the uptake was related to their rate of resorption in the intact animal. Phlorrhizin inhibited absorption of glucose *in vitro* as well as *in vivo*. It therefore seemed probable that we were dealing with 'active absorption' when using such a preparation.

Though glucose disappeared from the lumen, glucose as such was not transferred across the intestinal wall, and the outer fluid showed no increased glucose content. When a similar experiment was carried out with radioactive glucose in the inner solution, a radioactive substance appeared in the outer fluid ; 30–60 per cent of the radioactivity which had disappeared from the inner solution could thus be recovered. The recovery increased with time of incubation up to one hour. The radioactive substance is not identical with glucose ; it is non-reducing and is not fermented by baker's yeast. It is not converted into glucose by acid hydrolysis, and so far has not been identified with any known intermediate of glucose dissimilation. Much of the glucose which had disappeared was retained in the lumen as a substance having characteristics similar to those of the substance appearing in the outer solution.

It was of interest to ascertain whether the conversion of glucose to a metabolite, in its passage across the intestinal wall, is a general phenomenon or is associated with the conditions prevailing in these *in vitro* experiments. It is generally believed that glucose absorbed from low concentrations (that is, during active absorption) is transferred to the portal vein as glucose. However, the evidence provided by the literature was found to be both scanty and unconvincing. Most papers dealt only with the fate of glucose in the intestinal lumen, but had very little to say about its appearance on the other side of the intestinal barrier.

In order to test this, glucose concentrations in the portal vein and in the artery were compared during resorption of glucose from a 400 mgm. per cent solution. In a representative experiment, 18 mgm. of glucose disappeared during 12 min. With a blood flow of 4 ml./min. (calculated from data of Birnie and Grayson[1]), the glucose concentration in the vena porta should have exceeded that in the artery by 37 mgm. per cent, if it was glucose which was transported by the vena porta. However, the glucose concentration in the vena porta was found to be even lower than in the arterial blood.

Further proof that no additional glucose as such appears in the vena porta during glucose absorption was then sought by perfusing the intestine *in situ* with blood of known composition. When a 400 mgm. per cent glucose solution was introduced into the loop of a perfused intestine, 17·2 mgm. glucose disappeared in 12 min. but no additional glucose could be found in the perfusion fluid. With radioactive glucose in the lumen, a substance could be demonstrated in the perfusion fluid similar to that found in the outer fluid in our *in vitro* experiments (making up 35 per cent of the glucose which disappeared).

It might be claimed that with low glucose concentrations a considerable part of the glucose is utilized by the intestine. However, measurement of oxygen consumption, both *in vivo* and *in vitro*, revealed that less than 10 per cent of the glucose taken up is burned to carbon dioxide. It seems that most of the absorbed glucose is transferred in the form of a metabolite through the portal system and is reconverted into glucose in some other organ, presumably in the liver. The active translocation of glucose from the intestinal lumen into the blood stream would thus involve the participation of both the intestine and the liver.

Experiments are being conducted to test this assumption.

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## Distribution of Substance *P* in the Central and Peripheral Nervous System

Substance *P* is a biologically active polypeptide found in extracts of brain and intestine[1,2]. It causes a transient fall of the blood pressure and stimulation of smooth muscle even in the presence of atropine and antihistamine drugs. Purified preparations exert biological effects even in concentrations of 1 μgm. per ml. The present communication deals with its distribution in the nervous system.

Extracts, obtained from the dog, were prepared by boiling the tissue in water at *p*H 4, and tested on the isolated guinea pig ileum in the presence of 1 : 2,500,000 atropine and 1 : 2,500,000 of antihistamine (Lergitin). The activity of the extracts was compared to a standard of a partially purified preparation of substance *P*, obtained from horse intestine by precipitation with ammonium sulphate[3]. The specificity of the active factor was proved by precipitation in some cases with ammonium sulphate and inactivation with chymotrypsin.

(1) *Central nervous system.* The highest values were found in the grey matter, which agrees with the results of Euler and Gaddum[1]. This may suggest that the substance is concentrated in the cell bodies. In the cerebellum, however, with its high content of cells, the amount of substance *P* is low. Its activity of the different parts of the central nervous system runs almost parallel to the acetylcholine content[4], except in the extracts of the hypothalamus, which show the highest concentration of substance *P* in the brain.

Table 1. Distribution of Substance *P* in the Central Nervous System

| Tissue | Units of subst. *P*/gm. tissue |
|---|---|
| Medulla spinalis | 35 |
| Pons | 45 |
| Cerebellum | 15 |
| Tegmentum | 75 |
| Hypothalamus | 180 |
| Tractus opticus | 50 |
| Thalamus | 85 |
| Basal ganglia | 130 |
| Corpus callosum | 8 |
| Bulbus et tractus olfactorius | 9 |
| Hemisphere | 20 |
| Plexus choroideus | 1 |

(2) *Peripheral nervous system.* Substance *P* activity is found in extracts of all kind of nerves and ganglia. The values obtained, however, are generally lower than those found in the central nervous system. The dorsal roots, the preganglionic sympathetic fibres and the vagus seem to be especially rich in substance *P*, whereas motor nerves such as the phrenic have a low content.

Table 2. Distribution of Substance *P* in the Peripheral Nervous System

| Tissue | Units of subst. *P*/gm. tissue |
|---|---|
| N. opticus | 7 |
| N. saphenus | 13 |
| Radices dorsales, reg. lumbalis | 45 |
| N. phrenicus | 5 |
| Radices ventrales, reg. lumbalis | 25 |
| N. ischiadicus | 10 |
| N. vagus | 25 |
| Truncus sympaticus cervicalis | 40 |
| N. splanchnicus | 15 |
| N. lienalis | 10 |
| Ganglion stellare | 20 |
| Ganglion nodosum | 15 |

A full account of this work will be published in *Acta Physiol. Scand.*, Suppl. 105.

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## A New Synthesis of some Derivatives of 4,4′-Stilbenediol

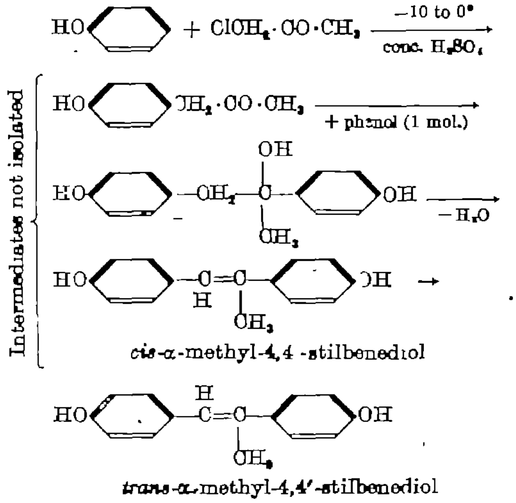
Syntheses of α-alkyl- or α,α′-dialkyl-4,4′-stilbenediols and of their derivatives, several of which exhibit remarkable œstrogenic activity, have so far mostly been by demethylation of the corresponding dimethyl ethers, and have invariably involved several stages[1,2]. A direct synthesis in one step, of *trans*-α-methyl-4,4′-stilbenediol (and some of its dialkyl ethers) from phenol (or its corresponding ether) and chloroacetone, has now been accomplished.

The condensation of chloroacetone with phenol in presence of concentrated hydrochloric acid at 100° has been reported to yield 2,2,3-tris(*p*-hydroxyphenyl)propane[3]. We have found that in presence of concentrated sulphuric acid at − 10° to 0°, the above reactants give a nearly 75 per cent yield of *trans*-α-methyl-4,4′-stilbenediol (earlier synthesized by Dodds and his collaborators[2]) (melting point 183–184°). The melting points of some ethers and esters of this substance, prepared by the usual methods, are shown in the accompanying table.

| Ether or ester of *trans*-α-methyl-4,4′-stilbenediol | Melting point |
|---|---|
| Dimethyl ether* | 124° |
| Diethyl ether | 105–107° |
| Dipropyl ether | 107–108° |
| Diallyl ether | 94–95° |
| Diacetate* | 124° |
| Dipropionate | 107–108° |

* Previously described by Dodds *et al.* (ref 2)

The above condensation, yielding *trans*-α-methyl-4,4′-stilbenediol, probably proceeds according to the following route :



The extreme activity of the chlorine atom of the chloroacetone molecule by reason of its vicinity to the carbonyl group, and the reactivity of the hydrogen atom *para* to the hydroxyl group in the phenol molecule, suggested a Friedel–Crafts type of reaction as the first step.

The above reaction would appear to be generally applicable to ketones of the formula $R$—CO—CHCl$R'$, where $R$ is a lower alkyl radical and $R'$ is hydrogen or a lower alkyl radical, and any simple aromatic compound containing a suitably activated available nuclear hydrogen atom. Thus, the dimethyl and diethyl ethers of *trans*-α-methyl-4,4′-stilbenediol have also been obtained, in very good yields, by condensing chloroacetone with anisole and phenetole respectively in presence of concentrated sulphuric acid.

In these reactions, the *cis* compounds seem to be formed first, and are probably converted to their *trans* isomers on heating in solution in solvents like alcohol or aqueous alcohol; thus in the condensation of anisole and phenetole with chloroacetone, the crude semi-solid reaction product, after treatment with water at 0°, yielded only a viscous oil (presumably the *cis* compound) when recrystallization from alcohol was attempted; but when an alcoholic solution of this oily product was refluxed for a few hours and then cooled, the *trans* form of the corresponding dialkyl ether of α-methyl-4,4′-stilbenediol crystallized out.

A fuller account will be published in due course. We are grateful to several colleagues for the benefit of discussion. One of us (P. M. B.) is indebted to the National Institute of Sciences of India for the award of a research fellowship.

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## Carbohydrate Metabolism in Protozoa and Metal-binding Substances

THE effect of cyanide on fermentation processes of living cells, which is on the whole much smaller than that on respiration, has been interpreted in the past as due to the interception by cyanide of intermediary products of fermentation, rather than to complex formation with heavy-metal catalysts; as pointed out again only recently, "no enzyme of fermentation is known to require the addition of a heavy metal except the aldolase of yeast"[1]. That not all living cells conform with this view has already been indicated by our previous work on the metabolism of certain Protozoa, and in particular by the finding that the anaerobic fermentation of glucose by the flagellate *Trypanosoma lewisi* is inhibited 50 per cent by 0·007 $M$ cyanide and also by such metal-binding substances as 2 : 2′-dipyridyl and 8-hydroxyquinoline[2]; on the other hand, the same metal-binding substances have been shown to have a small but definite stimulating effect on intracellular glycogen fermentation in the ciliate *Tetrahymena pyriformis*[3]. These effects have now been investigated further.

Under aerobic conditions at 37° C., washed suspensions of *Trypanosoma lewisi* in the absence of extracellular nutrient respire with a $q_{O_2}$ of about 40 and a respiratory quotient of 0·80 for a period of 1–2 hr. During this time, the flagellate shows a small degree of motility; but, within 5–10 min. of the addition of glucose, motility increases considerably, and the $q_{O_2}$ rises to about 600, with a respiratory quotient of almost unity. When, however, the flagellate is incubated for longer periods of time in the absence of substrate, the endogenous respiration and motility gradually fall, and the ability to respond to added glucose is lost, death of the trypanosomes soon taking place. The respiration of the trypanosome in the presence of glucose is not markedly influenced by 0·001 $M$ 2 : 2′-dipyridyl, there being only a 10 per cent inhibition of respiration and scarcely any effect on motility over the first hour, with a somewhat greater inhibition of respiration and motility after 2–3 hr.; a similar effect is produced by 8-hydroxyquinoline. If, however, substrate-free trypanosomes are incubated with 0·0003 $M$ 2 : 2′-dipyridyl, their ability to respond to added glucose is quickly lost; after 30 min. incubation, the recovery of respiration and motility is slow and incomplete, while after 90 min. the trypanosomes become immotile, and will not respond to added glucose, although, in the absence of inhibitor, normal motility is restored within 15 min. of the addition of glucose.

Under anaerobic conditions, the effects of 2 : 2′-dipyridyl and 8-hydroxyquinoline on carbon dioxide production by the trypanosomes in the presence of glucose and a carbon dioxide – bicarbonate buffer are much greater. When added to actively fermenting trypanosomes, 0·0003 $M$ 2 : 2′-dipyridyl reduces carbon dioxide output by 65–75 per cent over a period of 45 min., metabolism and motility having ceased completely by this time. On addition of the reducer sodium dithionite to such a suspension, a pale pink colour is produced, indicating the formation of a ferrous iron–dipyridyl complex. 0·0001 $M$ 2 : 2′-Dipyridyl is almost as effective, while 8-hydroxyquinoline produces a slightly quicker inhibition. These metal-binding substances are more effective when added to substrate-free trypanosomes at the same time as glucose, rather than to actively fermenting cells. The effect of 2 : 2′-dipyridyl on fermentation is irreversible.

During studies of the intermediary metabolism of *Trypanosoma lewisi*, using homogenates prepared by shaking an aqueous suspension of cells with glass beads, the effect of 2 : 2′-dipyridyl on aldolase activity was investigated. The disappearance of fructose-1 : 6-diphosphate and the production of alkali-labile phosphate were followed in a system containing cell homogenate, incubated at 37° C. in the presence and in the absence of 0·06 *M* potassium cyanide. At pH 7·0 or 6·4 in carbon dioxide – bicarbonate or acetate – veronal buffers, the reaction was scarcely affected by 0·001 *M* 2 : 2′-dipyridyl, while 0·005 *M* 2 : 2′-dipyridyl produced only a 33 per cent inhibition of aldolase activity. This result is quantitatively similar to that obtained with the ciliate *Tetrahymena pyriformis* (GL), an organism the respiration of which is insensitive to 2 : 2′-dipyridyl, and the fermentation of which is slightly stimulated by this substance[3].

It has recently been reported that aldolase activity in homogenates of the closely related flagellate *Trypanosoma cruzi* is not affected by 2 : 2′-dipyridyl; but no mention was made of the effect of this substance on the metabolism of intact cells[4]. The present results with *Trypanosoma lewisi* suggest that, although aldolase activity is probably independent of the presence of a heavy metal ion, such an ion, very probably ferrous iron, is involved at some stage in the glucose fermentation process. Inhibitions produced by 2 · 2′-dipyridyl are not prevented by the presence of hæmoglobin, and neither respiration nor fermentation is influenced by 0·0003 *M* 4 : 4′-dipyridyl; this indicates that if ferrous iron participates in fermentation, it is involved as the free ion, and not bound as a hæm compound. Under aerobic conditions, iron would be mainly in the ferric condition, and therefore not removed by 2 : 2′-dipyridyl; but under anaerobic conditions it would be reduced to the ferrous state, and could be quickly removed by chelation with 2 : 2′-dipyridyl.

I should like to thank Prof. D. Keilin and Dr. T. Mann for helpful discussions during the course of this work, and the Medical Research Council for a research studentship.

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## Nature of Cold Agglutinin Linkage

If sera containing auto-agglutinins ('non-specific cold agglutinins') are repeatedly absorbed in the cold with *O* cells, one of three results may be obtained: (1) activity against *A* and *B* cells may cease; this is the only result reported by numerous earlier workers; (2) activity against *A* and *B* cells may persist to a greater or lesser extent; subsequent absorption with *A* cells may leave some residual anti-*B* activity[1]; (3) activity against *A* and *B* cells may be enhanced[2].

These results support the view that auto-agglutinins are 'non-specific', because they consist of multiple specific components which may exhibit a varying degree of agglutinin linkage[3]. The multiple specific components may be anti-*O* (or *H*), anti-*A*, anti-*B*, and possibly also anti-$A_1$, anti-*M*, anti-*N*, anti-*P*, etc. The combination of non-specific cold agglutinins with an anti-*M* 'iso-agglutinin' reported by Macfarlane[7] may have been auto-agglutinins containing a relatively powerful anti-*M* component. It is not surprising that Henningsen[5], "by using a sensitive technique", could demonstrate anti-*P* antibodies in most *P*-negative sera. Some of these agglutinin components may figure in the lists of numerous antibodies occasionally detected in a single serum[9].

The enhancement of anti-*A* and anti-*B* activity in some sera after absorption with *O* cells may be of importance in providing a pointer to the structure of auto-agglutinins. The cold auto-agglutinins present in almost all sera are believed to be of heterogenetic bacterial origin[8]. These stimuli are continuous, minimal, and of varying antigenicity. It is not inconceivable that certain antibody receptors are first formed and followed by other more superficial receptors. Suppose anti-*A* and anti-*B* receptors are laid down in the beginning, and later a relatively large number of anti-*O* receptors are laid down. It would then be easy to visualize how the absorption of the anti-*O* receptors would unmask the anti-*A* or anti-*B* receptors.

This view is not inconsistent with Dodd's concept[4] of iso-agglutinin linkage, and might also account for the phenomenon of Hooker and Anderson[6]. These workers noted that, by absorbing certain immune rabbit anti-*B* sera with *O* cells, the sera developed the ability to act on *A* cells as well.

It is considered that this concept may also be of value in the elucidation of the true structure of antibodies in general.

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## Short-Term Carbon Dioxide Fixation in Mouse Liver

In a previous report[1], there were presented findings which were unexpected if the entire polycarboxylic acid cycle were involved in carbon dioxide fixation by animals. At 5 and 15 min. after the injection of radioactive sodium bicarbonate ($NaH^{14}CO_3$) (obtained as $Ba^{14}CO_3$ from the Atomic Energy Commission, Oak Ridge, Tennessee) there appeared to be a more direct path of carbon to succinate than that previously postulated. In addition, the labelling in such acids as α-ketoglutarate, citrate and aconitate was not measurable. It was thought desirable to examine the path of carbon dioxide employing paper chromatography, because by this technique compounds retained by the silica gel (used in previous studies) which escaped examination would become detectable.

The active bicarbonate was injected intraperitoneally into mice weighing 20 gm. and the animals were sacrificed 3 min. later. Extracts were prepared by homogenizing the liver in 80 per cent ethanol, centrifuging and removing the supernatant. This solution was reduced in volume to 0·7 ml. 25 µl. was added in 1-µl. quantities to Whatman paper (No. 1, 14 in. × 16 in.) and chromatographed in glass cylinders. Phenol–water (4–1 v/v) and butanol – propionic acid – water[2] were the developing solvents used for the two-dimensional ascending chromatography[3]. After development, the paper was air-dried at 20° C. and placed over X-ray film for two weeks in a dark room.

In order to identify the darkened spots the solutes were chemically located on the paper, and thereby the radioactive spots on the film were described by super-position. Amino-acids were detected by the use of ninhydrin, and, when each amino-acid having activity was rechromatographed with the corresponding inert amino-acid, a single spot was obtained for the mixture in each case. Urea was identified with the phenol-chlorox reagent[3] and it was rechromatographed similarly. Since the quantities of organic acids were too small to be detected with the use of $p$H indicators, their distributions between 0·1 $N$ hydrochloric acid in ether were studied, following extraction from the paper. Naturally occurring malic, oxalacetic and succinic acids showed distribution coefficients of 0·17, 0·045 and 0 012 respectively, as compared to 0·16, 0·043 and 0 15 for the authentic corresponding acids. Glucose was identified by the benzidine–acetic acid–ethanol reagent[4], and its position was confirmed by rechromatographing with reagent glucose. Since the distribution coefficients of succinate deviated by more than 10 per cent from the reagent value, the liver extract was chromatographed on silica gel[5], and the chromatographic zone assigned to succinate was assayed for activity.

Our results show, as previously, that the labelling in aconitic, fumaric and α-ketoglutaric acids is not detectable. The extent of incorporation of the tracer into succinate, oxalacetate and malate indicates, at least, that the total activity of these acids is greater than that of the other acids in the cycle. The relative concentrations[6] of these acids alone could not account for these results. This labelling of succinate and the absence of labelling of the other acids of the polycarboxylic acid cycle would seem to indicate that the cycle is not involved in a way that would be expected. Moreover, the lack of detectable activity in fumarate, the chemical concentration of which is greater than succinate[6], rules out the possibility that the oxalacetate served as a precursor of succinate by way of a reversed dicarboxylic acid cycle. The presence of the label to a small degree in glutamic acid but its absence in α-ketoglutarate can be explained by the higher concentration of the former in the liver. The most active compounds formed were glucose, urea, succinate, oxalacetate and malate. The appearance of the label in a large number of compounds suggests that the results for these short-term periods of carbon dioxide fixation *in vivo* cannot be accounted for by non-equilibration, and that the incorporation of the carbon-14 dioxide proceeds rapidly.

This investigation was supported in part by a grant from the Damon Runyon Memorial Fund.

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## Influence of Ovarian Hormones on Uterine Infection

Willett *et al.*[1] and Brook and Rowson[2] reported that pyometra frequently followed the insemination of cows when in the luteal phase of the œstrous cycle; but no definite reason for this occurrence was forthcoming. The present communication gives the results of experiments carried out on cows at various stages of the œstrous cycle and also on cows that had been ovariectomized.

A standard technique was adopted throughout the experiments, whereby the cervices of all animals were swabbed in the mid-cervical region for bacteriological culture using a sterile sheathed swab and sterile speculum. Immediately afterwards, the cows were inseminated by passing a normal sterile insemination pipette through the cervix and into the body of the uterus where the inseminated material was deposited. The material injected was either buffered semen known to be infected or cultures of *Corynebacterium pyogenes* isolated from bull semen. Two days after insemination, all cows were slaughtered and the reproductive organs removed for bacteriological examination.

The experiments were divided into three parts: (1) bacteriological examination of the uterus both before and after insemination with infected material in the luteal and follicular phases of the œstrous cycle; (2) bacteriological examination of the uterus after insemination following the injection of stilbœstrol or progesterone into ovariectomized cows; (3) studies of the effect on bacteria of penicillin, streptomycin and sulphanilamide added to infected material inseminated during the luteal phase.

The work proved quite conclusively that when infected material was injected into the uterus during the luteal phase of the cycle, pyometritis invariably resulted. On the other hand, all cows which were inseminated during œstrus had sterile uteri on slaughter two days later.

It was found that these phenomena could readily be reproduced in ovariectomized cows by the administration either of progesterone or stilbœstrol. In some cases pure cultures of *Corynebacterium pyogenes* were used instead of infected semen; yet in the animals given stilbœstrol, the uteri were sterile two days later. In ovariectomized control cows not receiving exogenous hormones, a sterile pyometritis resulted.

The results on control animals indicated that this phenomenon is due more to a stimulating effect of progesterone rather than to an inhibiting effect of œstrogen, but that the latter, in sufficient doses, will tend to overcome the effect of the former.

In the third experiment it was found that although the antibiotics and sulphanilamide prevented severe pyometritis and gave sterile uteri at slaughter, a certain amount of cellular debris had collected in the uterus giving the appearance of a mild pyometritis.

These results are of particular interest because they indicate quite clearly the tremendous bactericidal properties of the uterus during œstrus. They may explain why cows sometimes recover spontaneously from *Vibrio fœtus* and trichomonad infections after a number of heat periods without re-infective coitus. They may also indicate why the bull does not recover spontaneously from infections of *Vibrio fœtus* and trichomoniasis, for the bull normally secretes testosterone from the testis, which has a similar effect to progesterone. If testosterone has a similar effect in the bull to progesterone in the cow, then continuous testosterone production by the testis would make spontaneous recovery from genital infection of the bull unlikely. Experiments now planned are designed to show whether or not it is possible to treat such infected bulls successfully with exogenous œstrogen.

The possibility of controlling by the use of œstrogens the infections which follow abortion or parturition in the human might also be worth investigation.

The experiments described here form part of the work being carried out by the Agricultural Research Council Unit of Animal Reproduction at Cambridge, and we wish to thank the Ministry of Food for the loan of the cows, Dr. John Hammond for advice and encouragement, and the staff of the Animal Research Station and Public Health Laboratory for their continuous help.

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## Mucin Secretion in the Ewe's Oviduct

As part of a study on the reproductive organs of the female sheep, histological and histochemical investigations were undertaken on the oviducts of thirty ewes to determine whether the epithelial cells exhibited secretory activity and, if so, to establish the nature of the secretion.

In this investigation it was found that material positive to Schiff's periodic acid[1] was secreted by the non-ciliated epithelial cells during pro-œstrus and œstrus. In pro-œstrus the secretory globules extended on each side of the nucleus towards the proximal part of the cell, whereas in œstrus the globules were confined to the distal portion. Secretion was found in the lumen during œstrus and metœstrus but not during di-œstrus or pro-œstrus. Positive reaction was obtained after treatment with saliva, showing that the secreted material was not glycogen. This is at variance with the findings of earlier workers using the human oviduct. A positive reaction was obtained also after hyaluronidase, which excludes the presence of hyaluronic acid. The material did not exhibit metachromasia on staining with toluidin blue or celestin blue; and accordingly it is not an acid mucopolysaccharide. Again, a positive reaction with the periodic acid test was obtained after the methanol and chloroform test[2], thus eliminating the presence of glycolipid. In the light of these staining reactions, it can be assumed that the material was mucoprotein or "neutral mucopolysaccharide"[3].

The secretory cells were most numerous in the ampulla, and therefore the secretion was most abundant in this situation. The number of secretory cells was greatly reduced in the isthmus, and none was present in the vicinity of the oviduct–uterine junction.

A detailed account of this work will be published elsewhere.

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## Paper Chromatography of Œstrogens

The Burton, Zaffaroni and Keutman[1] method for the paper chromatographic analysis of the adrenal cortical steroids has been found to be suitable for the non-steroid œstrogens of the hexœstrol series (hexœstrol, stilbœstrol, dienœstrol, trienœstrol[3]) and ethinyl œstradiol. It can also be used for the natural œstrogens (private communication from H. Grundy). Development is carried out using the toluene – propylene glycol system, and the detecting reagent, a mixture of 1 per cent ferric chloride and 1 per cent potassium ferricyanide as used by Barton, Evans and Gardner[2], gave a blue spot with less than 2 µgm./sq. cm. of the run synthetic œstrogen. In addition, stilbœstrol, dienœstrol, trienœstrol but not hexœstrol gave a strong absorption at 2300 A., and dienœstrol a blue and trienœstrol a green fluorescence at 3600 A.

The presence of trienœstrol in the urine, fæces, but not blood extracts of animals injected with the œstrogen, has been demonstrated using this paper chromatographic method, and the amount estimated by the modified Allen Doisy[4] bioassay technique. Trienœstrol, when added to blood, could be easily detected. Similarly, in animals injected with ethinyl œstradiol, the unchanged œstrogen, but no œstrone or β-œstradiol, could be detected in the fæces.

This method of chromatography is, however, not very suitable for detecting œstriol in urine or fæces, as other very slow-moving chromogenic compounds interfere. A fuller account of these results as well as those obtained from the injection of other œstrogens will be published elsewhere.

ŒSTROGENS CHROMATOGRAPHED IN TOLUENE – PROPYLENE GLYCOL IN ORDER OF DECREASING MOVEMENT

| Compounds | Movement ratios |
|---|---|
| Œstrone—<br>11-Deoxycorticosterone | 0·40 |
| Ethinyl œstradiol—<br>11-Deoxy-17-hydroxycorticosterone | 0·73 |
| 17-β-Œstradiol —<br>11-Deoxy-17-hydroxycorticosterone | 0·65 |
| Hexœstrol —<br>11-Dehydro-17-hydroxycorticosterone | 1·1 |
| Stilbœstrol —<br>11-Dehydro-17-hydroxycorticosterone | |
| Dienœstrol —<br>11-Dehydro-17-hydroxycorticosterone | |
| Trienœstrol —<br>11-Dehydro-17-hydroxycorticosterone | 0·81 |
| Œstriol | Extremely slow |

I wish to thank Prof. E. C. Dodds for having made this work possible, and Mr. W. Lawson for his interest in the work and for supplying the œstrogens.

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## Iodination of Keratin

FOR the purposes of another investigation, it has been found necessary to devise a method of iodinating the tyrosine side-chains of keratin exclusively and completely. With aqueous solutions of iodine (0·1 *N*), no more than 75 per cent of the tyrosine of wool was iodinated under the best conditions used (64 hr. at 22·2° C. and *p*H 9). It has, however, been found that almost complete conversion into 3 · 5-di-iodo-tyrosine is obtained by treating wool (0·421 gm.) with a 0·78 *N* solution of iodine in absolute alcohol (50 c.c.) for 72 hr. at 25° C.

The tyrosine contents of the treated and untreated wools were determined by the method of Block and Bolling[1], and were found to be 0·214 and 4·77 per cent, respectively. If 3 : 5-di-iodo-tyrosine is the only reaction product, the fall in tyrosine content corresponds almost exactly to the amount of combined iodine (6·45 per cent). In agreement with this result, similar experiments with amino-acids showed that whereas tyrosine is readily iodinated under the above conditions, histidine reacts only to a negligible extent and tryptophane and proline not at all. Partial iodination of tyrosine gives more mono-iodo-tyrosine than di-iodo-tyrosine, contrary to Li's deduction[2] that tyrosine is slowly iodinated to mono-iodo-tyrosine, which then reacts instantaneously to give di-iodo-tyrosine.

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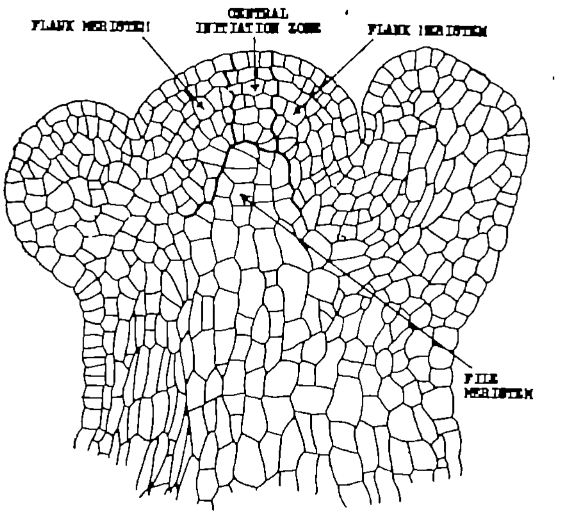
## Structure of the Angiosperm Inflorescence Apex

ALTHOUGH there is a considerable amount of information available concerning the structure of the angiosperm shoot apex, relatively little research has been carried out into the anatomical construction of the inflorescence apex. Grégoire's theory of the histological differences between vegetative and reproductive apices is well known to the student of developmental anatomy. He was unable to find tunica and corpus zones in the reproductive apices he examined. However, this observation has been challenged by recent workers, and these zones are now recognized in both types of growing-point. Few attempts have been made to interpret reproductive apices in the light of the cyto-histological zonation now generally recognized to be present in the vegetative apex[1]. Philipson[2] and Popham and Chan[3] have investigated the zonal changes that take place in the apex in the transition from the vegetative to the reproductive state in a number of dicotyledonous plants. It is claimed that, although central initiation, flank meristem and file meristem zones can be identified in the early inflorescence primordium, the central initiation zone later disappears and is replaced by flank meristem.

Anatomical investigations have been carried out by us on certain members of the Cruciferæ where the main inflorescence definitely terminates the leafy axis. Of the plants examined, *Arabidopsis thaliana* (L.) Heynh. proved the most instructive because it was possible to fix material grown under carefully controlled photoperiodic treatment, and thus apices in all stages from the purely vegetative to the flowering condition were obtained.

The first obvious change in the transition is an increased rate of cell division in the file meristem zone to convert the slightly convex vegetative apex into a large dome-shaped inflorescence primordium, down the sides of which extend the flank meristem. In this flank meristem are initiated first the cauline leaf primordia and then the flower primordia.

The cell-outline drawing shown is of a median longitudinal section through the *Arabidopsis* inflorescence apex with two flower primordia cut obliquely. The three main zones of the apex are labelled. The cells of the central initiation zone, as usual, stain less densely with protoplasmic stains than the surrounding flank meristem where mitotic divisions are to be observed frequently. This apex is more convex than the vegetative one, and file meristem cells, cut off from the lowermost cells of the central initiation zone, soon elongate in a plane parallel to the longitudinal axis of the inflorescence and undergo repeated transverse and longitudinal divisions. In the vegetative apex, the file meristem is poorly developed. Apart from these differences, the *Arabidopsis* apex producing flower primordia is essentially the same as that producing leaf primordia. Both differences are obviously related to growth processes. It has been stated[1] that the poor development of file meristem in the *Arabidopsis* vegetative apex is connected with the rosette habit of the plant. The active development of file meristem in the inflorescence apex, now under consideration, is obviously related to the active growth in a vertical direction of the inflorescence axis. The difference in shape of the two types of apex seems to be the result of the production of different types of lateral member. It has been observed, from an examination of numerous



Cell outline drawing of median longitudinal section of the inflorescence apex of *Arabidopsis*. (× 200)

series of sections, that a greater expansion of flank meristem needs to be reconstituted by the central initiation zone of the inflorescence apex before a flower primordium is initiated than in the vegetative apex before the initiation of a leaf primordium. As this greater expansion of flank meristem is being produced, the file meristem cells are undergoing active divisions to produce growth in length of the axis. A combination of these two growth processes will obviously produce a very convex apex.

Another interesting feature of this flowering apex is the retention of a two-layered tunica, in which no periclinal divisions occur, at all times during its growth. The flower primordia are initiated by periclinal divisions in the third flank meristem layer from the surface. This is in contrast to the initiation of leaf primordia by periclinal divisions in the second flank meristem layer. It is significant that this initiation of flower buds is similar to that of vegetative buds. The two-layered tunica, present in the early flower primordia, is disturbed later by the initiation of the floral members in its second layer.

These observations on *Arabidopsis* have been found also to apply to *Capsella* and *Iberis*. So far as we are aware, no other record has been made of the persistence of the central initiation zone in the inflorescence apex. It would seem then that, so far as these plants are concerned, vegetative and inflorescence apices are essentially similar and that the profound differences claimed by Grégoire cannot be applied to them. The inflorescence apex of these Cruciferæ is essentially similar to any shoot growing-point producing lateral members while actively promoting longitudinal growth of its subjacent axis. It is intended to publish this work in detail in due course.

We are indebted to Prof. F. G. Gregory and Mr. G. Hussey for the plant material on which these observations were made, and also to the Central Research Fund of the University of London for the loan of a microscope.

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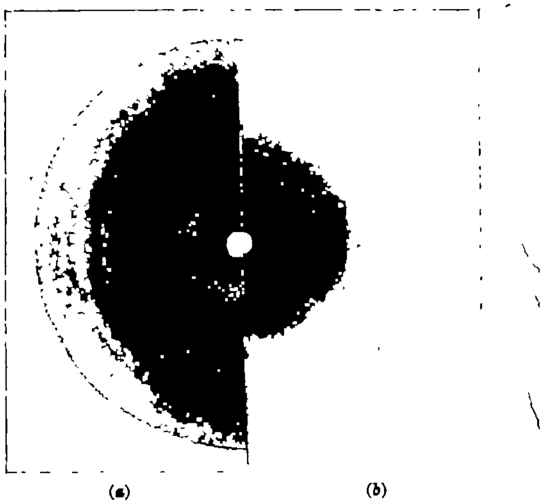
# Variability in the X-ray Diagram of the Cell Walls of the Marine Alga *Spongomorpha*

In a recent communication[1] we have shown by the methods of X-ray analysis that the two closely related green algæ *Cladophora* and *Spongomorpha* differ fundamentally in the submicroscopic organization of their cell walls. Whereas the cells in *Cladophora* filaments have walls in which the skeletal substance is a highly crystalline, well-oriented native cellulose (cellulose I), those of *Spongomorpha* contain a poorly crystalline, scarcely oriented modification of cellulose which might be mercerized cellulose (cellulose II) or a derivative. It was pointed out some time ago[2] that the air-drying of the material, necessary for X-ray investigation, does not produce any undesirable artefacts in algæ, and it was therefore concluded that the structures derived in this way could legitimately be applied to the fresh material. Even preservation in formalin or alcohol does not cause any observable change in the X-ray diagram.

These conclusions still stand for *Cladophora* and therefore presumably for the whole group of algæ with the *Cladophora* type of structure. While making a re-examination of *Spongomorpha*, however, in preparation for a projected publication on this and other differences from *Cladophora*, it has been noticed that the X-ray diagrams of *Sp. lanosa* var. *uncialis* and of *Sp. arcta* (the only species we have yet examined from the point of view of this note) vary with the manner of specimen preparation. If the material is dried first and then washed in distilled water (the normal treatment), the X-ray diagram is of the type already published[1] (Fig. *b*) and leads to the interpretation of structure mentioned above.

If, however, the material is washed in distilled water while alive and then dried, the X-ray diagram is of an entirely different kind (Fig. *a*), showing many more lines and indicating a much higher crystallinity.

Some of the lines which appear in this second type of photograph are due to the presence of salts and have been identified as belonging to potassium chloride and sodium chloride. Others, however, undoubtedly arise from organic material. The number of these latter lines varies from collection to collection, and we are not certain whether or not this represents


(*a*) (*b*)

X-ray photographs of *Spongomorpha lanosa* (*a*) specimen washed alive and then dried; (*b*) same specimen rewashed a seasonal variation. Some of the lines show marked orientation, and we conclude that these correspond to material incorporated in the walls.

The change in the X-ray diagram is apparently caused by the extraction of substances from the walls, and the dried extracts yield X-ray diagrams containing several lines which have disappeared from the diagram of the filaments. The extract undoubtedly contains material from sources other than the wall, but we have nevertheless thought it necessary to carry out a preliminary chemical investigation. The material chars on heating and the elementary analysis is as follows: C, 16·6 ± 0·3 per cent; N, 2·15 ± 0·3 per cent; H, 2·51 ± 0·3 per cent; S, 2·49 ± 0·4 per cent; P, 0·0 per cent. It contains a good deal of SO$_4''$, which may account for some of the sulphur, though it should be remembered that even then the sulphur may be organic[3]. This material appears to consist in part of organic substances of the nature of soluble proteins, but carbohydrates are absent. Somewhat similar material is extractable from *Cladophora rupestris* but in much smaller quantity and without noticeable effect on the X-ray diagram.

Among the soluble substances, known to be present in algæ, the one yielding an X-ray diagram most similar to—indeed, almost identical with—that of our material has proved to be synthetic thetine (dimethyl β-carboxyethyl sulphonium bromide) presented to us by Prof. F. Challenger of the Chemistry Department at Leeds. Prof. Challenger has since shown that dead *Spongomorpha arcta* produces large quantities of dimethyl sulphide on treatment with water, so that it must contain substances of the thetine type.

We thus have here X-ray evidence that substances which appear to occur in the wall are nevertheless extractable only after the filaments have been killed. This is of great interest in view of the growing conviction that the wall of a cell is more than a mere dead envelope. If, in addition, these substances include thetine, a trans-methylating agent, then this might be a point of decisive importance. These points will be discussed elsewhere when the results can be presented in fuller detail.

The work reported here is part of a programme financed through a grant from the Department of Scientific and Industrial Research, to which the thanks of one of us (R. D. P.) are due.

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# Differential Fluorescence in Identification of Tobacco Trashy Leaf

Trashy leaf is brown, worthless leaf occurring in flue-cured tobacco; its prevalence causes a substantial loss to the Australian tobacco industry[1]. In the investigation of this phenomenon, it is essential that means be available of detecting trashiness at an early stage in uncured leaf. Cured leaf can usually be separated on physical properties into several grades varying from normal to fully trashy. This does not apply to uncured leaf, where gradation in trashiness remains masked. A method is described here whereby the presence of trashiness in dried uncured leaf can be readily detected. This method is based on the differential fluorescence of normal and trashy leaves under ultra-violet light.

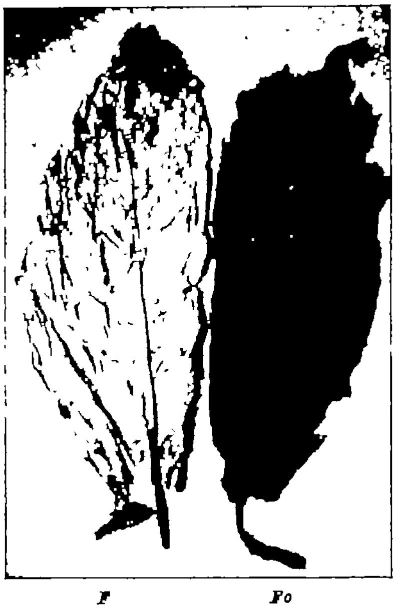

Fig. 1. Typical normal (*F*) and trashy (*Fo*) uncured tobacco leaves under ultra-violet light

It has been observed that the underside, but not the upperside, of normal tobacco cured or uncured leaves fluoresces with a brilliant bluish-white light tinged with green when exposed to ultra-violet radiation. On the other hand, fully trashy leaves, whether cured or uncured, remain dull, showing only a reddish-brown colour (see Fig. 1).

Some chemical characteristics of cured and uncured trashy leaves have been reported previously[1]. It has now been found that absence of fluorescence is associated with the chemical composition typical of trashy leaf (that is, low sugar, carbohydrate and amide–nitrogen and high total nitrogen, protein–nitrogen and ammonia–nitrogen). The data in the accompanying table are for fluorescent (*F*) and non-fluorescent (*Fo*) leaf from the same stalk position obtained from two rows of plants, one normal and the other showing extensive trashiness. Over the past two years, the use of ultra-violet light has indicated the degree of trashiness that can be expected in the cured leaf.

Chromatographic separation in various solvents, and absorption spectrum measurement of the fluorescent fractions, indicate that fluorescence in

Per cent total sugars, total nitrogen and protein–nitrogen contents (dry-weight basis) in fluorescent (*F*) and non-fluorescent (*Fo*) uncured tobacco leaves, and reducing sugars in corresponding flue-cured leaves estimated by methods described in ref. 1. Values are the means of several estimations and do not deviate from the true mean by more than ± 0·30 for sugars and ± 0·02 for nitrogen

| Leaf position on stalk | Total sugars | | Reducing sugars | | Total nitrogen | | Protein-nitrogen in 'protein' preparation | |
|---|---|---|---|---|---|---|---|---|
| | (*F*) | (*Fo*) | (*F*) | (*Fo*) | (*F*) | (*Fo*) | (*F*) | (*Fo*) |
| 5, 6, 7 | 37·9 | 17·0 | 17·1 | 3·9 | 1·43 | 2·52 | 1·71 | 2·82 |
| 8, 9, 10 | 43·1 | 14·8 | 19·6 | 3·6 | 1·38 | 2·69 | 1·74 | 2·92 |
| 11, 12 | 44·2 | 13·8 | — | 3·0 | 1·48 | 2·59 | 1·73 | 2·92 |

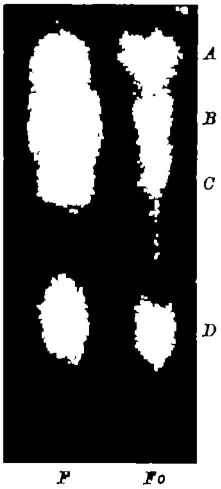

Fig. 2. Chromatogram of fluorescent components from normal (*F*) and trashy (*Fo*) leaves. These compounds are colourless in white light. *A* fluoresces with light grey, *B* with light blue, *C* with mauve and *D* (β-methylesculetin) with deep blue. (When taking the photographs a 2*A* Kodak haze filter was interposed between the object and camera lens)

tobacco leaf is a resultant of four major components *A*, *B*, *C* and *D*; typical chromatograms for normal and trashy leaves are shown in Fig. 2. The amount of fluorescent material present diminishes with increasing trashiness. There are indications that the relative amounts of the four components change as the fluorescence diminishes. Thus, there is a differential loss in component *C* with the development of trashiness. Component *D* has been isolated and identified as β-methylesculetin by comparison with an authentic sample. So far as is known, the difference in fluorescence of the two types of leaf and the presence of compounds represented by *A*, *B* and *C* has not been reported previously, although β-methylesculetin has been isolated from a variety of plants, including tobacco[2].

Further details of this work will be published elsewhere. I wish to express thanks to Miss I. D. Verners for sampling under ultra-violet light, and to Dr. R. J. Best of the Waite Agricultural Research Institute, Adelaide, for the authentic sample of β-methylesculetin.

R. JOHANSON

Division of Plant Industry,
Commonwealth Scientific and
Industrial Research Organization,
Canberra. Oct 29.

[1] Johanson, R., *Aust. J. Sci. Res.*, B, 4, 231 (1951).

[2] Best, R. J., *Aust. J. Exp. Biol.*, 26, 223 (1948). Andreae, W. A., *Nature*, 170, 83 (1952).

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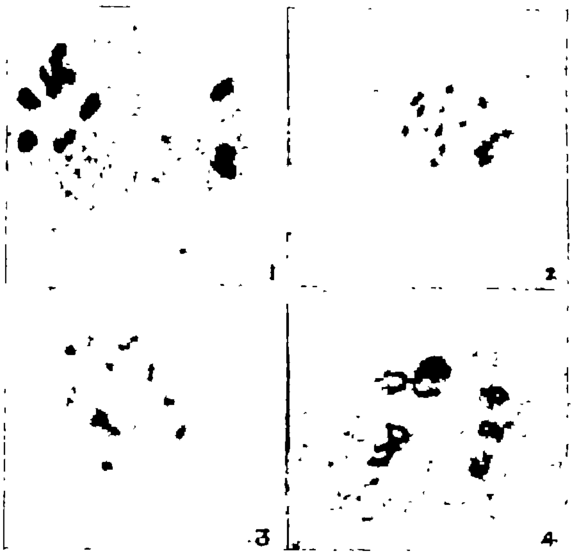
## Chromosomes of the Genus *Corchorus*

BANERJI[1] was the first to study the chromosome numbers in the genus *Corchorus*, and he found that seven was the haploid number. His survey included two varieties of *C. olitorius* Linn., four varieties of *C. capsularis* Linn. and *C. acutangulus* Lamk. Later, Nakajima[2] confirmed the observations of Banerji in the case of *C. capsularis* Linn.

The behaviour of chromosomes in meiosis in a large number of *Corchorus* species has been studied in this laboratory. In *C. trilocularis* Linn., pairing is normal and seven bivalents are the rule, although occasionally two chromosomes fail to pair and appear as univalents.



(1) Pollen mother cell showing hyperploidy; seven bivalents in one group and one univalent and one bivalent in another group (*C. fascicularis*). (2) Meiotic metaphase of pollen mother cell showing $n = 14$ (*C. siliquosus*). (3) Polyploid pollen mother cell, $n = 14$ in diakinesis (thirteen bivalents are in focus) (*C. fascicularis*). (4) Pollen mother cell showing one quadrivalent and five bivalents (*C. fascicularis*)

*C. siliquosus* Linn. is a natural polyploid and fourteen bivalents appear at $M_1$ (Fig. 2). Multivalents are infrequent, which shows that this is a polyploid by age. Pollen mother cells with one quadrivalent and one trivalent or with two trivalents have also been observed.

In *C. fascicularis* Lamk., pairing leads to the formation of seven bivalents with a single nucleolus, and occasionally two univalents appear due to failure of pairing. Often two bivalents are in connexion with two nucleoli. This species appears to be a structural hybrid, because a quadrivalent appears frequently (Fig. 4). By far the most interesting feature in this species is the occurrence of pollen mother cells with fourteen bivalents along with those bearing the normal seven (Fig. 3). There is an indication that these polyploid cells elongate and the fourteen bivalents separate into two groups of seven bivalents each. Abnormal pollen mother cells have been recorded which have arisen due to irregularities in the pre-meiotic divisions. These hyper- and hypoploid cells show varying numbers. When the cell receives more than the normal seven, there is a tendency to eliminate the extra bivalents and thus one cell retains the normal seven bivalents (Fig. 1). These abnormalities are observed in several other species of *Corchorus* under investigation and appear to be a characteristic of this genus.

Lagging at anaphase has been noticed. Multipolar spindles are formed in the second division, leading to the formation of micro-nuclei.

Further details of this work will be published later. We thank Dr. K. V. Srinath for his guidance, and Dr. B. C. Kundu, director of this Institute, for his encouragement.

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[1] Banerji, I., *J. Ind. Bot. Soc.*, 11, 82 (1932).

[2] Nakajima, G., *Jap. J. Genet.*, 12, 211 (1936).

## Longevity and Production in the Buffalo

An attempt has been made to estimate the extent to which selection for yield might be expected to influence the productive life of the buffalo. The calculations were carried out on data from animals that were not in the course of their productive herd-life. These animals were either dead, or culled from the herds studied. They were grouped together within herds according to their number of calvings. The average first lactation yield for the different groups was calculated and expressed as a percentage of their herd average. The total results for the herds were obtained by weighting the relative yields in similar groups in the different herds according to the number of animals contributing to them.

| No. of calvings | Relative yield (%) | $\sigma$ (gallons) | $C/V$ | No. of animals |
|---|---|---|---|---|
| 1– 2 | 84·1 | 112·3 | 29·6 | 41 |
| 3– 4 | 94·2 | 106·4 | 28·3 | 81 |
| 5– 6 | 104·3 | 108·8 | 26·6 | 65 |
| 7– 8 | 116·6 | 116·6 | 24·5 | 34 |
| 9–11 | 108·7 | 94·2 | 20·4 | 29 |
| Average and total | | | | |
| 5·00 | 100 | 107·8 | 26·6 | 250 |

The above results showed that the average productive herd life of these animals was five calvings. The coefficient of variation of the first lactation milk yield decreased from the first to the eleventh calf. The increase in the first lactation yield with the number of calvings made in the herds could be due to culling of low producers on lactations after the first, owing to the repeatability 0·55. However, the high first lactation producers lived up to eight lactations, and animals living longer, and of relatively lower first lactation yield, might be those with which the farmers built up their herds.

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Sept. 14.

## Infectivity of Aphids after Several Hours on Tobacco Infected with Potato Virus Y

Watson showed that fasted *Myzus persicae* (Sulz.) were more than 60 per cent infective after 5 min. on tobacco infected with potato virus *Y*, but after 4 hr. on infected plants only about 10 per cent of the aphids were infective[1]. During investigations on the aphid transmission of potato virus *Y*, it was observed that, after several hours on tobacco, some aphids appeared to be feeding, others were just commencing to insert their stylets, and still others were wandering about the plant. The present communication reports which aphids transmit potato virus *Y* after a group has spent several hours on an infected plant.

Regular excretion of honeydew is generally accepted as evidence that an aphid is imbibing liquid from a plant[2], and previous work has shown that continuously feeding *M. persicae* usually have the stylets inserted into the phloem[3]. To learn whether *M. persicae* is infective after excreting regularly for more than an hour on tobacco infected with potato virus *Y*, single aphids were allowed to feed on infected leaves over filter paper which had been soaked in a solution of bromo-cresol green. Visible blue spots formed on the filter paper wherever drops of honeydew fell[4]. When an aphid fed continuously for more than an hour without changing its feeding site, three or four drops of honeydew fell on the paper within a circle of about 1 cm. diameter. Aphids that had excreted regularly for more than an hour from infected leaves were transferred to healthy White Burley tobacco plants (*Nicotiana tabacum* L.), and allowed to feed for several hours. Not one of twenty-five aphids tested in this manner transmitted the virus; but fasted aphids that spent 5 min. on the same infected plants were more than 60 per cent infective.

When feeding *M. persicae* are gently disturbed with a camel's-hair brush, the stylets can be seen, with the aid of a hand-lens, extending beyond the tip of the proboscis. Aphids do not appear to be injured when disturbed in this way, for the proboscis slowly elongates over the stylets, and usually feeding is renewed within a few minutes. The length of the stylets visible immediately after an aphid is disturbed may be taken as the distance they were inserted into the plant. About twenty-five feeding aphids were disturbed, and dropped at once into a hot fixative. The distance that the stylets of each aphid extended beyond the tip of the proboscis was measured under a microscope, and the aphids were then observed with a × 15 hand-lens. After a little practice and with the dead aphids as standards, it was possible to tell at a glance whether the stylets of disturbed aphids extended 25–50 μ, 50–100 μ, or more than 100 μ. When aphids with their stylets inserted less than 25 μ were disturbed, the proboscis elongated so quickly that the stylets could rarely be seen. Furthermore, after several hours on a plant, nearly all aphids that appeared to be feeding had their stylets inserted more than 25 μ.

About fifty *M. persicae* were transferred from cabbage to tobacco infected with potato virus *Y*. After a few hours on the infected plant, aphids that appeared to be feeding were disturbed, and the length of the stylets visible recorded as 25–50 μ, 50–100 μ, or more than 100 μ. Each aphid was then transferred to a healthy tobacco plant for several hours. Aphids were disturbed on various occasions from ten infected plants, and more than fifty aphids were tested for each of the three groups. A total of two hundred aphids was tested in all, but not one transmitted the virus. Disturbing the aphids did not appear to affect their ability to transmit, for aphids disturbed a second time about a minute after the stylets were re-inserted into the leaf were more than 30 per cent infective. Aphids that were observed to withdraw their stylets voluntarily, and disturbed about a minute after re-inserting their stylets, were also more than 30 per cent infective. Those aphids wandering about the leaves were observed to make a few feeding punctures lasting about a minute before settling down to continuous feeding. These aphids were transferred to healthy tobacco plants after they had completed one such puncture, and were more than 40 per cent infective. Thus, after several hours on tobacco infected with potato virus *Y*, virus was only transmitted by aphids commencing to insert the stylets, or by aphids that had made a brief feeding puncture.

The epidermis of the infected plants was about 20 μ thick. Therefore, aphids with their stylets inserted 25–50 μ must have only penetrated to the first or second mesophyll cells, and the majority of those with their stylets inserted more than 100 μ must have reached the phloem[3]. During feeding punctures lasting about a minute, the stylets are only inserted into the cells of the epidermis[5]. Thus, when the stylets were inserted into the epidermis, *M. persicae* acquired potato virus *Y* that could later be used to infect healthy plants; and aphids are never, or only rarely, infective when the stylets have penetrated as far as the mesophyll or to the phloem.

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Oct. 9.

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[1] Watson, M. A., *Proc. Roy. Soc.*, B, **125**, 144 (1938).

[2] Broadbent, L., *Proc. Roy. Ent. Soc.*, A, **26**, 7 (1951).

[3] Roberts, F. M., *Ann. App. Biol.*, **27**, 348 (1940). Smith, K. M., *Ann. App. Biol.*, **13**, 109 (1926).

[4] Smith, L. M., *J. Agric. Res.*, **54**, 345 (1938).

[5] Bradley, R. H. E., *Ann. App. Biol.*, **39**, 78 (1952).

## An Unusual Form of Carbon

In the course of experimental work on the deposition of carbon in the brickwork of blast furnaces (deposition which may cause the disintegration of the bricks), it has been found by electron micrography that the carbon is deposited as minute vermicular growths which can penetrate considerable thicknesses of brickwork. The carbon is formed by the interaction of carbon monoxide and iron oxide in the so-called iron-spots in the brick. It has been found possible to reproduce this reaction in the laboratory by exposing samples of brick containing iron spots to the action of carbon monoxide at an optimum temperature of about 450° C. Moreover, a similar form of carbon growth is observed if iron ore, magnetite or any form of iron oxide is substituted for the brick samples.

The carbon vermicules have a characteristic appearance which is easily recognized—they may vary in thickness from 100 A. or so up to about 0·2 micron, and they are generally somewhat helical in form. Stereoscopic examination has shown that many of the thicker threads consist of a number of thin ones twisted together in the form of a rope. We have, so far, been unable to find any other source of carbon of similar appearance, with the possible exception of soot from a domestic chimney where the same reaction may well have taken place.

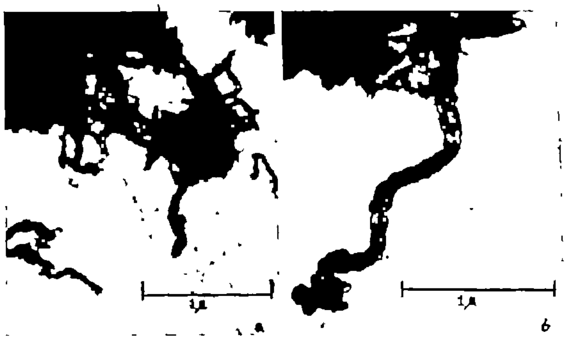
X-ray examination of the deposited carbon showed, in addition to amorphous carbon, cementite ($Fe_3C$) and an iron percarbide ($Fe_{20}C_9$). It is suggested, therefore, that the following reactions may take place:

$$\begin{aligned} Fe_3O_4 + CO &\rightarrow 3FeO + CO_2 \\ FeO + CO &\rightarrow Fe + CO_2 \\ 3Fe + 2CO &\rightarrow Fe_3C + CO_2 \end{aligned}$$

$$\begin{tikzcd}[column sep=small] & Fe_3C \arrow[dl] \arrow[dr] & \\ Fe_3C \rightarrow 3Fe + C & & \begin{array}{c} 20Fe_3C + 14CO \rightarrow 3Fe_{20}C_9 + 7CO_2 \\ 3Fe_{20}C_9 \rightarrow 20Fe_3C + 7C \end{array} \end{tikzcd}$$

Thus the reaction $2CO \rightarrow CO_2 + C$ may be considered to be catalysed either by iron which is alternately converted to cementite and back to iron, or by cementite which is alternately converted to the percarbide and back to cementite.

It would appear that the catalyst, whether it be iron or iron carbide or both, is formed originally as specks on the surface of the iron oxide—each speck giving rise to a thread of carbon. An isolated speck produces a thin thread, but the threads from a collection of catalytic points become twisted and probably coalesce to produce the characteristic vermicule. Once the growth of carbon has commenced, the position of the catalyst is less certain. We suggest that the particles of catalyst are located on the growing ends of the threads. This would explain the coalescence of multiple threads and also the mechanism by which the carbon can penetrate the bricks.



(*a*) Carbon growth in firebrick after 30 hr. in carbon monoxide at 450° C., showing mass of characteristic vermicular threads. (*b*) Large vermicule formed by coalescence of smaller threads

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Nov. 24.

## *Murex* from the Red Sea

In the early months of 1951, Sir John Graham Kerr collected some three hundred *Murex tribulus* shells on the western shore of the Great Bitter Lake south of the village of Fayid. It will be remembered that the entire animal population has been introduced subsequent to the cutting of the Suez Canal in 1869, which opened the way for immigrant organisms from the Red Sea. Now, granted the inherent tendency of living creatures to vary when relieved of the shackles of environment, Sir John argued that, in their new environment of the Bitter Lakes, these *Murex* specimens had had an opportunity of responding to this tendency, and hence the remarkable variety of sculpture in the random collection. Moreover, this variation exhibited in spines and tubercles is not a matter of mere superficial markings, but rather of deep-seated causes such as the localized growth of the mantle edge or the depth in the mud occupied by the individual animal. The shells were in perfect condition, there being practically no tides in the Bitter Lakes and no violent wave action, and the bottom is soft mud.

Sir John very kindly presented me with this collection for the Notre Dame Museum. My successor in the lectureship at Notre Dame, Sr. Marie Josephine Parkes, has carried out a most painstaking investigation in detail of the variations shown by the individual shells, but is now held up at this point for lack of a corresponding series of shells from the open waters of the Red Sea. The object of this communication is to make an appeal for help to anyone with an opportunity for collecting in the Red Sea to fill this deficiency. A photograph of the particular species of *Murex* will be gladly forwarded to anyone willing to help.

MONICA TAYLOR

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# FORTHCOMING EVENTS

(*Meetings marked with an asterisk * are open to the public*)

## Monday, April 27

University of London (in the Physiology Theatre, University College, Gower Street, London, W.C.1), at 4 45 p.m.—Sir Rudolph Peters, F.R.S.: "Inhibitors and Intracellular Chemical Dissection".* (Further Lectures on May 4, 11 and 18.)

University of London (in the Eugenics Theatre, University College, Gower Street, London, W.C.1), at 5 p.m.—Prof. W. Feller (Princeton): "On Diffusion Processes and their Statistical Applications".* (Further Lecture on April 29.)

British Society for the History of Science, Philosophy of Science Group (in the Joint Staff Common Room, University College, Gower Street, London, W.C.1), at 5.30 p.m.—"Induction and Scientific Legitimacy" (Chairman's Address).

Royal Institution, Library Circle (at 21 Albemarle Street, London, W.1), at 5.30 p.m.—Mr. H. Ironmonger: "The Tyndall Manuscripts".

University of London (at King's College, Strand, London, W.C.2), at 5.30 p m.—Prof. H. S. Taylor, F.R.S.: "Catalysis—Modern Trends".* (Further Lecture on April 28.)

## Tuesday, April 28

Wool Education Society (at the Royal Society of Arts, John Adam Street, Adelphi, London, W.C.2), at 7.15 p.m.—Mr. John Barritt: "The Mothproofing of Wool".

## Tuesday, April 28—Friday, May 1

Library Association (in the Pier Pavilion, Llandudno).—Annual Conference.

Royal Sanitary Institute (in the White Rock Pavilion, Hastings).—Health Congress.

## Wednesday, April 29

Iron and Steel Institute (at 4 Grosvenor Gardens, London, S.W.1), at 9.45 a.m.—Special Meeting on "Boron in Steel".

Royal Society of Arts (at John Adam Street, Adelphi, London, W.C.2), at 2.30 p.m.—Dr. O. H. Wansbrough-Jones: "The Scientist's Place in the Services" (Sir William Jackson Pope Memorial Lecture).

Textile Institute (at the University, Bristol), at 3 p.m.—Annual General Meeting; at 4 p.m.—Dr. C. M. Whittaker: "Common Sense and Colour in Textiles" (Mather Lecture).

University of London (in the Physiology Theatre, University College, Gower Street, London, W.C.1), at 4.45 p.m.—Prof. George Wald (Harvard): "The Molecular Basis of Vision".*

Geological Society (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Annual General Meeting; Presidential Address on "The Evolution of the Shrinking Earth".

Royal Meteorological Society (at 49 Cromwell Road, London, S W.7), at 5 p.m.—Dr. T. W. Wormell. "Lightning" (Symons Memorial Lecture).

## Thursday, April 30

Royal Society (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Miss Edith Bulbring, Prof. J. H. Burn, F.R.S., and Miss Heather J. Shelley: "Acetylcholine and Ciliary Movement in the Gill Plates of *Mytilus edulis*"; Mr. F. W. Shotton: "The Pleistocene Deposits of the Area between Coventry, Rugby and Leamington and their Bearing upon the Topographic Development of the Midlands".

Society of Chemical Industry (at the Royal Institution, 21 Albemarle Street, London, W.1), at 6 p.m.—Dr. R. T. Colgate: "Science, Food and the People" (Third H. E. Armstrong Memorial Lecture).

Chadwick Public Lecture (in the Lecture Hall, Walker Art Gallery, William Brown Street, Liverpool), at 7.30 p.m.—Prof. S. E. Finer: "Public Health—a Comparison between the Age of Chadwick and our Own".*

Chemical Society (at Burlington House, Piccadilly, London, W.1), at 7 30 p.m.—Prof. H. S. Taylor, F.R.S.: "The Scientific Problems of Surface Catalysis".

## Thursday, April 30—Friday, May 1

Iron and Steel Institute (at 4 Grosvenor Gardens, London, S.W.1).—Annual General Meeting.

## Friday, May 1

University of London (in the Anatomy Theatre, University College, Gower Street, London, W.C.1), at 5.15 p.m.—Prof. J. Kampé de Fériet (Lille): "The Statistical Theory of Turbulence".*

Institution of Mechanical Engineers (at Storey's Gate, St. James's Park, London, S.W.1), at 5.30 p.m.—Mr. J. Reeman, Mr. R. W A. Buswell and Mr D. G. Ainley: "An Experimental Single-Stage Air-cooled Turbine".

## Friday, May 1—Saturday, May 2

Society of Chemical Industry (joint meeting of the Food and Agriculture Groups and the South-Western Section, at Newton Abbot).—Symposium on "Potatoes as a Crop and an Industrial Raw Material".

# APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Lecturer in the History of Mechanical Engineering—The Registrar, King's College, Newcastle-upon-Tyne (April 30).

Assistant Lecturer in Biochemistry at the University of Malaya, Singapore—The Secretary, Inter-University Council for Higher Education in the Colonies, 1 Gordon Square, London, W.C.1 (May 1)

Senior Assistant Physicist in the Radiotherapy and X-Ray Diagnostic Departments—The Clerk to the Governors, St. Thomas's Hospital, London, S.E.1 (May 2).

Lecturer in Experimental Physics, and Assistants in Experimental and Theoretical Physics—The Secretary, The University, Aberdeen (May 5).

Assistant Lecturers in Chemistry—The Registrar, The University, Manchester 13 (May 6).

Assistant Lecturer in Botany (preferably with special interest in ecology and morphology)—The Registrar, Queen Mary College, Mile End Road, London, E.1 (May 8).

Experimental Officers (Ref. F.139/53A) and Assistants (Scientific) (Ref. F.140/53A) in the Chemical Inspectorate, Ministry of Supply, for analytical work related to the Atomic Energy Production programme in establishments at Sellafield, Salwick, Capenhurst and S.E. London—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S W.1, quoting the appropriate Ref. No. (May 9).

Ph.D. in organic or biochemistry, for an applied chromatography research scheme—Dr. R. T. C Pratt, National Hospital, Queen Square, London, W.C.1 (May 9).

Scholarship in the School of Theoretical Physics—The Registrar, Dublin Institute for Advanced Studies, 64 Merrion Square, Dublin (May 11).

Geologists at the Geological Survey and Museum—The Civil Service Commission, Scientific Branch, Trinidad House, Old Burlington Street, London, W.1, quoting S.168/53 (May 14).

Assistant (male, with degree in horticulture, agriculture or botany) in the Scientific Liaison Section—The Secretary, East Malling Research Station, East Malling, Maidstone, Kent (May 16).

Reader or Senior Lecturer in Civil Engineering—The Registrar, The University, Nottingham (May 16).

Scientific Technical Officers for metallurgical and chemical research at the Central Research Establishment, Isleworth—The National Coal Board, Establishments (Personnel), Hobart House, Grosvenor Place, London, S.W.1, quoting TT/623 (May 18).

Assistant Lecturer in Statistics—The Secretary, Bedford College, Regent's Park, London, N.W.1 (May 22).

Scientist (Grade I) to supervise the design and operation of pilot plants—The National Coal Board, Central Research Establishment, Stoke Orchard, Cheltenham, Glos, quoting TT/620 (May 23).

Lecturer in Philosophy at the University of Hong Kong—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (May 31).

Lecturer in Geology and Mineralogy—The Secretary, The University, Aberdeen (June 1)

Pfeiffer Scholarship in Aeronautics—The Warden, College of Aeronautics, Cranfield, Bletchley, Bucks (June 1).

Lecturer (Grade II) in Chemistry (with special qualifications in physical chemistry, and who should have undertaken independent research in some branch of this subject, other than reaction kinetics)—The Registrar, The University, Reading (June 13).

Physicist (with university honours degree in science, or equivalent qualifications, with research experience in the use of X-ray diffraction, preferably as applied to studies of the structure of proteins or high polymers) to the Biochemistry Unit, Wool Textile Research Laboratories, Parkville, Melbourne, to participate in an intensive programme of research on the structure of wool and other fibrous proteins by chemical and physical methods—The Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting No. 462/51 (June 26).

Lecturer in Mathematics at the University of Natal, Durban—The Secretary, Association of Universities of the British Empire, 5 Gordon Square, London, W.C.1 (June 30).

Assistant Professor in the Department of Civil Engineering—The University of British Columbia, Vancouver, B.C., Canada.

Associate Professor of Mathematics—The Acting Head of the Department of Mathematics, Memorial University of Newfoundland, St. John's, Newfoundland, Canada (apply by air mail).

Biologist (Fishery Research), Kenya, for survey of freshwater fisheries—The Director of Recruitment, Colonial Office, Great Smith Street, London, S.W.1, quoting CDE.152/7/01

Geologist in Northern Rhodesia—The Director of Recruitment, Colonial Office, Great Smith Street, London, S.W.1, quoting CDE. 105/3/01.

Geologist in Tanganyika—The Director of Recruitment, Colonial Office, Great Smith Street, London, S W.1, quoting CDE.105/8/03.

Lecturer or Assistant Lecturer in Geology, an Assistant Lecturer and a Demonstrator in Organic Chemistry—The Registrar, The University, Nottingham.

Metallurgist (with honours degree or equivalent) to take charge of small metallurgical and chemical laboratory, and Research Engineers (good honours degree essential) for (*a*) general automobile engineering problems, (*b*) investigations concerning mechanical properties (in particular, fatigue strength) of materials and components, (*c*) investigations into loadings experienced by vehicle components on the road, riding characteristics of vehicles, etc—The Director, Motor Industry Research Association, Lindley, Nuneaton.

Mines Surveyor in Uganda—The Director of Recruitment, Colonial Office, Great Smith Street, London, S.W.1, quoting CDE. 103/9/03.

Physicists (with at least second-class honours in physics, applied mathematics or engineering) for fundamental research on felt and applied research in the felt-making industry—The British Hat and Allied Felt-makers Research Association, Stanley House, Manchester Road, Fairfield, Droylsden, Manchester.

Professor of Experimental Physics, Professors (2) in Chemistry (one in physical chemistry), a Professor of Mathematics, a Professor of General Mechanics and Oscillations (mechanics of continua), an Associate Professor (general mechanics and vibrations), a Senior Lecturer in Physics (with special qualifications in nuclear physics or solid state physics), a Senior Lecturer in Chemistry, a Senior Lecturer in Mathematics (with special qualifications in mathematical statistics), a Senior Lecturer in the Division of Mechanics, Professors (2) in the Department of Chemical Engineering (one with special qualifications in food technology and biotechnology), a Professor of Metallurgy, Professors (2) of Electrical Engineering or Electronics and Telecommunications Engineering, an Associate Professor of Electrical Power Engineering, a Senior Lecturer in Electronics and Telecommunications Engineering, Professor of Mechanical Engineering (with special qualifications in thermodynamics and machines), a Professor of Hydraulic and/or Sanitary Engineering, an Associate Professor of Hydraulic and/or Sanitary Engineering, an Associate Professor (with special qualifications in tooling processes, machine tools and metrology), a Senior Lecturer (with special qualifications in applied thermodynamics and machine laboratory work), a Senior Lecturer of Hydraulic and/or Sanitary Engineering, a Professor or Associate Professor or Senior Lecturer of Aircraft Structures, a Professor of Aircraft Propulsion or Applied Aerodynamics, an Associate Professor of Aircraft Propulsion or Applied Aerodynamics and two Senior Lecturers, and a Professor or Associate Professor in Farm Power and Machinery; in the Hebrew Institute of Technology, Haifa, Israel—The Secretary, Technion Society of Great Britain, 13 Mansfield Street, London, W.1.

Senior Research Fellows and Research Fellows to work in the Department of Theoretical Physics, Australian National University, Canberra, on problems of nuclear and particle physics and in field theory—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1.

Senior Research Worker and a Research Assistant, to undertake a fundamental study of the viscosity of liquid metals—The Registrar, The University, Edmund Street, Birmingham 3.

Technical Officer (with degree or diploma in agriculture, horticulture or biology) for potato trials—The Secretary, National Institute of Agricultural Botany, Huntingdon Road, Cambridge

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# ADULT EDUCATION IN GREAT BRITAIN

SPEAKING in the House of Commons on April 23, Miss Horsbrugh, Minister of Education, announced that the grants for adult education next year would be the same as for this year. Thus has ended a period of uncertainty and vigorous discussion which followed the proposal early this year for a reduction of government support of this aspect of the national educational system. Miss Horsbrugh stated that, after consideration of information provided by bodies responsible for adult education in Great Britain, she had concluded that the arrangements by which government support was afforded required reviewing in the light of post-war developments. She proposes, therefore, to set up a small committee to advise her on administrative and financial aspects; until the committee reports, the grants are to be maintained, and even additional assistance may be made available.

The Prime Minister's letter of March 13 to the Trades Union Congress had already stated that no actual decision to cut grants had been made. There was, he added, perhaps no branch of the educational system of Great Britain which should more attract, within its particular sphere, the aid and encouragement of the State than adult education. "How many must there be in Britain, after the disturbance of two destructive wars, who thirst in later life to learn about the humanities, the history of their country, the philosophies of the human race, and the arts and letters which sustain and are borne forward by the ever-conquering English language? This ranks in my opinion far above science and technical instruction, which are well sustained and not without their rewards in our present system. The mental and moral outlook of free men studying the past with free minds in order to discern the future demands the highest measures which our hard-pressed finances can sustain."

The Prime Minister's words recall those of Prof. S. E. Raybould, the first occupant of the new chair of adult education in the University of Leeds, in the survey of university extra-mural education in Great Britain which he contributed to a volume, "Universities in Adult Education", recently issued by the United Nations Educational, Scientific and Cultural Organization[*]. Most valuable of the results of such education, Prof. Raybould thinks, is "the development of habits of systematic study, of critical thinking, of disciplined discussion; and the result has been the more widespread diffusion throughout the population of the qualities of tolerance, judgment and responsibility which are necessary for democratic life". Nevertheless, to recognize the necessity and importance of adult education is, however, as the Prime Minister concluded, no reason for not looking through the accounts and making sure that all that we can give is turned to real advantage.

The Prime Minister's letter shows clearly that the Government is concerned, and rightly, to ensure that there are no instances of our limited funds being spent without proportionate result, even on a vital service, where this could be corrected by careful investigation. It is concerned also to examine the prospect of increasing the income for adult education from sources other than, or in addition to, the Exchequer grant. The possibility of an increase in students' fees at least warrants careful attention, and so too does the list of subjects for which public grants are payable.

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[*] Universities in Adult Education. (Problems in Education, 4.) Pp. 172. (Paris: Unesco; London: H.M. Stationery Office, 1952.) 8s. 6d. net.

The agitation will have done good if it stimulates in Britain a more searching public discussion of these matters. Something much more vital, however, is involved than the amount of public grants for such purposes under the conditions of to-day. The fundamental issue is the appropriateness of the whole system of adult education in present conditions. The raising of the school-leaving age and the extension of public grants for scholarships and awards have doubled the number of university students, and the majority of the latter now receive grants from public funds in some way or another. This has transformed the social structure as well as placed severe strains on the universities, and the questions can fairly be asked: Are the methods by which adult education has been conducted in the past really adapted to the new conditions? What should be the function of the Workers' Educational Association to-day? How far is the extra-mural work of the universities in this field consistent with and not inimical to their other duties and the maintenance of academic standards?

Like recent discussions on higher technological education and on the universities and industry, consideration of the place of the universities in adult education brings us to the question of the purpose and function of a university. Without a clear conception of the nature of a university and of its purpose and function in the society of which it forms a part, the allocating of its resources to the best advantage, the scope of its studies, the balance of research and teaching, and of staff and students cannot wisely be determined. How serious such problems have become may be judged from Sir John Stopford's remarks at a recent dinner of the Yorkshire Association of Graduates of Manchester University.

One of the biggest problems of British universities to-day, said Sir John, is the danger that public work may deflect university dons from their prime duty of teaching and research, and there is a possibility that this may get out of hand. He said that at Manchester there are always four or five members of the staff away on the Continent advising foreign governments, and others are helping the British Council or government departments in Britain. The outside responsibilities of the universities have increased enormously since the War, and Sir John referred in particular to the claims made by the National Health Service on the medical staff of the universities. The heavy responsibility of big research enterprises is a further factor. Many such proposals should be rejected by the universities, in Sir John's opinion, because the schemes are too big for the limited resources of a university and would be better undertaken by industry or a research institute.

Such proposals, like projects for sponsored research, must clearly be considered in relation to Great Britain's organization and resources for scientific and industrial research in general, and not purely against the existing resources and commitments of the universities. Above all, however, they should be considered against some clear view of the nature and purpose of a university such as Dr. A. L. Goodhart sought to formulate in his Haldane Memorial Lecture last May (cf. *Nature*, 169, 986; 1952). Only when we are clear in our minds as to the precise functions of a university and what it should impart to its graduates can we proceed to decide exactly what should be the nature of its teaching or the duties of its staff. Dr. Goodhart laid all the weight of his emphasis on the teaching function of the university: that to his mind is and always will be the primary function. Research of great importance will always be proceeding in any university worthy of its name; but research is not, in his view, the essential purpose of the university. Dr. Goodhart, agreeing with Newman, then urged that it is not what a man has learned but how he has learned it that matters; and he claimed that the habit of mind the university should seek to impart does not depend on the particular subject which the student is studying. The basic mental training of the science scholar and the arts scholar is the same, and failure to recognize this means failure to understand the true purpose of a university, and what it can give to its students. Elaborating this further, Dr. Goodhart stated that clarity of thought and intellectual curiosity are the two transcendent qualities which a university should impart to its members. The first is of supreme importance in national life to-day, and the second, with its emphasis on inquiry, marks the essential difference between a university and a purely technical school.

Dr. Goodhart pleaded that in determining how many students it should admit and what subjects it should teach, a university should above all be mindful of the importance of maintaining its standards, and of ensuring that it fosters the adventurous inquiring mind which has been trained to be accurate; this is in line with Lord Haldane's own ideal of a university. It is encouraging to find that such ideas were reflected in many of the addresses and discussions at the Conference on Industry and the Universities at Ashorne Hill last October, particularly in connexion with the qualities which industry seeks in the university graduate. Their force was equally admitted by Prof. R. S. Edwards in a plea for administrative studies in the universities (*Three Banks Review*, September 1952)—a plea which, however, found little support at that Conference. Prof. Edwards's purpose, however, was at least in part to indicate what is already being done by the universities in this field, and particularly the opportunities for research in the fields lying between the natural and social sciences. The value of such research was stressed at an earlier conference of the Federation of British Industries, when a plea for closer co-operation between industry and the universities in the study of industrial organization and management was advanced by Dr. F. A. Wells.

In this whole context it is appropriate that, as was urged by Prof. Raybould in his book "The English Universities and Adult Education" in 1951, the universities should reconsider their place in extra-mural work, and the nature and extent of their contribution to adult education. Simultaneously, but independently of the Government's suggestions concerning the financial and administrative aspects of adult education as a whole, the value and utility of the Workers' Educational Association—the other means through which Government grants to education have been given in the past—has been challenged by critics, who point to the public library as a more appropriate instrument for public support of adult education. The character of the Workers' Educational Association has indeed changed. By 1932, the proportion of manual workers had dropped to a third and is now not more than 18 per cent. In 1951 the three-year tutorial classes which form the hard core of academic studies were only 14 per cent of all classes, with 12·5 per cent of all students.

Prof. R. H. Tawney's call in 1950 for a return to the first principles of strong working-class membership and exacting educational standards has to be considered in the light of the great social changes of the past fifty years, and especially in public education. To concentrate on working-class students who are capable of sustained study at the university-level means acquiescence in a drastic contraction of the work and influence of the Workers' Educational Association, whereas, in fact, its activities have expanded. Since 1930 the number of students attending its classes has nearly doubled, and the question which has to be asked is whether the Association is the appropriate 'responsible body' for all these activities. Inquiry might indicate that some of them should be entrusted to the university extra-mural departments which are already working on parallel lines, while others might be made more nearly self-supporting or entrusted to local education authorities, which now have responsibilities for further education.

What is clearly required is fresh thinking about the whole problem of further education, and the responsibilities and effectiveness of the several agencies working in that field, in the light of the new social situation and its current trends.

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# ZOOGEOGRAPHY

## Ecological Animal Geography

By Prof. W. C. Allee and Karl P. Schmidt. Second edition. An authorized edition, rewritten and revised, based on "Tiergeographie auf ökologischer Grundlage" by the late Richard Hesse. Pp. xiii+715. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1951.) 76*s*. net.

WHEN the originator of this large compilation, Richard Hesse, wrote his German book in 1924, the science of animal ecology was in its early development. That of zoogeography, though with a long history behind it, was confused by the cross-currents of unbridled speculation, now happily beginning to be brought into more orderly notions by the aid of palæontological evidence. In 1924, also, zoologists were beginning to turn towards physiological facts for explanations of the limitations of the range of species and geographical differences of external form. It was natural and useful that the emphasis of Hesse's book should be given to a description of the geographical and physical zones of the world, the more obvious adaptations of animal life to existence in them, and to the relating of animal form and function to physical gradients. Ideas of population—and indeed of time changes at all—were mainly excluded. The American authors who have largely rewritten this book for the second time (the first version appeared in 1937) have not deviated very much from this general outlook, except to mention rather more modern work both on ecology and zoogeography. The book is still a static picture of the world and its animal life—it presents a series of huge 'life groups' from different parts of the sea, land and fresh water; and historical and dynamic processes are almost completely excluded from the story. It is a series of pictures, not the foundations of a special science, for any development from this kind of ecological animal geography would have to study physiological or genetical process, population balance or zoogeographical history. For this reason the book is fairly dull to read, an effect increased by the authors' passion for stating every bit of information in the same tone of voice. There is a curious mingling of absolute platitudes like "Sufficiency of water is most completely assured to animals that live in it" with tongue-twisters for the student like "the camel is a stenohygric animal of arid country", which may at first reading conceal the fact that a tremendous amount of careful scholarship and distillation of written knowledge has gone into making the treatise; and since much zoological information is still rather a chaos of small bits about species or taxonomic groups, except in so far as it has been brought into the field of evolution theory, one must welcome such a solid attempt to describe the faunal features of the world as a whole.

The book falls into four sections. The first is general and, as usual in the Chicago school of zoology, starts with the physical and geographical environment and ends with animal communities (biocœnoses). An indication of the verbal atmosphere in these first 165 pages is illustrated by the following sentence: "The biochores and superbiochores are finally combined into still higher groupings, which may be called 'biocycles' ". Some readers might feel that they needed a 'biocycle' to enable them to get around the 'chores' of reading this sort of superbly unnecessary jargon. Phrases like the "spruce-moose biome" are likely to amuse, without illuminating.

The two succeeding sections, on marine and fresh-water animal life respectively, are much the best parts of the treatise. They are clearly the result of a great deal of search for good information, and, although the separate subjects have to be dealt with in a condensed form, there is no doubt of their real value both to students and to zoologists generally who cannot find time to keep abreast with the wide-ranging research that is going on in our oceans and lakes. It is when we reach the last section, on the distribution of terrestrial animals, that compression defeats its aim. One cannot be satisfied with the eleven lines that are devoted to the coniferous forests of the Holarctic region, or the two and a half pages about the deciduous forests. Modern ecological surveys of the Arctic land regions are not mentioned.

It will be seen that this book is a serious and great effort of scholarly compilation, covering such a huge field that its omissions are not entirely unexpected. It falls somewhere between an encyclopædia and a text-book; but it will prove a valuable work of reference for facts, so long as it is realized that the facts are bound to be very incomplete, that the abundance of rolling jargon does not conceal a dynamic philosophy about animal life, and that the future of zoology lies in the study of processes rather than of panoramas. CHARLES ELTON

## JAPANESE OPISTHOBRANCHS

### Opisthobranchia of Sagami Bay

Collected by H.M. the Emperor of Japan. Described, with an Introduction, by Dr. Kikutaro Baba. Edited by Dr. Hirotaro Hattori. Pp. 194+50 plates. (Tokyo: Iwanami Shoten, 1949.) £7.

THERE is now ample evidence of the existence of an opisthobranchiate fauna of great variety and wealth in the seas around Japan—a fauna made the more interesting by its admixture of temperate and tropical forms. The first hint of this was given as long ago as 1880–81, when Rudolph Bergh[1] published his "Beiträge zur Kenntniss der japanischen Nudibranchien", which, although containing descriptions of only fifteen species, showed that a considerable range of types existed. Bergh's publication, based on collections made by a number of naturalists, was the first attempt at a comprehensive account of the Japanese species. This pioneer work was followed in later years by accounts of further collections, notable among which is Sir Charles Eliot's[2] "Japanese Nudibranchs", published in 1913. This latter is a report on the nudibranchs then in the collection of the College of Science in the Imperial University of Tokyo and describes no fewer than forty-three species belonging to several groups. Coming to more recent times, no one has done more to add to our knowledge of the Japanese representatives of this group of the Mollusca than Dr. Kikutaro Baba, whose long series of investigations, beginning in the early 1930's, are happily still in progress. His contribution to the work recently compiled by the Japanese Imperial Household has been a major one.

It is well known to men of science in general that H.M. the Emperor of Japan is keenly interested in marine biology, and, as is recounted in the preface to this volume, he has long made it a rule, every time he goes to stay at his villa at Hayama, on the eastern shore of Sagami Bay, to organize and take part in shore collecting expeditions. Detailed surveys of many parts of the shore of the bay itself and of the many off-shore islands have been made, and frequently he has gone to sea to collect by dredging, trawling and other means off the coasts of Enoshima and Jogashima Islands in water three hundred or more metres deep.

Sagami Bay is situated roughly in the centre of Japan proper, on the south-east coast of Honshu, and, clearly, many factors combine to make it a rich collecting ground. Bounded on the east by the Miura Peninsula and on the west by the Izu Peninsula, the bay has a wide opening to the ocean. South from its mouth there extends the long chain of the Izu Shichto Islands. The shore is good for inter-tidal collecting; off-shore rocks and reefs abound, forming rich habitats, and beyond them there is water of varying depths dropping to a thousand metres or more in the central part of the bay. Also, at certain seasons of the year, a branch stream of the warm Japan Current (*Kuro-shiwo*), flowing eastwards between Oshima Island and the southern tip of the Izu Peninsula, enters the bay, bringing with it a rich flora and fauna including many species characteristic of more southern waters.

The series of investigations, part of which forms the basis of this book, have covered a period of somewhat more than twenty years and have resulted in the amassing of a large number of specimens of marine algæ and animals belonging to various phyla now suitably preserved for future research. Whilst providing a comprehensive account of the opisthobranchiate Mollusca of this region, it is to be borne in mind that the work is concerned solely with those species taken by the Emperor himself at various stations in Sagami Bay. It is the first volume to be published by His Majesty's Biological Laboratory and, so we are told, will be followed in due course by others on different groups. The species recorded in it are described by Dr. Baba, who has also written the brief introduction. The coloured figures, all of which have been painted from living specimens, and of which there are no fewer than 170, have been executed by the late Hiroo Sanada and Shiro Kato, and the whole work has been edited by Dr. Hirotaro Hattori, chief of the Biological Laboratory of the Imperial Household.

Although partly translated into English, most of the book is written in Japanese, the difficulty of obtaining an adequate translation of which has occasioned the somewhat long delay in the appearance of this notice. That the section in English, which follows the initial Japanese part, is approximately half as long (64, as against 114 pages in Japanese) is not due solely to typographical differences between the two languages, but largely to the fact that a number of interesting and important chapters in Japanese have not been translated into English. Although this has been done, one must suppose, in order to keep the book to a reasonable size, it is much to be regretted, for the topics dealt with in them range from an historical review of work on Japanese forms, an account of geographical distribution, and a brief review of different modes of classification to the phylogeny and relationships of the Opisthobranchiata—matters of great interest to the malacologist in particular and to the zoologist in general.

The longest section in both the Japanese and English parts is the chapter on classification, which contains brief, though evidently accurate and adequate descriptions, accompanied by line figures, of the species which have been collected. One hundred and forty-three species are recorded, fifty of which are new, and five new genera have been established. A world-wide acquaintance with opisthobranchs would be necessary before pronouncing judgment on the validity of the new species described; but it is encouraging to note that in the majority of them the descriptions have been based on series of specimens often collected at different times and from different localities. The description of each species is followed by the briefest of field notes giving the dates and localities of collection and details of distribution.

Coloured figures are an essential accompaniment to any taxonomic work on opisthobranchs, and the fifty plates which form the last section of the book are attractively produced, sometimes strikingly beautiful, and, so far as can be judged, true to life.

There is no doubt that this work is a valuable contribution to marine zoology and in particular to our knowledge of the Opisthobranchiata of Far Eastern seas; but let us hope that the Emperor and his team of investigators will see fit to follow it up with further publications dealing with some other aspects of the biology of this interesting group of the Mollusca. With such admirable facilities for study in what must be the finest of collecting grounds, it is not too much to expect that observations on general biology, spawning habits and larval and post-larval development, to mention only a few of the topics on which detailed information is so sadly lacking, will be undertaken.

The book is expensive in British money; but it is well printed and in all respects most attractively produced. It is stoutly bound in pale green with gold lettering—in English on the cover and Japanese on the spine. To the British reader, who can scarcely be expected to boast familiarity with all the localities mentioned, the inclusion of a large-scale map of Sagami Bay and neighbourhood would have been an asset.

J. E. Forrest

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[1] Bergh, R., *Verh. k.k. zool.-bot. Gesell., Wien*, 30, 31 (1880–81).

[2] Eliot, C., *J. Coll. Sci. Imp. Univ. Tōkyō*, 35, Art. 1 (1913).

# TEXT-BOOK OF LIGHT FOR DEGREE STUDENTS

## Light

(Student's Physics Series, Vol. 1.) By Prof. R. W. Ditchburn. Pp. xxii+680. (London: Blackie and Son, Ltd., 1952.) 45s.

THIS book is a most welcome addition to the series which contains, for example, J. K. Roberts's "Heat and Thermodynamics". Despite the multiplicity of books on the subject of light, there are few which are suitable for honours students, and still fewer which approach the degree of completeness and attention to detail shown by this volume. Prof. R. W. Ditchburn is to be congratulated on the production of a work which is a testimony both to his extensive knowledge of the subject and to his powers as a teacher.

The book covers all that is required in physical optics for a degree course, starting from Intermediate level; it does not include geometrical optics, as the title might imply. Problems, on which the student can test his powers, are interspersed throughout the book, and often brief guides to the methods of solution are given.

Having made clear my unqualified opinion of the book as a whole, I should like to direct attention to two aspects in which I feel that the author does not live up to the high standard which he has set for himself. First, he claims, in the preface, that the wave theory has been described in such a way that the quantum theory appears as a natural development. One looks forward to some interesting new approach to the teaching of this rather awkward episode in the history of science, but it is not there; one meets the usual presentation of the quantum-theory as a device for explaining, for example, odd effects such as photoelectricity.

Secondly, it is possible that more could be made of Abbe's theory of image formation. I agree that the treatment is at least as full as in any other text-book of light; but, in a book in which so much attention is paid to practical details, it is a pity that the author has not taken the opportunity to reproduce some practical illustrations, which would make the theory so much more real to the student. The concept of resolving power is of such importance in physics that it is unsatisfactory merely to refer students to the original work, which is often not readily accessible to them.

The difficulty is aggravated by the fact that the only practical illustration related to resolving power (Fig. *l*, Plate III) is given a misleading legend; it is actually the Fraunhofer diffraction pattern of a single circular aperture obtained from two point sources near the limit of resolution, but it is described as the "pattern due to two circular apertures which are just resolved".

These are the only aspects of the book which I feel to be unsatisfactory. There are some very minor errors, such as the omission of two minima in Fig. 6.3, and the mention of "the molecule" of mica; but, on the whole, the reading of the book can engender nothing but admiration that one man can cover so adequately the different aspects of physical optics.

H. Lipson

# LEAF-MINING INSECTS

## Biology of the Leaf Miners

By Prof. E. Martin Hering. Pp. iv+420. ('s-Gravenhage: Dr. W. Junk, 1951.) 36 guilders.

PRIMARILY, this book is an investigation into the feeding patterns of leaf-mining insects and is the result of years of research by Prof. E. M. Hering on the leaf-mining habit. It is an attempt, based on the nature of the damage inflicted on the plant, which is in itself dependent upon the specific behaviour of the individual species, to identify, often down to species level, a diverse collection of insects.

The first chapter includes the definition and classification of the miners; each type of mine, which is well illustrated, is given a specific name depending upon its shape and form and the part of the plant where it is to be found. The following chapter deals with fundamental morphological characters which separate the four orders of insects—namely, the Lepidoptera, Coleoptera, Diptera and Hymenoptera—to which the leaf-mining habit is restricted. It also discusses the modifications in structure of the larvæ induced by the mining habit and emphasizes the disparities existing between mines caused by members of the different orders.

The author then considers the general life-history of mining insects, with much space devoted to the pupal stage, which tends to show greater variance between species, particularly concerning the selection of pupation sites. There is a tendency for leaf-mining insects to complete their life-history in a shorter time than that required by other phytophagous insects. Reasons for this, such as the consumption of highly nutritious food material and the uniformity of the micro-habitat, are dealt with in a separate chapter.

The extent of Prof. Hering's studies is indicated by the next chapter on disposal of frass, where he utilizes the types of frass deposition as a means of identification. In addition, the problem associated with the disposal of frass to prevent contamination of the mines is discussed.

The special adaptations of case-bearing miners and aquatic plant miners are considered individually. This is followed by a detailed account correlating mining habits with larval morphology, where the influence of environment on the development of the species is fully appreciated.

Associated with a chapter on host selection is a comprehensive list of plant families known to support a leaf-mining fauna. Opposite each family will be found the orders of insects recorded on them. The last part of the book covers the colour of the mines; the effect of mining on the growth of the plant; parasites, inquilines and symbionts; and, finally, a section on collecting, breeding and the difficulties in determination of the more difficult species.

This book contains a wealth of knowledge, the result of more than thirty years detailed study of the subject. It is well indexed, and the bibliography comprises nearly one hundred pages. The work makes interesting reading, the only marring feature being the unusual number of errata.

V. W. Fowler

## A PIONEER OF PLANT PATHOLOGY

### Erwin Frink Smith

A Story of North American Plant Pathology. By Andrew Denny Rodgers, III. (Memoirs of the American Philosophical Society, Vol. 31.) Pp. x+675+4 plates. (Philadelphia: American Philosophical Society, 1952.) 5 dollars.

Erwin Frink Smith (born in 1854), and from 1886 until his death in 1927 a scientist in the service of the United States Department of Agriculture, was not only the acknowledged 'dean of American plant pathology', but also a man of international reputation, whose pioneer work will always be remembered. In this considerable volume the author has produced an unusually well-documented biography of a great man. The story is simply told and the reader, almost unawares, finds himself living in that great period of botanical renaissance in Europe and of botanical exploration and discovery in the vast regions of the United States. On this period, Mr. A. D. Rodgers is particularly qualified to write. His first pictures of Erwin Smith are of a modest young man of unusual perceptiveness and competence, gradually finding his feet in science and in a philosophy of life, and enjoying in its manifold aspects the poetry of existence in a great and varied continent. Smith's inherent qualities were soon to become evident in an insatiable curiosity about the objects of Nature in general, and plants in particular, in a devotion to the precision of scientific methods, and an eye alert for innovations in ideas and techniques that would open up new high-roads in biology. Thus, a time came when his researches into fungal pathogens, and more especially into the quite new field of the bacterial diseases of plants, were to lead the world. These studies, which were characterized by great thoroughness and a mastery of illustration, have long occupied a fundamental place in this branch of biological science, and will continue to do so. He also made important contributions to our knowledge of plant viruses.

Although this book tells the life-story of a man, it also records the history of an unusually important period in biological and medical science, and in agricultural economy, both in the Old and New Worlds. Accordingly, this volume should prove of value as a source-book for information about the progress of pathology in general, as well as of Smith's own significant and numerous contributions. In this connexion it is probably a pity that in so extensive a book space was not found for a chronological list of Smith's papers and books. The book can also be recommended to all who like to read of lives well lived, and who wish to gain some insight into the springs of contemporary knowledge.

## OLD HAWAII

### Hawaiian Antiquities (Moolelo Hawaii)

By David Malo. Translated from the Hawaiian by Dr. Nathaniel B. Emerson, 1898. (Bernice P. Bishop Museum, Special Publication 2.) Second edition. Pp. xxii+278. (Honolulu: Bernice P. Bishop Museum, 1951.) n.p.

David Malo was a Hawaiian of good family, born about 1793, who spent his early life at court and became a great authority on native customs and traditions. When he came in contact with Christian civilization, he soon became an enthusiastic convert, and finally a Christian minister. He died in 1853.

His book "Hawaiian Antiquities" was written in the Hawaiian language, and the translation, with notes, by Dr. N. B. Emerson, edited by W. D. Alexander, was published by the Bishop Museum as long ago as 1903. It has long been out of print, and this second edition, which is little altered apart from improvements in format, has been issued in response to many requests.

The title of the book is misleading, since it is not an archæological treatise but rather an account of Hawaiian ethnology before contact with European civilization. It deals with many things, including customs, ceremonies, myths, traditions, the code of conduct, political organization, sports and material culture. Under the last-named heading are accounts of such matters as house building, furniture, food, bark cloth, stone adzes, canoes and articles of value, which will be particularly useful to those who have Hawaiian collections under their care. The few drawings which accompany these sections are probably Emerson's. Wherever appropriate, the native names of objects, ceremonies, etc., have been quoted in the translation, which therefore constitutes a kind of glossary of Hawaiian terms.

As a convert to Christianity and an admirer of Western civilization, Malo was bound to regard the old ways with disapproval, which comes out in such statements as "The newly imported articles are certainly superior to those of ancient times" and "Some of these miserable practices of the ancient Hawaiians were no doubt due to their devotion to worthless things"; but remarks of this kind are confined to a few lines at the ends of chapters, and most of the work seems purely objective. If he had known to what extent future generations would have to depend on writings such as this for information about his forbears, he would doubtless have dealt with many matters more fully than he did; nevertheless, we can learn a great deal from the book, and in the circumstances it is greatly to his credit.

G. H. S. Bushnell

## The Aphid Genus *Periphyllus*

A Systematic, Biological and Ecological Study. By Prof. E. O. Essig and Frieda Abernathy. Pp. ix+166. (Berkeley and Los Angeles: University of California Press; London: Cambridge University Press, 1952.) 22*s*. 6*d*. net.

IN a family of insects remarkable for the variety of forms which may be assumed by a species during the course of a single life-cycle, the aphid genus *Periphyllus* van der Hoeven is peculiar in that most of its members produce, in addition, specialized æstivating larvæ which remain in the first instar from the spring until the autumn, when growth and development are resumed. The members of this genus are nearly all confined to trees of the maple family, on which they complete their life-cycles.

This book embodies the results of six years of study of a number of American species of *Periphyllus*, and includes descriptions of others from Europe and eastern Asia. In their accounts of species which they have been able to study at first hand, the authors have contributed materially to our knowledge of this group, and, with the aid of copious illustrations, have shown the remarkable degree of variation in form which can occur during the life-cycle of a single species. The inclusion of lists of synonyms, host plants, notes on history and distribution, together with an impressive bibliography, usefully brings together a quantity of relevant material within the compass of a single volume. But in their survey of the genus as a whole, it is disappointing that the authors appear to have overlooked some important contributions from European workers. There is no mention of the recent work of Borner, nor of Hille Ris Lambers's very full and detailed account of the known European species of *Periphyllus* (*Tijdschr. Ent.*, 88, 225; 1947).

In an otherwise attractively produced book, it is difficult to understand why most of the numerous line-drawings have been reproduced in half-tone, a process which, besides obscuring important anatomical details, does much less than justice to Frieda Abernathy's fine draughtsmanship. J. P. DONCASTER

## Amino Acids and Proteins

Theory, Methods, Application. Compiled and edited by Prof. David M. Greenberg. Pp. ix+950. (Springfield, Ill.: Charles C. Thomas; Oxford: Blackwell Scientific Publications, Ltd., 1951.) 110*s*. net.

THIS is an omnibus volume intended "to acquaint students and investigators with the more general methods employed in the study of the proteins, and to give a summary of the current knowledge and advances of the subject matter". Its aim is therefore nothing less than a comprehensive treatment of amino-acids and proteins from the physico-chemical, organic and biochemical points of view. There is, in fact, no marked emphasis on any particular aspect; there are four chapters on the organic chemistry of amino-acids and peptides, two on the organic chemistry of proteins, three on the physical chemistry, and four on biochemical topics. Most of the major lines of protein research are represented; there is, however, little about the determination of the sequence of amino-acids in proteins, and nothing about specific chain-configurations.

In a book of such scope, with a multiplicity of authors, it is almost inevitable that the treatment should be uneven and perhaps inadequate in parts. The accounts of paper chromatography and peptide synthesis are, for example, well below the average standard of the work. A rather more serious criticism is that the text is not always as up to date as one would wish. In my opinion the book does, however, succeed in bringing to the reader, in the form of a series of separate essays, a large amount of information, some of which is not readily available elsewhere. The numerous tabulations of data are a particularly praiseworthy feature. I have no doubt that students and investigators will find the book useful. It is very well produced, and contains remarkably few misprints.

C. H. BAMFORD

## Sound

An Advanced Course. By Dr. H. F. Boulind. Pp. vii+104. (London: John Murray, Ltd., 1952.) 6*s*.

IT is difficult to believe that a small book of a hundred pages on sound can cover adequately the required ground for all stages of the sixth form and up to university scholarship-level, no previous knowledge of the subject being assumed. This, however, is what is claimed for this book which, on the whole (and understandably in the circumstances), is rather utilitarian in its approach, with one eye constantly on the examination question.

One has a great deal of sympathy with the author in his admission that his chief aim is to produce a book at a cost within the financial allocation for sixth forms. But surely the correct approach is to supply a really satisfying account of the subject, especially in sound, which has for so long been neglected, and then press the authorities to bring the allocation more in accord with present prices. Sixth-form and scholarship students certainly need, and deserve to have, a full and comprehensive volume for their studies, and it is high time that this serious defect on the part of those responsible was rectified.

What is done in this book is, as is to be expected, done well. The mathematics is well within the scope of the students for whom the book is intended, and there is an excellent set of graded questions. It is a pity that a bigger quantity of information of the same high quality could not be included.

## Gods, Graves and Scholars

The Story of Archæology. By C. W. Ceram. Translated from the German by E. B. Garside. Pp. xii+433+32 plates. (London: Victor Gollancz, Ltd., in association with Sidgwick and Jackson, Ltd., 1952.) 21*s*. net.

THIS book is not intended for the specialist in prehistoric archæology; it is rather meant to fascinate the ordinary intelligent reader and to inspire him to delve more deeply into the subject. The author describes in graphic language the story of the discovery of several different sites in a number of localities; for example, he relates the earliest discovery of, and the first explorations at, such city sites as Pompeii, Troy, Mycenæ and Crete, and the origins of Egyptology. Again, the unearthing of Nineveh is recounted, as well as how the deciphering of Babylonian writings took place. The New World is not forgotten, and there is an exciting chapter on the empires of the Toltecs, the Aztecs and the Mayas. The historical approach to the subject is a good one and will undoubtedly excite many readers to dig more deeply into its problems, and the book can therefore be recommended. But even on the historical side it does not pretend to do more than dip into the subject here and there; it does not cover the ground as does such a work as Daniel's "Hundred Years of Archæology". None the less, it makes good reading. The translation runs smoothly. M. C. BURKITT

# BEHAVIOUR OF ENGINEERING STRUCTURES*

By Prof. A. J. S. PIPPARD, M.B.E.

Imperial College of Science and Technology, London

THE intelligent and economical design of engineering structures demands knowledge of their behaviour under load, and it is only in the light of this knowledge that the technical efficiency of a design can be assessed. It is, however, usually considered sufficient merely to estimate the distribution of stresses in a structure under normal load-conditions and to design to a factor of safety; while this will often produce a safe result, reliance upon such a simple method may very likely in special cases be either uneconomical or dangerous. In such cases detailed knowledge of stresses and displacements throughout the whole range of loading is desirable.

For idealized structures in which all the material and every member is assumed to obey Hooke's Law, the analysis of stresses and deformations is usually possible by well-known classical methods; but while over-simplification is tempting, it may well prove inadequate in many real structures, where practical factors complicate behaviour.

In many forms of construction one such factor is flexibility, which causes certain members to bow and even become unstable under load; the structure then behaves differently from the manner which would be forecast on the assumption of a linear load-displacement law. This form of elastic instability may occur, for example, in ship plating, which is thin in relation to its unsupported width, with the result that, while the distribution of tensile stress across the deck under a hogging bending-moment is reasonably uniform, the distribution of compressive stress under a sagging bending-moment is not. At the boundaries, where the deck is stabilized by the side plates, the stress is larger than that calculated by simple bending-theory, but at the centre it may drop to a very small value, in some cases almost to nothing. Instability in compression, by thus modifying the stress distribution deduced from the Bernoulli assumptions, may reduce the load-carrying capacity of the hull considerably.

Experiments carried out in the Civil Engineering Laboratories of the Imperial College of Science and Technology, London, on an idealized model of a hull illustrate this point, and a typical set of results are shown in Fig. 1.

Again, most constructional materials depart from Hooke's Law at stresses considerably below failure. In mild steel the breakdown of the linear relation between stress and strain is followed by yield during which strains increase greatly with no increase in stress. So long as the load on a structure is below that required to produce a stress causing yield in any member, the results obtained by classical mathematical methods will, in many instances, give excellent approximations both to stresses and displacements throughout the structure; but if this loading be exceeded, such calculations may be seriously in error.

For some years attention has been focused in a number of countries upon the problems of design introduced by a consideration of the phenomenon of plastic yield, with the object of basing the design of steel structures upon the ultimate load which they can carry rather than upon their behaviour in the elastic state. In Great Britain the lead in this work has been taken by Prof. J. F. Baker, of the University of Cambridge, and in the United States, where the method is known as 'limit-design', by Prof. W. Prager, of Brown University, and Prof. J. van der Broek, of the University of Michigan. More recently, a somewhat similar method for application to reinforced concrete frames has been developed by Prof. A. L. L. Baker, of the Imperial College of Science and Technology, London.

It may be remarked that there is nothing essentially new in the philosophy underlying these ideas, since for aeroplane frames ultimate strengths have always been adopted for specification purposes, and design based on a load factor has ensured a reasonable margin over normal flight conditions.

In the application of limit design to structures built of mild steel, however, the phenomenon of yield introduces the need for special treatment. When yield starts, the portion first affected can stretch considerably without carrying any more stress, and adjacent portions will have increased stresses thrown upon them. They in turn will yield, and ultimately the whole region will become plastic and form a hinge with a constant moment of resistance which can be calculated solely from the dimensions of the member. If such a hinge develops in a redundant structure and if the load on the structure be further increased, the bending moment at the plastic section will remain constant and further hinges will develop successively at other sections of the structure. When a sufficient number have formed, the structure will be statically determinate, and if loading is still further increased it will become a mechanism and collapse. It is evident that if the positions of all the plastic hinges can be foretold, the load required to cause this failure of the structure can be readily calculated.

It should be noted that with the development of each hinge the structure changes its character, and a simple parallel to this behaviour may be observed in a voussoir arch, a structure formed of a number of wedge-shaped blocks the mortar joints of which

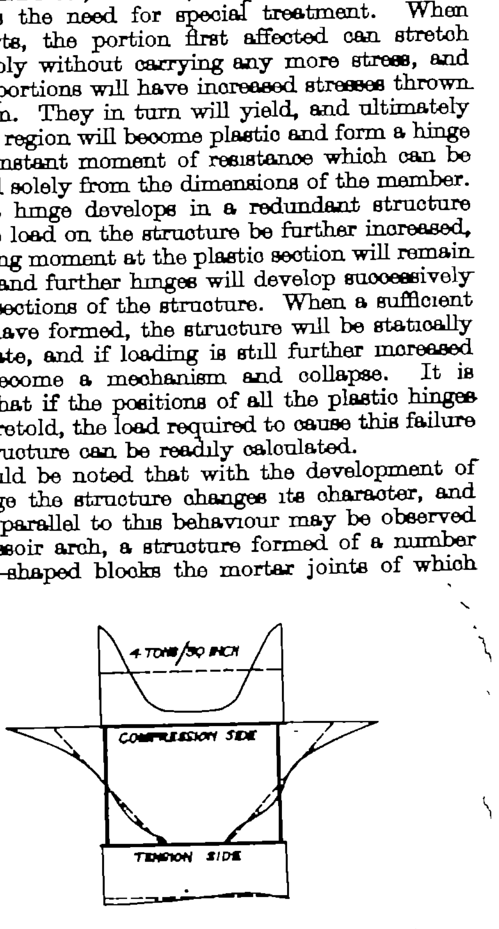

Fig. 1. Typical stress distribution around thin-walled box girders. The broken line shows the Bernoulli distribution

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* Based on a series of lectures given at the Royal Institution on February 17, 24 and March 3.

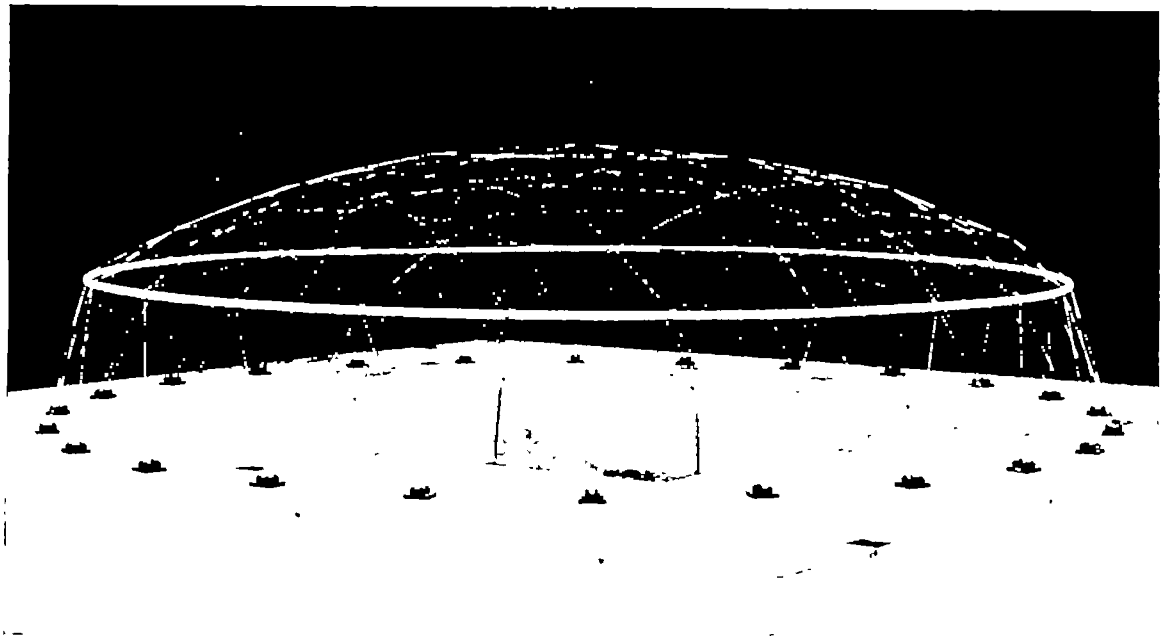

Fig. 2. Elastic model of the Dome of Discovery

are generally assumed to be incapable of resisting tensile stress. Under dead loading the arch behaves as a solid encastré rib, having three degrees of redundancy. If an increasing load be applied to any voussoir, the structure will continue to function as a solid rib up to a certain, calculable, value at which the loaded voussoir and that adjacent to it which is nearer the crown of the arch will make contact only along their edges on the outer boundary or extrados, and a virtual pin-joint will be established. The degree of redundancy is reduced to two, and, with further increases in the load, additional virtual pins will develop successively until the structure is effectively hinged not only near the load point but also at points on the inner boundary or intrados and at, or near, one springing of the arch. The structure is then statically determinate until the load is increased to a value which produces a fourth virtual pin at the other springing. It then becomes a mechanism, and its collapse, as shown in a film record of an experiment carried out on a model structure with steel voussoirs, is practically instantaneous[1]. We are concerned, then, not with a single arch but with four different arches each corresponding with a certain range of load carried. In a steel frame the number of effectively different structures may be much greater since the initial degree of redundancy can be very much higher. It is therefore a matter for discussion as to whether it is more rational to base a design on the particular structure which operates just before the failing load is reached, and which it is never expected even to approach, or upon that which does in fact carry the normal working loads. It is perfectly legitimate to adopt the former basis of design, and it will, in some cases at least, simplify calculations considerably; but the claim sometimes made that it produces economy in material does not appear yet to be established and must in any case depend upon the relative values of the load factor and factor of safety used in applying the two methods.

The logical position would appear to be to recognize that, unless we can calculate the failing load of a structure, there will always be uncertainty as to what working stresses we may justifiably use. The more we know about the behaviour of a structure, both in the elastic and plastic phases, the surer will be our position in the effort to achieve economy. It may be hoped, therefore, that we shall not see the growth of two rival schools of thought, the 'elastics' who see no good in the new approach and the 'plastics' who profess to believe that a new era in engineering has dawned in which the classical methods will find no place. Such a dichotomy might easily result in well-proved methods sinking into disrepute on one side, and first-class research being neglected on the other. There should, in fact, be no fundamental antagonism between the two points of view; each concerns itself with the behaviour of structures under certain defined conditions, but both are necessary for proper understanding. Surely the approach to design should be neither exclusively plastic nor elastic but 'elasto-plastic'.

Our present knowledge of structural theory is the sum of mathematical speculation, during a period of two or three hundred years, of many experiments made in the laboratory, of a comparatively few full-scale tests and lastly, but very important, of observed structural behaviour, especially in accidental failures.

The development of elastic theory has been dealt with at length in many publications, and it is unnecessary, and indeed impossible, to traverse the ground in a short article.

As an example of the lessons to be learnt from accidents, the failure of the Tacoma suspension-bridge may be cited[2]. Soon after its completion, this bridge developed a tendency to oscillate in a wind, and was in consequence subjected to continuous close observation. After it had been in service about five months, a steady 40-m.p.h. wind set up a violent motion which grew steadily worse; longitudinal and torsional oscillations increased in amplitude, and within a short time the whole structure collapsed. Cinematograph records throughout the final stages furnished a complete story of the disaster, and

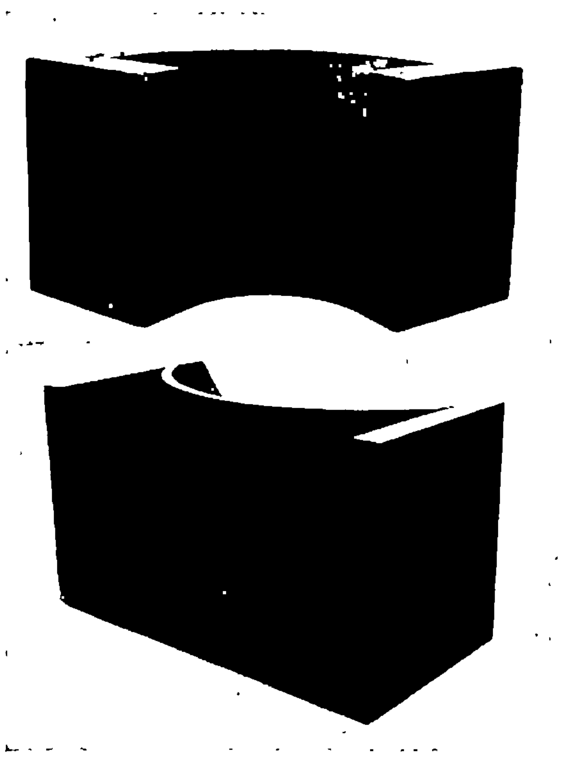

Fig. 3. Models of arched dams in indiarubber

mathematical and experimental study showed it to be due to the aerodynamic phenomenon of flutter which had hitherto been associated only with aeroplane wings and control surfaces. This disaster, although tragic in itself, served to attract attention to vital points in design which up to then were unsuspected as potential sources of danger, and no designer would now consider building a large suspension-bridge without making a very full investigation into its aerodynamic properties. As a case in point, the design for the proposed Severn Bridge has been subjected to exhaustive wind-tunnel tests under the direction of Dr. R. A. Fraser, of the Aerodynamics Division of the National Physical Laboratory, Teddington.

Learning from accidents is, however, expensive and uncertain, and, just as there are ways of roasting pig cheaper than burning down the house, so there are other methods of studying structural behaviour. The development of research into plastic behaviour, partly mathematical and partly experimental, has already been mentioned. A new and powerful analytical weapon has been provided by Sir Richard Southwell, who has devised the relaxation process which enables numerical answers to be obtained for a wide range of problems which are difficult or even intractable by classical methods.

The development of laboratory techniques for the study of structural behaviour is comparatively modern. Some of these are so simple that it is now fairly common, for example, to find experimental stress analysis by celluloid models carried out in the offices of practising engineers either as a sole method or in conjunction with calculation. This, based on Clerk Maxwell's reciprocal theorem, is an indirect method—that is, it requires no direct measurement of stresses; these are inferred from a comparison of measured displacements. A recent extension of the method[3] has been a study by means of an elastic model of the stresses in the Dome of Discovery of the Festival Exhibition, London (shown in Fig. 2). The experimental results were very good compared with those found by a relaxation process and indicate that space as well as plane frames can be reliably analysed in this way.

Photoelastic investigations are proving valuable in plane and three-dimensional stress problems, and considerable use is being made of electric-resistance strain gauges to obtain complete pictures of stress distribution in a variety of structures. One such investigation has already been mentioned, and the curves of Fig. 1 give an idea of the possibilities opened by this post-war technique.

In 1907 Wilson and Gore[4] used rubber models to study the stresses in gravity dams, but it was not until 1947 that Zienkiewicz[5], using relaxation methods, provided exact theoretical solutions. The agreement in the patterns of distribution obtained was very good[6].

The study of dams by models has hitherto presented certain difficulties, one of which has been to reproduce pressure and gravity loading in the right proportion. This has usually been met by using mechanical loading to represent both systems.

Another difficulty has been to obtain material which could be formed to the correct shape, which satisfied Hooke's Law and which was sufficiently flexible to give displacements large enough for accurate measurement. Rubber Technical Developments, Ltd., of Welwyn Garden City, by a newly developed technique, have produced excellent pilot

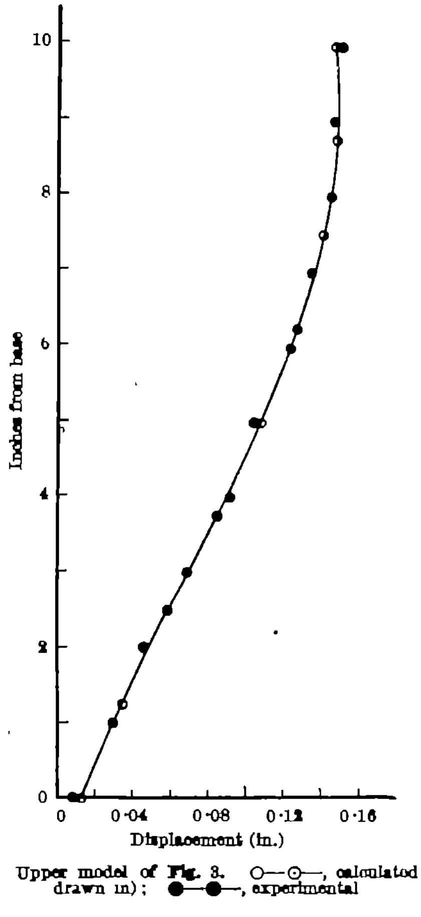

Fig. 4. Upper model of Fig. 3. ○—○—, calculated (curve drawn in); ●—●—, experimental

models of arched dams in suitable material having a Young's modulus of about 120 lb./sq. in., and these are shown in Fig. 3. Fig. 4 shows the measured deflexions of the centre line of the first model due to water pressure, compared with those calculated by relaxation methods. A much larger model of a projected dam has now been successfully moulded, and an extensive programme of research started in the Civil Engineering Laboratories of the Imperial College.

To determine gravity stresses at any point on the surface of the dam, the strains produced when the model is turned upside down will be measured; these will be twice those due to gravity loading, and the stresses deduced from them, when multiplied by the scale factor and by the ratio of the densities of the prototype and the model, will give the gravity stresses in the real dam. The full-scale stresses deduced from strains in the model due to water pressure alone can then be added.

The objective of the engineer in actual construction, and the crucial test of the value of calculation or research will always be the extent to which it helps to give a true idea of the behaviour of real structures. More full-scale tests for comparison with the results obtained by calculation or experiment are consequently vital if progress in structural engineering is to continue, and arrangements are being made by the Institution of Civil Engineers for a conference on this subject in 1955. Any engineer who is in a position to contribute records of results obtained from actual stress or displacement measurements on real structures, especially if correlated with calculations or tests, is invited to communicate with the Secretary of the Institution so that tests can be co-ordinated to yield the maximum amount of information.

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# SULPHATES IN AFRICAN INLAND WATERS

## By R. S. A. BEAUCHAMP

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THE larger African lakes receive from their inflows small amounts of water relative to their volume, and these inflows usually contain inconsiderable amounts of sulphate. Data from Lake Tanganyika[1] show how sulphates are being removed from solution. The outflow from this lake is small and at times, when the lake-level is low, no water flows out of the lake. Consequently, one might expect the values for most dissolved salts in this lake to be higher than the mean values for these substances in the inflows. This is in fact so for sodium, potassium, chloride and phosphate, being three or more times the values obtaining in the inflows; but the concentration of sulphates in the lake is less than half the mean concentration contained in the inflows.

In any lake a shortage of sulphates may arise unless adequate amounts are supplied by inflowing streams, as the balance of biological processes acts in such a way that sulphates in solution are utilized and precipitated faster than they are released by the decomposition of organic matter. The main loss of sulphates is brought about by protein synthesis and the subsequent precipitation of this organic matter, both vegetable and animal, on to the bottom. Decomposition of this organic matter usually occurs under anaerobic conditions leading to the formation of hydrogen sulphide and insoluble sulphides. Sulphates may also be reduced directly by bacterial action to sulphides. Once they have been reduced, either directly or indirectly, to metallic sulphides in the mud, and then overlaid by further deposits, little of this sulphur is recovered and put back into circulation. On the other hand, sulphates are returned to the water when organic matter is decomposed aerobically; however, in most lakes there is usually less opportunity for aerobic decomposition than there is for anaerobic decomposition, and not all the organic matter which is decomposed aerobically is broken down completely. Thus, on balance, the biological processes occurring in lakes cause a continuous removal of sulphates from solution. This is a matter of little consequence in lakes which are fed by inflows containing amounts of sulphate sufficient to maintain an adequate supply.

Though Lake Tanganyika has been used for illustrating the contention that sulphates are continually being removed, it does not show how far this process may be carried, probably because biological activity is limited in this lake by marked thermal stratification. The waters of Lake Tanganyika[2] contain about four parts of sulphate per million, but many of the African lakes contain less. In some of these it seems that sulphate deficiency may be a factor affecting the growth of phytoplankton. The following values as parts per million have been recorded:

| | |
|---|---|
| Lake Rukwa[2] | 2·9 |
| Lake Bangweulu[3] | 2·3 |
| Lake Albert[4] | < 2·0 |
| Lake Victoria[4–6] | 0·8–1·8 |
| Lake Mweru[7] | "traces indosable" |
| Lake George[4] | < 0·5 |

The last lake is not infertile or unproductive, it is probably the most fertile lake in East Africa; but clearly there are occasions when the available sulphates are reduced by the phytoplankton to a very low value. Data collected suggest that sulphates may be a factor controlling the level of productivity both in Lake Victoria and in Lake George.

The small amount of sulphate in solution in Lake Victoria appears to be restricting the growth of the phytoplankton, judging by experiments with algal cultures at present in progress. It is hoped that the results of these experiments, which are being carried out in this laboratory, will be ready for publication shortly; they indicate that values for sulphate below 0·5 p.p.m. are too low for algal growth. These results are surprising when one considers that phosphorus, which occurs in algae in about the same amount as sulphur, is absorbed from water containing concentrations of phosphate so low as one part per hundred million or less. It is, of course, extremely difficult to make a really close assessment of the value at which a particular chemical substance becomes limiting in any particular lake. This is especially so under tropical conditions where in the absence of a marked seasonal cycle the release of nutrients and their utilization is a more or less continuous process, except in such lakes as Tanganyika, Nyasa, Edward, and parts of Lake Victoria, where periodic thermal stratification leads to interruptions in the growth of the phytoplankton.

Lake George was described as probably the most fertile lake in East Africa: it supports a dense phytoplankton and a very large population of fish; yet sulphates, which are essential for plant growth, are not detectable in solution in the water. This statement invites consideration of the question: What determines productivity in tropical lakes? It may be assumed that light and heat are not limiting factors. It seems that in the shallower tropical lakes, such as Lake George, which have a free circulation between surface and bottom water, the level of production must be determined by the rate at which nutrient salts can be taken up, turned into organic matter, both vegetable and animal, and then decomposed to provide nutrient salts again. If this cycle is completed rapidly, production will be high; if slowly, production over a given period will be low. Our observations indicate that the slower processes in this cycle, and therefore the ones controlling its rate, are those concerned with the decomposition of organic matter, particularly matter of vegetable origin. Thus anything tending to increase the rate of decomposition will accelerate the whole biological cycle and increase productivity. The part played by animals in determining the rate of this cycle is certainly considerable, as animal matter decomposes rapidly, whereas plant matter decomposes slowly. Animals also during their lifetime are continually breaking down organic matter and fertilizing the water with their excreta, both fæcal and urinary[9]. Urinary excretions may be of particular significance with regard to the release of sulphates. Thus up to a point the more herbivorous animals in a tropical lake, whether they be copepods, fish or hippopotami, the faster the biological cycle and the higher its fertility and the greater the density of fish it can support. This theory contrasts strongly with ideas derived from the study of temperate lakes and may have an important bearing on problems concerning the overfishing of tropical lakes, particularly those where the industry is based on herbivorous fish such as *Tilapia*, which feed directly on the phytoplankton. Apart from these considerations regarding the way the fauna may affect the rate of production in a lake, productivity is also determined by the total amount of nutrients in circulation.

Sulphur is essential to living organisms, as all proteins contain this element; but it has not received as much consideration by either hydrobiologists or agriculturists as either nitrogen or phosphorus, as in most parts of the world sulphates occur in considerable quantities in both inland waters and the soil. In many parts of Africa this would seem not to be so. Unpublished records of water analyses made by government chemists and public analysts have been collected from rivers, streams and boreholes in different parts of Africa, including Nigeria, the Belgian Congo, Northern and Southern Rhodesia and Natal, as well as from East Africa. Unfortunately, in many cases no estimates have been made for sulphates, but in a great many cases where they have, the values recorded are low; often they are referred to as nil or negligible. This naturally raises the question whether or not the soils of Africa are short of sulphates; requests for information to the various agricultural departments have yielded little positive information, as estimations for sulphates are not usually included in routine analyses. However, P. R. Hesse, a member of the East African Agriculture and Forestry Research Organization, who is working on the effect of termites on the soil, has determined the sulphate content of a great many soils in Northern and Central Tanganyika, the Eastern Rift Valley in Kenya, also near Kisumu, and at Kawanda and Jinja in Uganda. These analyses were carried out in order to compare the chemical composition of the surrounding soils with that of the termite mounds. His results are not yet published, but in all the areas quoted only traces of soluble sulphates were found.

The red upland soils in the Kongwa area were found to contain no soluble sulphates; these analyses were done by B. Anderson. High values for sulphates were found, however, in the grey mbuga clays in the same area—these will be referred to later.

Certain soils in Nyasaland[9] were found to be deficient in sulphates; this deficiency had a serious effect on the tea crop.

Fertilization experiments carried out by agriculturists with the intention of discovering the value of adding nitrogen to the soil have shown excellent results in many parts of East Africa, but the fertilizer used for this purpose has been ammonium sulphate; it is possible that the sulphate radicle has played a part in giving these good results. In other fertilization experiments using superphosphates, it is possible that in some cases beneficial results have been partly due to the presence of calcium sulphate contained in this fertilizer; superphosphates[10] may contain up to 20 per cent of calcium sulphate.

Many more data are required, but there are indications that at least some African soils are deficient in sulphates; apart from the work done on the Nyasaland tea crop, there appear to be no other records of experimental work specifically designed to show this. It would be interesting to know whether in certain areas the addition of sulphates, such as calcium or sodium sulphate, can increase the growth of crops. One record of such an experiment[11] comes from the Gezira, Sudan, where the application of two tons of gypsum per feddan increased the yield of cotton by more than thirty per cent; but this experiment was carried out with the idea that gypsum would improve the texture of the soil and the results were attributed to this effect, as in this region sulphates do occur in considerable amounts in the subsoil.

Brief reference should be made to those waters in Africa in which sulphates have been found in both moderate and large amounts. The streams on Mount Meru[12], Tanganyika Territory, can be divided into two groups—those originating from the less-weathered rocks and those from the more-weathered rocks; the former have a sulphate content of less than ten parts per million, the latter a sulphate content of between twenty to sixty parts per million. Three streams contain more than one hundred parts per million of sulphates. Mount Meru is composed of igneous rocks and lavas.

The soda lakes of the Eastern Rift Valley form a series in which the sulphate content is high, culminating in Lake Nakuru[13], with a value of two hundred and fifty-three parts per million, and Lake Magadi, which is the extreme example but is usually dry. The sulphates in these lakes may not have been utilized fully and precipitated biologically, because the high soda content has restricted the growth of both flora and fauna. The drainage basins of these lakes contain alluvial deposits formed by lakes which existed earlier; at the present time these lakes have no outlet, and thus their chemical content is the result of the leaching of the surrounding soil and the concentrating of their inflows over a long period of time. Lakes Naivasha and Baringo[13] contain seventeen and forty parts per million, respectively.

The grey mbuga clays in the Kongwa area, referred to earlier, have high sulphate values. Mbuga is the local name for low-lying depressions in the ground which in the past probably contained lakes. These depressions have accumulated salts leached from the surrounding countryside. Borehole waters in this area contain very large amounts of sulphate, ranging from one hundred parts per million to two thousand parts per million.

Hot springs may contain large amounts of sodium and calcium sulphate; one in Northern Rhodesia[14] contains one thousand and fifty parts per million, another in Uganda[4] contains approximately five thousand parts per million. The Northern Rhodesian spring contains ninety parts per million of calcium, whereas the Uganda spring contains two thousand parts per million of calcium. As this spring flows into the Semliki River, and so into Lake Albert, it and other springs in the neighbourhood may be responsible for the relatively high value for calcium in this lake. At the same time, it is worth noting that, as recorded above, the value for sulphates in Lake Albert have been found to be less than two parts per million, indicating that most of the sulphate that finds its way into the lake is used up.

Some swamps in the Kigezi district[15] of Uganda contain very large quantities of ferrous sulphate; these may receive water from some volcanic source.

Streams contaminated by washings from dumps formed by concerns smelting copper are rich in sulphates. Examples of these from Northern Rhodesia[14] show values for sulphate ranging between four hundred and seven hundred and eighty parts per million, whereas streams near by are recorded as containing no sulphate. The refining process of copper is usually carried out by calcining the copper sulphide ore with lime; the waste product formed is mainly calcium sulphate. This by-product may prove to be a valuable fertilizer for fish farms and possibly for agricultural purposes. In this connexion it is worth recording that the smelters also discharge vast quantities of sulphur dioxide from their chimney-stacks. The safe disposal of this gas presents some problems as it is not in Africa an economic proposition to convert all this sulphur dioxide into sulphuric acid, although this acid is in great demand in other parts of the world. Greater demands for sulphuric acid may soon arise in East Africa, including the need to produce superphosphates from rock phosphate. A by-product of this process is again calcium sulphate.

One generalization may perhaps be permissible in order to explain the apparent shortage of sulphates in Africa. In other parts of the world sulphates are usually derived from sedimentary rocks, mostly ancient marine deposits; such rocks are rarely found in Africa. The fact that the only sources of gypsum in East Africa are those contained in the cretaceous deposits along the coast of Tanganyika Territory may serve to emphasize the point.

More data are required; but the evidence we have at present indicates that many of the natural waters of Africa are short of sulphates, and some of the soils also. The main purpose of publishing this account is to arouse interest in what may be a most important problem, not only to those concerned with inland fisheries but also to those concerned with agriculture and animal husbandry.

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# THE FIFTH PAKISTAN SCIENCE CONFERENCE AND THE PAKISTAN ACADEMY OF SCIENCE

By SIR HAROLD HARTLEY, K.C.V.O., C.B.E., F.R.S.

IN February Dr. George Taylor and I, representing the British Association, were the guests of the Pakistan Association for the Advancement of Science for its Fifth Science Conference at Lahore, and for a study tour of Pakistan. The Conference was opened by the Governor of the Punjab, who spoke of the progress that had already been made in the Punjab both in strengthening scientific education and in establishing a number of research laboratories which are attacking urgent problems such as water-logging and the salinity of agricultural land. He spoke of the need of Pakistan, an under-developed country, for scientists and engineers, and the help that international co-operation would bring. The president, Dr. Bashir Ahmad, vice-chancellor of the University of the Punjab, took as the subject of his address "Our Problems of Higher Education and Science". His main theme was the position of science in general education not merely for its material benefits but also for its unique function in guiding sound emotional development. Science, he said, is the systematic knowledge of Nature and her ways. That knowledge has cultural value which is as significant as that of philosophy, fine arts or literature. He made a strong plea that science should be a compulsory subject in the school curriculum. He emphasized the need of Pakistan for institutions of higher learning and science, which must remain free from political control in order to achieve their objectives.

The work of the Conference was done mostly in eight sections covering the main branches of science, engineering, agriculture and medicine. Many papers were read describing recent research work in universities and research laboratories in both Western and Eastern Pakistan. Most of them dealt with applied science, and they showed what a realistic and successful contribution is being made to national development, particularly in agriculture, genetics, entomology, chemistry and economics.

In addition there were a number of general lectures; for example, by Prof. H. J. Bhabha, director of the Tata Institute of Fundamental Research, on cosmic rays, by Dr. Taylor on south-east Tibet and on the work of the British Museum, and by myself on the art of discovery and on limiting factors in production.

The Conference was extremely successful. Large numbers of young students came to the meetings and were obviously keenly interested in the papers. Both during the meeting and after its close, the twenty-five foreign delegates were able to visit a number of research laboratories, including Dr. Chaudhury's new nuclear physics institute at the Government College, Lahore, which will be finished shortly, and the Punjab Agricultural College and Research Institute at Lyallpur, where a large programme of research is in full swing. It covers the main agricultural problems of Western Pakistan and much progress has been made in improving the strains and the methods of cultivation of the staple crops.

We then motored to Peshawar, where we saw the University and the fine engineering laboratory which will soon be completed. We visited the Khyber Pass, the Malakand and Dargai power stations, and the site of the hydro-electric scheme on the Kabul River at Warsak which will produce both cheap electric power and irrigate some 65,000 acres of land on the North-West Frontier, making it available for cultivation by the frontier tribes. Financial assistance from Canada under the Colombo Plan will enable work on this site to start at once.

We were greatly impressed by the progress which is being made in the North-West Frontier Province under the dynamic leadership of the Chief Minister, Abdul Qayum, in education, hospitals, rural electrification and factories for the processing of agricultural products, like the sugar refinery at Bialpur. We went next to Rawalpindi to see the hill station at Murree, the Himalayan forest, and the ruined city of Taxila, with its fine Romano-Buddhist museum under the curatorship of Mr. Harundur Rashid.

In Karachi we saw the new University in its improvised home, the laboratories of the Department of Scientific and Industrial Research, where important researches have already started without waiting for full equipment, the Central Testing Laboratory, and the Cotton Research Institute. During our visit we were impressed by the excellent work which is being done in various centres by the British Council.

The most urgent problems of Pakistan, apart from her food shortage, seem to be supplies of irrigation water, drainage and electric power. These are all inter-connected, and it is to be hoped that the negotiations with the World Bank will soon result in engineering works for the control of the headwaters of the Indus, which could provide both perennial irrigation and ample power. The experience of irrigated zones in Egypt and Arizona suggests, however, that the problem of the salting up of the soil, which is becoming increasingly serious, will only be met by extensive drainage systems.

### The Pakistan Academy of Sciences

In the afternoon of the first day of the Conference, February 16, we were present at the inauguration of the Pakistan Academy of Sciences, by the Prime Minister of Pakistan, Al-Haj Kwaja Nazimuddin. He spoke of the heritage of scientific and cultural achievement in Muslim history and of the dark Middle Ages of the West, when Muslim scientists kept the spirit of scientific inquiry alive. The Government recognizes, he said, the importance of pure scientific research as the bed-rock of all important forms of development, and it welcomes the establishment of the Academy, which was destined to play a vital part in the life of the nation.

The nine Foundation Fellows of the Academy were then presented to the Prime Minister, and they later elected the following office-bearers: *President*, Prof. M. Afzal Husain, formerly vice-chancellor of the University of the Punjab; *Secretary*, Prof. M. Raziuddin Siddiqui, director of research, University of Peshawar; *Treasurer*, Dr. Bashir Ahmad, vice-chancellor of the University of the Punjab. The other Foundation Fellows are: Dr. Nazir Ahmad, chairman, Tariff Commission, Pakistan Government; Dr. S. Siddiqui, director, Scientific and Industrial Research, Pakistan Government; Dr. M. Qudrat-i-khuda, scientific adviser, Ministry of Defence, Pakistan Government; Dr. M. Ishaq, principal education officer, Pakistan Military Academy; Dr. H. K. Bhatti, chairman, Department of Zoology, University of the Punjab; and Dr. M. Sharif, professor of zoology, Government College, Lahore.

The aims and objects of the Academy had been defined as the promotion of research in pure and applied sciences by means of publications, by the establishment of scientific libraries, laboratories, museums and research institutions, and by awarding grants, scholarships, fellowships, prizes and medals for research. The Academy will act as the National Research Council of Pakistan, for undertaking such scientific work of national or international importance as it may be called on to perform by the public and the Government. It will offer advice on all scientific matters to the Government and will represent internationally the scientific work of Pakistan.

Not more than five ordinary Fellows, distinguished for their original contributions to science, will be elected into the Academy each year until the limit of a hundred is reached. Eminent scientists of foreign countries will be elected as foreign members. These will be limited to thirty in number.

The Academy has already started work and plans are being prepared for the publication of *Proceedings* and research journals.

## OBITUARIES

### Prof. S. N. Winogradsky, For.Mem.R.S.

With the death on February 24 of Sergei Nikolaevitch Winogradsky, science has lost the greatest figure in soil microbiology. Winogradsky was born in Kiev in 1856 and spent his childhood there. He was a student in the University of Kiev and, later, that of St. Petersburg, where he studied chemistry and plant physiology. There, after graduation in 1881, he investigated the effects of nutrient supply and other environmental factors on the growth of the wine yeast *Mycoderma*.

This early work was one of the pioneer investigations on the effects of specific nutrients on micro-organisms grown in pure culture under adequately controlled conditions. In 1885, Winogradsky moved to the University of Strassburg, where he became interested in micro-organisms concerned with the oxidation of sulphur and sulphides. He found that *Beggiatoa* was able to assimilate carbon dioxide, obtaining the necessary energy by oxidation of sulphur. This discovery started him on the classic series of investigations concerning autotrophic bacteria which opened up one of the most interesting fields in bacterial nutrition. He next passed to the study of the iron bacteria, some of which he claimed could similarly derive energy by the oxidation of ferrous iron.

Winogradsky went to Zurich in 1888 and in the following year began research on the problem of nitrification, that is, the oxidation of ammonium salts to nitrate. The importance of this process had already resulted in a search for the causative agents, and there was evidence that the process proceeded in two stages with the formation of nitrite and nitrate, and that the causative agents were biological. But attempts to isolate the responsible organisms had been unsuccessful. Winogradsky, with his experience of sulphur-oxidizing organisms, divined that those causing nitrification were also autotrophic, and he therefore used for their isolation an inorganic medium with a base of silica jelly. By this means he obtained two groups of autotrophic bacteria, one able to oxidize ammonium salts to nitrite and the other nitrite to nitrate. His investigation of the physiology of these organisms constitutes one of the classic researches in bacteriology. In 1891 Winogradsky returned to St. Petersburg, where he was appointed chief of the Division of General Microbiology at the Institute of Experimental Medicine. There he began work on a second soil process of fundamental importance in the economy of Nature, the fixation of atmospheric nitrogen. When he began this investigation, Hellriegel and Wilfarth had recently demonstrated symbiotic nitrogen fixation in the nodules produced by bacteria on the roots of leguminous plants. Winogradsky studied the gains in nitrogen of soil and showed the existence in it of an anaerobic organism, *Clostridium pastorianum*, that was capable of fixing nitrogen. This was the first non-symbiotic organism shown to possess this ability.

In 1905, after a period of ill-health, Winogradsky retired from scientific work and lived on his estate in Russia until 1921, when he finally left the country and, after a short stay in Switzerland, accepted the offer by the Institut Pasteur of a post and a laboratory at Brie Comte Robert, about twenty miles from Paris. During this phase of his work, he was much concerned with the difficulty in studying the micropopulation as it actually exists in the soil. He pointed out that most of the methods that were in common use consisted in isolating a number of organisms from soil and studying their behaviour under the unnatural conditions of the laboratory. He therefore devised methods for the purpose of investigating the micropopulation in the soil itself. In the first place, he developed and used a technique previously tried by H. J. Conn, namely, the microscopic examination of a film of soil suspension, dried and suitably stained to reveal the micro-organisms. Samples of soil with and without the previous addition of organic matter were thus examined. Winogradsky concluded from these observations that untreated soil contained a static micropopulation, but that the addition of decomposable nutrients caused the rapid increase in numbers of certain groups of organisms, the soil then passing from the static to the dynamic condition. A special example of this differential increase, that of *Azotobacter* in soil enriched with mannitol or starch, was investigated. This led to the invention of a method for detecting phosphate deficiency in soil, by observing the growth of *Azotobacter* colonies on the smoothed surface of a soil sample wetted to a thick paste after the addition of starch.

Another method developed by Winogradsky was that of sprinkling fine granules of soil on the surface of silica gel plates to which a specific nutrient had been added. He used this method for studying the development of colonies of *Azotobacter* arising from the soil granules. Later the method was used, with appropriate media, to obtain nitrifying organisms from soil. In the course of this further study of nitrifying organisms, several new genera were described. By similar methods, Winogradsky also studied aerobic soil organisms that attack cellulose, and made a special study of the Myxobacteria possessing this power, for which he proposed the generic name *Cytophaga*.

But his work at Brie Comte Robert, while yielding valuable new information on interesting groups of soil organisms, owes its main importance to his individual approach to the subject and to his constant aim at discovering what organisms were active in the soil itself and what were the conditions governing their activity therein. The methods that he developed all had this object in view. Indeed, throughout his life's work, Winogradsky showed an unequalled ability to devise experimental methods of elegant simplicity, but directly suited to the problem under investigation. This ability, together with the clarity of thought which characterized his work, enabled him to discover and develop new fields in bacterial physiology, particularly relating to specialized organisms of the greatest importance in the economy of Nature, and later on to change and enlarge our views on the ecology of the soil micropopulation.

H. G. THORNTON

## Prof. R. D. Laurie

ROBERT DOUGLAS LAURIE, whose death occurred on April 7, was born in 1874; he was educated at Birkenhead School. After a period on the staff of the Bank of Liverpool (1891–99), he studied in the Universities of Liverpool and Oxford, and was afterwards appointed to the staffs of the Zoology Department first of the latter and afterwards of the former. He remained at Liverpool for some years; but in 1918 he was appointed head of the Zoology Department in the University College of Wales, Aberystwyth, and was given professorial status four years later. He remained at Aberystwyth until his retirement in 1940.

Laurie's scientific work was of two main types. He published systematic reports on some Brachyura collected by Herdman in Ceylon in 1902 (Ceylon Pearl Oyster Fisheries Reports, 1906) and on the Anomura of Stanley Gardiner's *Sealark* Expedition (1926). After his appointment at Aberystwyth he took a keen interest in local problems of natural history—especially in the bottom-fauna of Cardigan Bay, and in the effects of pollution of certain Welsh rivers by lead. In collaboration with various colleagues he produced a number of reports on these subjects, notably a paper (with Erichsen Jones) on the faunistic recovery of the Rheidol after lead-pollution (*Journal of Animal Ecology*, 1938).

As a professor, Laurie was genial, imperturbable, persistent in the face of difficulties, and regarded with sincere affection by students and colleagues. His personal characteristics—he was like a cheerful robin—gave rise to a whole series of tales (true and legendary) which in time constituted a veritable collection of affectionate 'Lauriana'. His unflagging attempts to develop his department, including a phase during which he and his students built a lecture-room with their own hands, were prevented by fate and the Second World War from reaching full fruition by the time of his retirement.

It was not, however, Laurie's activities as a zoologist or as a professor which will be remembered as his leading contribution to the welfare of his subject or his colleagues. The outstanding interest of his later years, and his chief service, lay in the field of organizations designed to promote the interests of university teachers and of university and educational affairs in general. It was Laurie's unfailing zeal, more than that of any other single person, which brought into existence the Association of University Teachers. He was its first president, in 1919, and was its honorary general secretary from 1920 to the time of his death. In addition (1943–53) he was honorary secretary-general to the International Association of University Professors and Lecturers, and it was at a conference of this organization that he died, after flying to Amsterdam, at the age of seventy-eight. Much of the credit for the achievements of these organizations may be traced back to Laurie's energy and enthusiasm. His educational interests were revealed in other ways, as in his reports for a British Association committee on the position of animal biology in the school curriculum; and he was responsible for the introduction of biological teaching in the grammar schools of Wales.

Laurie married Elinor Beatrice Ord in 1912, and both she and his daughter survive him. Mrs. Laurie has also for many years been beloved, not only by her family, but also in no common degree by her many friends, including those connected with her husband's enterprises. T. A. Stephenson

## Dr. T. A. Jaggar

Dr. T. A. Jaggar, dean of American volcanologists, died in Honolulu on January 17, just one week before his eighty-second birthday. Born in Philadelphia, Pennsylvania, on January 24, 1871, Thomas Augustus Jaggar, jun., was trained in public and private schools, and in 1893 received the degree of bachelor of arts in geology from Harvard University. He remained at Harvard to take his M.A. degree in 1894, and then spent most of the next two years studying at Munich and Heidelberg. Returning to Harvard, he was awarded the doctorate of philosophy in 1897.

During 1895–1903, Jaggar held an appointment as instructor in geology at Harvard, and in 1903 he was made an assistant professor. In 1906 he became professor and head of the Department of Geology at the Massachusetts Institute of Technology. During the summers he was a member of the United States Geological Survey, working in the Black Hills region of South Dakota and adjacent parts of Wyoming, in the Yellowstone National Park region, and in Arizona. In 1901 he published, in the Annual Report of the Geological Survey, an important study of the laccoliths of the Black Hills.

Very early, Dr. Jaggar's interest turned to experimental geology, and the study of earth processes in the field. His visit to Martinique in 1902, to study the results of the catastrophic eruption of Mont Pelée, decided him to adopt as his life-work the field-study of geophysics. From that time forward his major interest lay in the fields of seismology and volcanology, with a strong emphasis on the humanitarian aspects of both. His aim was the saving of human lives and property through the prediction of earthquakes and volcanic eruptions, the design of suitably resistant structures for countries subject to frequent earthquakes, and development of methods of protecting communities from the ravages of lava flows, glowing clouds, and heavy ash falls. Although he took part in many expeditions, Jaggar was firmly convinced that the only satisfactory way of studying volcanoes was by means of permanent observatories, keeping continuous records.

In 1912, Dr. Jaggar established the Hawaiian Volcano Observatory, for the continuous study, by direct physical methods, of Kilauea and Mauna Loa volcanoes. This was made possible by money provided from the Whitney Fund of the Massachusetts Institute of Technology, and funds subscribed by a group of business and political leaders of Hawaii that had formed the Hawaiian Volcano Research Association. For more than forty years the Hawaiian Observatory has carried on its work, under the Massachusetts Institute of Technology and later under successive agencies of the United States government. Dr. Jaggar remained its director until his retirement, in 1940. He then became research associate in geophysics in the University of Hawaii, a position he still held at the time of his death.

Dr. Jaggar's contributions to the science of volcanology have been very great. Studies of the Kilauea lava lake demonstrated its complex nature, with a shallow pool of hot fluid lava lying on a semi-solid but mobile plug. Measurements ascertained the distribution of temperature in the lake, and the composition of the liberated gases was determined. Tumescence and detumescence of the volcanic structure were demonstrated, probably resulting from changes in magmatic pressure beneath. The entire picture of volcanic activity was augmented and clarified. Perhaps most important of all, however, was the development by Jaggar and his associates of methods of aerial bombing to deflect lava flows, and the concept of huge diversion barriers to protect cities or harbours from inundation by lava. Jaggar never lost sight of the fact that the real purpose of science is to serve mankind.

Gordon A. Macdonald

We regret to announce the following deaths:

Sir David Anderson, president during 1943–44 of the Institution of Civil Engineers, on March 27, aged seventy-two.

Dr. F. W. Edridge-Green, C.B.E., for many years special examiner and adviser to the Ministry of Transport on vision and colour vision, on April 17, aged eighty-nine.

Dr. G. F. Herbert Smith, C.B.E., formerly of the British Museum (Natural History), and honorary secretary since 1921 of the Society for the Promotion of Nature Reserves, on April 20, aged eighty.

# NEWS and VIEWS

## Royal Society: Foreign Members

The following have been elected foreign members of the Royal Society: Louis Victor Pierre Raymond, Prince de Broglie (Paris), distinguished for his contributions to quantum theory; Marie Jules Constant Robert Courrier (Paris), distinguished for his contributions to endocrinology; Hermann Joseph Muller (Bloomington, Indiana), distinguished for his contributions to the chromosome theory of heredity; Wolfgang Pauli (Zurich), distinguished for his contributions to theoretical physics, in particular the formulation of the exclusion principle.

## Lister Institute of Preventive Medicine: Appointments

Prof. W. T. J. Morgan has been appointed deputy director of the Lister Institute of Preventive Medicine; Prof. Morgan is already on the staff of the Institute and is professor of biochemistry in the University of London.

Dr. B. A. D. Stocker has been appointed head of the newly created Guinness Unit for Microbiology at the Lister Institute. The establishment of this Unit, for the study of general microbiology, was made possible through the generosity of Arthur Guinness, Ltd. After a war career in the medical branch of the R.A.F.V.R., with which he served mostly in India and Burma, Dr. Stocker was successively demonstrator, lecturer and senior lecturer in the Department of Bacteriology and Immunology in the London School of Hygiene and Tropical Medicine. His research work has been directed mainly to bacterial genetics, particularly mutation-rates of flagellar antigens in *Salmonella typhi-murium*; and, during the tenure of a Commonwealth Fund Fellowship in the United States, with type transformation in *Pneumococcus* and with the transduction of genetic characters by bacteriophages in which he applied the discoveries of Zinder and Lederberg to the transduction of flagellar characters in *Salmonella*. Dr. Stocker is thirty-five.

## Contributions of Science to Peace

In his Alexander Wood Memorial Lecture for 1953, "Contributions of Science to Peace", delivered at Friends House, London, on February 18 (pp. 28; from the Fellowship of Reconciliation, 38 Gordon Square, London, W.C.1; 1*s*. 6*d*.), Prof. C. A. Coulson rejects equally the view that science alone can lead us into the world of peace or that science should be abandoned. Science, he said, will always be with us, and we can ignore neither the dangers nor the benefits it offers. There are ways in which science, by providing a better understanding of ourselves, can assist those who seek for peace. Analysis of statistical data presented by Quincy Wright in 1942 suggested that wars, of all sorts and sizes, differ qualitatively as well as quantitatively from personal quarrels and that there is no basis for the belief that the world learns by experience that war is foolish, or fruitless, or an anachronism out of which we are continually growing. It also suggests that the problems of peace are not just technological, but composite both of technology and morals. Directing attention to the way in which mankind lives continually on the brink of famine, Prof. Coulson concluded that only an enlightened scientific policy can deal constructively with situations of under-nourishment such as confront us, for example, in Persia or in the British Colonial Empire. Science, moreover, is required to improve world supplies of energy as well as of food, and Prof. Coulson referred particularly to the value which nuclear power might hold for the Middle East or India if developed there, as well as to the possibility of utilizing wind-power, the tides or solar energy. Science, properly directed and shared, he said, can help to build the defences of peace and to safeguard the freedom and spirit of men. In one sense the responsibility of the man of science does not differ essentially from that of anyone else: scientific workers are not necessarily wiser than their comrades in the use of science. Science alone is not enough; but Prof. Coulson, while welcoming the increasing concern of scientific workers with the social implications of science, did not advocate the adoption of some sort of Hippocratic oath for scientists. He suggested that what is needed is a new dedicated type of scientific worker who, recognizing the wholeness of life and the place of science in that wholeness, will not be deterred by danger or difficulty from seeking to further the contribution which science can render in shaping a new world.

## British Agricultural History Society: Inaugural Conference in Reading

The inaugural conference of the British Agricultural History Society was held at the University of Reading on April 13 and was attended by more than a hundred people representing a very wide variety of interests and professions from all over the British Isles. Sir James Scott Watson addressed the conference on "The Scope of Agricultural History", and Sir Frank Stenton spoke on "The Manor in English History". Later in the day, the conference had the opportunity of visiting the Museum of English Rural Life, University of Reading. The officers of the Society are as follows: *President*, Sir James Scott Watson (chief scientific adviser to the Ministry of Agriculture); *Treasurer*, Prof. E. Thomas (professor of agricultural economics, University of Reading); *Executive Committee*, Mr. Alexander Hay (*chairman*) (general secretary of the Association of Agriculture), Mr. Frank Atkinson (director of the Halifax Museums), Mr. John Cripps (editor of *The Countryman*), Mr. R. N. Dixey (director, Institute of Agrarian Affairs, Oxford), Mr. G. E. Fussell (author), Captain E. N. Griffith (president of the Agricultural Engineers' Association), Mr. Stuart Maxwell (National Museum of Antiquities, Edinburgh), Mr. W. E. Minchinton (lecturer in economic history, University College, Swansea), Mr. G. Ordish (Plant Protection, Ltd.), Mr. F. G. Payne (Welsh Folk Museum), Mrs. Joan Thirsk (senior research fellow in agrarian history, University College, Leicester) and Mr. R. Trow-Smith (*Farmer and Stockbreeder*). The main object of the Society, as outlined in the constitution, is to promote the study of the history of agriculture and rural economy, though it is not intended that the interests of the Society should be solely confined to the history of the British countryside. It is hoped that, by publishing a journal and holding occasional conferences, the Society will be able to bring together all those working on, or merely interested in, any aspect of rural history. Membership is open to all, the annual subscription being one guinea. Membership forms and copies of the constitution will be available shortly. All inquiries should be sent to the secretary of the Society, Mr. J. W. Y. Higgs, Museum of English Rural Life, 7 Shinfield Road, Reading.

## *Science Abstracts* on Index Cards

FROM time to time the Editor of *Science Abstracts* is asked whether an edition printed on index cards can be produced; the reply has hitherto been that the high cost of production and the limited circulation of such an edition would make the subscription-rate prohibitively high—in the neighbourhood of £40 per year for Section B (Electrical Engineering) alone. As an alternative, an edition printed on one side only was made available for anyone wanting to compile a card index of abstracts. However, a recent survey has shown that the labour of cutting and mounting single-sided issues may, in fact, raise the overall cost to a figure comparable with that of a card edition, which would, if so, be preferable for other reasons. Naturally, no precise estimate of the subscription for a card edition can be made until the probable extent of the circulation is known. To enable such an estimate to be made, the Editor of *Science Abstracts*, Institution of Electrical Engineers, Savoy Place, London, W.C.2, would be glad to hear from those willing to subscribe up to £40 per year for *Science Abstracts*, Section B, printed on index cards, 3 in. × 5 in. A similar card issue of Section A (Physics) could also be contemplated if sufficient demand was known to exist.

## Southern Regional Council for Further Education

THE fifth annual report of the Southern Regional Council for Further Education shows that, besides its regional academic board, many industrial and advisory committees have been set up since the Council was established in 1947. Most of the work of the advisory committee is concerned with trying to reconcile the requirements of industry, the requirements of students and the economic provision of further education facilities. Among the Council's activities during 1952 have been the sponsoring of courses in teaching methods which have been arranged for technical and commercial teachers. A number of conferences have also been arranged to make recommendations on metallurgical education facilities required in the region, and to discuss facilities for training agricultural craftsmen and young men in the heating and ventilating engineering industry. The Council has also published papers on the future development of higher technological education; the education and training of technologists in engineering, building, physics, chemistry and agriculture; recruitment of staff for technical colleges; instruction of rural craft workers; courses for building craftsmen; part-time instruction for agriculturists, horticulturists and domestic producers; agricultural education; and education for industrial citizenship.

## Extra-mural Function of Universities

IN an address to the Liverpool Branch of the Association of University Teachers, Mr. Thomas Kelly, the director of extra-mural studies in the University of Liverpool, indicated that the extra-mural task of a university is to make the maximum impact on the region within which it stands. The means will vary—classes; lecture courses, long and short; single lectures, recitals; exhibitions—all will have their place. In the vocational field, the university should limit its extra-mural provision to work which cannot easily be provided by other agencies; in the non-vocational field, it should seek to make provision for all groups able to profit by its services. Standards will look after themselves if the right tutors are appointed. This is the crux of all extra-mural work, and all tutors and lecturers need to be people of special qualifications. Because of this, the extra-mural resources of a university are necessarily limited, and the major task of an extra-mural department is the organization of these scarce resources in the most effective manner. A secondary task is that of studying the history, theory and techniques of adult education itself, and providing facilities for the training of tutors (*Univ. Rev.*, **25**, No. 2; February 1953).

## International Congress on Electroacoustics

AN International Congress on Electroacoustics will be held in the Netherlands during June 16–24 under the auspices of the International Commission on Acoustics of the International Union of Pure and Applied Physics. The Congress will open in the Hague on June 16 and on the following day will move to Delft, where most of the technical sessions will be held, but there will also be technical sessions (and excursions) in Hilversum and Eindhoven. The Congress will be made up of seven sections, each with a chairman who will give a general review of recent developments in the field (so arranged that all members will be able to be present), and these reviews will then be followed by individual papers and discussions. The sections, with the chairman shown in brackets, are as follows: (1) sound recording (R. Vermeulen, Netherlands); (2) public address systems (E. Meyer, Germany); (3) acoustic measurements (L. L. Beranek, United States); (4) hearing-aids and audiometers (P. Chavasse, France); (5) electro-acoustics in ultrasonics (G. Bradfield, Great Britain); (6) electroacoustics applied to musical instruments (E. G. Richardson, Great Britain); and (7) sound insulation of light-weight structures (C. W. Kosten, Netherlands). The last-named section will be in the form of a symposium. The official languages of the Congress will be English, French and German. Summaries of the papers will be circulated in advance. Application forms for membership and further information can be obtained from P. A. de Lange, Organizing Secretary of the Electroacoustics Congress, Mijnbouwplein 11, Delft.

## Chemical Meetings in Paris during June

THE second Salon de la Chimie will be held during June 18–29 in the Parc des Expositions, Paris, in conjunction with the next session of the Rassemblement des Arts Chimiques. The Salon will be organized by the Société de Chimie Industrielle, which this year will hold its twenty-sixth international congress of industrial chemistry during June 21–27 as a part of the Salon; other chemical bodies will similarly profit by the occasion by holding meetings at the same time, among which will be the following: the second session of chemical engineering, the seventh international congress of æsthetics and cosmetology, and the second symposium on proximate and functional analysis. The Salon will be divided into five sections: laboratory work and apparatus; chemical engineering; raw materials and products; organization, documentation, hygiene, etc.; and plastics. Further information of all these events can be obtained from the Secretary of the Société de Chimie Industrielle, 28 rue Saint-Dominique, Paris 7e.

## Commonwealth Fund Fellowships for Study in the United States

THE Commonwealth Fund has awarded fellowships, tenable in American universities for one year beginning next September, to the following British graduates, among others: W. G. Chaloner, University of Reading (palæobotany); R. I. Gillespie, University College, London (chemistry); H. L. Kornberg, University of Sheffield (biochemistry); D. D. Mears, King's College, London (engineering); P. G. Moore, University College, London (statistics); E. A. Power, University College, London (physics); G. C. Shephard, University of Birmingham (mathematics); R. J. Tayler, Clare College, Cambridge (astrophysics); D. G. Verney, University of Liverpool (sociology); and J. M. Williams, St. John's College, Oxford (chemistry). In addition, Dominion Civil Service Fellowships have been awarded to H. P. A. De Boom, South Africa (veterinary science), J. J. Kitshoff, South Africa (economics) and M. J. Moriarty, New Zealand (agricultural economics); and Colonial Civil Service Fellowships to F. A. Loyd, Kenya (conservation) and C. S. Ramage, Hong Kong (meteorology).

## "Protection from the Effects of Radiation"

COMMANDER P. L. CHANDLER, writing from 50 Montgomery Road, Sheffield, 7, says: "In *Nature* of February 28, p. 378, certain remarks are attributed to me, the nature of which I wish to disclaim. The policy of protection of personnel in the Naval Ordnance Inspection Department is not determined by the 'delivery of the goods'. The regulations laid down by their Lords Commissioners to the Admiralty are strict and conform to recommendations as accepted throughout the radiological world. These regulations as laid down are fully complied with in the Naval Ordnance Inspecting Department and those in force are such that the very minimum dose is obtained by personnel employed in the Radiological Department, and this is confirmed by daily readings with ionization chambers and regular readings by N.P.L. film batches".

## Announcements

SIR ROBERT ROBINSON, Waynflete professor of chemistry in the University of Oxford, has been awarded the Priestley Medal of the American Chemical Society, the Society's highest award.

SIR JOHN LENNARD-JONES has been awarded the Hopkins Prize of the Cambridge Philosophical Society for his work on the mathematical theory of molecular structure. The Prize is awarded every three years to a member of the University of Cambridge adjudged to have published the best original work in connexion with mathematico-physical or mathematico-experimental science in the relevant three-year period. The present award is intended to refer to the period 1945–48. The first recipient was Sir G. G. Stokes in 1867.

THE COUNCIL of the Institute of Metals has elected Sir Arthur Smout (past-president) a Fellow, in recognition of his long and distinguished services to the Institute; the number of Fellows is limited to twelve. Sir Arthur Smout was chairman during 1934–42 of what is now known as Imperial Chemical Industries, Ltd., Metals Division.

MR. DAVID P. RAMSOME, a descendant of Robert Ramsome, the well-known agricultural engineer, and managing director of E. H. Bentall and Co., Ltd., has been elected president for 1953–54 of the Institution of British Agricultural Engineers.

DR. W. IDRIS JONES, director-general of research to the National Coal Board, has been elected president of the Institute of Fuel for the session 1953–54; he will succeed the retiring president, Dr. G. E. Foxwell, in October.

THE following appointments have been made in the University of London: Dr. L. F. Lamerton to the readership in physics applied to medicine, tenable at the Institute of Cancer Research, Royal Cancer Hospital; Dr. Miles Weatherall to the University readership in pharmacology, tenable at the London Hospital Medical College.

DR. S. F. MASON, formerly of Wadham College, Oxford, has been appointed a Research Fellow of the Department of Medical Chemistry of the Australian National University; he took up his duties on April 1 in the Department's laboratories, which are at present at 183 Euston Road, London, N.W.1.

THE fifth annual symposium on phytopharmacy, organized by a number of Belgian and Dutch organizations and companies interested in this field, will be held in the Institute of Agronomy, 233 Coupure, Ghent, on May 5. The majority of the papers will be in Dutch or French. Further information can be obtained from the secretary, R. H. Kips, Rijkslandbouwhogeschool, Coupure 233, Ghent.

THE Scientific and Technical Group of the Royal Photographic Society is organizing a conference on "Photographic Science and Technique", to be held in the Arthur Worthington Hall, University of Manchester, on May 16. A number of short papers will be read, with subsequent discussion, on some problems and uses of photography in scientific, industrial and medical work. The conference will be open to all; those who hope to attend should inform the Group Honorary Secretary (D. H. O. John, 62 Chelmsford Road, Shenfield, Brentwood, Essex), from whom further information can be obtained.

THE Society for Endocrinology is arranging a symposium on "The Determination of Adrenal Cortical Steroids and their Metabolites", to be held at the Medical Society of London, Chandos Street, W.1, on May 21 at 9.30 a.m. Non-members of the Society wishing to attend should write to Prof. N. F. Maclagan, Westminster Medical School, London, S.W.1. The Society also announces that a lecture on "The Prostatic Glands as Targets for Steroids" will be given by Dr. Charles Huggins (Ben May Laboratory for Cancer Research, University of Chicago) at the Royal Society of Medicine, Wimpole Street, London, W.1, on June 23 at 5.30 p.m. Admission is free and without ticket.

A COURSE on "Geography and Food Resources", to be held at Westham House Adult Residential College, Barford, near Warwick, during May 22–26, has been arranged by the Association of Agriculture with the co-operation of Captain F. Owen, principal of Westham House. After an opening talk on factors limiting world food production, other lectures will deal with land use and agricultural geography of Great Britain, the Dominions, Europe and the tropics. The fee for the course, which is residential, is £3 12*s.* 6*d.* Applications should be addressed to the General Secretary, Association of Agriculture, 238 Abbey House, 2 Victoria Street, London, S.W.1, from whom further details can be obtained.

ERRATUM. In the account of the Bose Institute, Calcutta, in *Nature* of March 14, p. 468, the director was referred to as Dr. R. C. Mazumdar. This should read Dr. D. M. Bose.

# ELASTICITY IN LIQUIDS

A SYMPOSIUM on elasticity in liquids, arranged under the auspices of the British Society of Rheology, was held on March 27 in the Department of Science of the Durham Colleges in the University of Durham. Mr. J. E. Caffyn organized the details of the meeting.

Prof. J. E. P. Wagstaff welcomed the members to Durham, and the morning session then opened with Prof. G. S. Rushbrooke in the chair. Dr. R. Roscoe first read a paper on elastic relaxation and flow in suspensions, in which he referred to the early experiments of Schwedoff on relaxing sols. The method involved placing a gelatine solution in a co-axial cylinder viscometer, suddenly applying a shear by twisting the torsion head which supported the inner cylinder and observing the stress on the system as it relaxed slowly. Schwedoff considered that the stress fell off exponentially; but later workers do not confirm this. Dr. Roscoe has found, however, by repeating their experiments, that departure from the exponential decay is a feature of viscometers with a wide gap between the cylinders. By writing down the flow equations for such an apparatus, he is able to deduce a form of decay for the stress which agrees with experiment.

In the second part of his paper, Dr. Roscoe discussed the relation between rate of shear and shear stress, under steady conditions. Equations of flow have been developed by a generalization of Maxwell's method, which reduce to Bingham's equation in the case of steady flow. The cause of observed departures from Bingham's equation was discussed.

Dr. S. Thornton, speaking on the rheological behaviour of some dispersions of solid particles in liquid media, considered the effect of particle concentration on the relative viscosity of suspensions of rigid non-flocculating particles, and he developed a general expression applicable not only to spherical particles, in agreement with Einstein's well-known equation, but also to non-spherical particles of a limited type over a limited range of concentration. After a brief review of the experimental work on this subject, he stressed the need for checking the absence of flocculation of the particles and for ensuring the validity of any corrections applied. He explained briefly the technique for measuring the absolute viscosity of thixotropic materials which do not exhibit elastic behaviour, and gave results for some special cases.

Dr. E. G. Richardson described some experiments now in progress on the relationship between shear and bulk viscosity. Stokes first deduced a formula for the absorption of plane waves in a gas, the theory making the coefficient ($\alpha$) proportional to the square of the frequency ($f$) and the kinematic viscosity ($\nu$). In many liquids $\alpha/f^2$ is constant (with frequency) but has a value much greater than that of Stokes's formula, if the shear viscosity is substituted for $\nu$. It has been suggested that the bulk, or dilatational viscosity, should be included in $\nu$ when the propagation of ultrasonic waves is concerned. One experiment, suggested by Eckart, for the determination of bulk viscosity is based on the mensuration of the acoustic streams in the neighbourhood of a vibrating source, and a study of this is being made using hot wires to measure the streaming velocities in various fluids at frequencies from 1 c./s. to 1 Mc./s. Another method is to study the absorption of ultrasonics in capillary tubes, wherein plane waves are propagated in the centre of the tube and shear waves in the acoustic boundary-layer near the walls. Some initial results in both experiments were quoted.

In the afternoon session, with Dr. J. G. Oldroyd in the chair, J. E. Caffyn and R. M. Underwood described a new method for delineating velocity profiles in visco-elastic liquids. This involves the delineation of the motion of isolated oil drops, suspended in the liquid under test flowing along a tube 1 cm. in diameter, by double-flash photography from two perpendicular directions. From the double exposure of the oil drop on the photograph, the velocity at different radial distances from the axis of the tube can be estimated (and incidentally any deviation from axial flow detected), and hence the velocity profile at the site of the photographs to be constructed. Examples in water (for calibration purposes) and in an ammonium oleate sol were shown. In the visco-elastic fluid the velocity distribution, in accordance with the theories of Oldroyd and of Reiner and Rivlin, is still parabolic.

The final paper, by Dr. A. S. Lodge, considered some theories of the Weissenberg effect, and dealt with the distribution of transverse pressure in a rotating cone-and-plate viscometer, when the interspace is filled with a visco-elastic liquid in which components of stress perpendicular to the direction of shear are set up. The paper was theoretical and dealt with the fluid in stationary laminar incompressible flow, for which the general stress determinant was constructed. The difference between stress components (zero in a Newtonian fluid) give rise to the Weissenberg effect, as Dr. Lodge showed. Having calculated these differences for various radial distances in the cone-and-plate apparatus, he can compare the theory with the measurements of Roberts, who erected a series of manometers from the centre to the rim of the cone above the rotating plate and so was able to measure the transverse (vertical) stress distribution in a number of visco-elastic liquids. In the discussion on this paper, Dr. K. Weissenberg pointed out that Roberts's experimental results agree with his own calculation of the stress distribution.

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# MATHEMATICAL ASSOCIATION

## ANNUAL GENERAL MEETING IN SHEFFIELD

THE annual general meeting of the Mathematical Association was held in the University of Sheffield during April 8–11. At a reception given by the University on April 8, Dr. J. M. Whittaker, the vice-chancellor, welcomed the members, among whom was his father, Sir Edmund Whittaker, honorary member of the Association and president in 1919.

On April 9, following the business meeting, the president, Mr. K. S. Snell (Harrow School), gave his address, his subject being "School Mathematics To-day and To-morrow". Mr. Snell began with a speculation on the probable content of the school curriculum fifty years hence, suggesting that many topics now regarded as well outside the school range would by then have become commonplaces of the grammar-school curriculum. He then went on to examine present-day tendencies, to discuss which items might be emphasized and which might be allowed to fall into oblivion. One way in which much time might be set free for the development of the school course in mathematics would be to reform the British weights and measures—those tables which demand for their acquisition a great deal of time and effort—and Mr. Snell made a strong plea for the adoption of a suitable metric system in Britain.

Prof. A. G. Quarrell (Department of Metallurgy, University of Sheffield) then gave a paper on "Metallurgy—Craft and Science", describing the combination of craftsmanship and scientific investigation required in the production of high-quality steel; by the courtesy of Firth Brown, Ltd., a colour film showing modern methods of steel production was shown to the audience.

On April 10 the proceedings opened with a discussion on "Infinity", in which Prof. A. G. Walker (University of Liverpool) elucidated the concept of infinite numbers, and Dr. C. Hamill (University of Sheffield) spoke on the meaning and place of infinity in geometry. In the succeeding discussion some members thought that a simple account of these topics might be presented to a sixth form; but others urged that this was a subject which should be reserved exclusively for the university course.

The next paper, "The Mathematics Division, N.P.L.: its Work and Equipment", was to have been given by Dr. E. T. Goodwin, the superintendent of the Mathematics Division in the National Physical Laboratory; in his absence, through illness, Dr. L. Fox, the deputy superintendent, spoke on this topic, describing the range of machines, from the hand-operated adding and multiplying machines up to the A.C.E. electronic computer. Dr. Fox also dealt with the part played by the mathematician in analysing and systematizing the problems submitted to the Division before handing them over to the computing machines.

In the afternoon of the same day, a long and lively discussion was held on a subject which has greatly concerned the Association in recent years: "From Primary School to Secondary School". The opening speakers were Mr. L. B. Birch (deputy director, Sheffield University Institute of Education), Mrs. E. M. Williams (principal, Whitelands Training College) and Mr. M. W. Brown (headmaster, Charlton Secondary School). It was urged that free activity is the only method which will enable the average child to understand the mathematical processes of the primary-school range; but some secondary-school teachers feared that the freedom of activity might encourage the child to avoid hard work and might lead to a state in which pupils arriving at the secondary school would not have the firm grasp of fundamentals required for the school programme. In return, it was argued that understanding must precede technical skill and that manipulatory techniques are much more rapidly acquired if genuine understanding and appreciation of mathematical principles have been fostered in the primary school. But no easy solution to the practical problem of applying modern ideas to classes of forty or fifty children was put forward. In the evening, Dr. S. Vajda (Admiralty Research Laboratory) gave a paper on the "Theory of Games", a subject which, initiated mainly by John von Neumann in the 1920's, has proved to have wide applications to economics and also to the highly important war-time study of operational research.

The final paper, on April 11, was by Mr. J. F. Hinsley (chief radiologist and physicist, Edgar Allen and Co., Ltd.), who chose as his subject "From Examination Question to Industrial Problem". Here Mr. Hinsley showed that certain familiar examination questions concerning the motion of a particle, usually thought of as possessing only academic interest, are in fact of very considerable practical value in the design and testing of cement-making machines.

The new president of the Association is Prof. T. A. A. Broadbent, of the Royal Naval College, Greenwich.

# SCOTTISH BRANCH OF THE SCIENCE MASTERS' ASSOCIATION

## ANNUAL MEETING IN EDINBURGH

THE Scottish Branch of the Science Masters' Association held its annual meeting during April 7–10 at the Heriot-Watt College, Edinburgh, under the presidency of Dr. H. G. Nisbet, principal of the College. In his address, on "Some Applications of Physics in the Fuel and Oil Industry", Dr. Nisbet described the various methods of cleaning and grading coal, using such principles as flotation and electrostatic attraction. The difficulty of efficient cleaning becomes greater as the size of the coal particles decreases, and he attributed much of the dirtiness of our coal to-day to the increased proportion of very small particles in coal won by modern mechanized techniques. Turning to liquid fuels, Dr. Nisbet explained how 'knocking' or 'pinking' is due to abnormal rates of flame propagation, which can be corrected by the use of suitable catalysts such as tetra-ethyl lead. He next dealt with the problem of making efficient use of the fuel resources of Great Britain, and ended with a plea for more chemical engineers who, by increasing this efficiency, could help the country to maintain its place as a leading industrial nation.

Mr. R. M. Sillito, of the University of Edinburgh, gave an excellent lecture-demonstration on "Sound in Schools", with special reference to the new Scottish Leaving Certificate syllabus. He ended by asking that school pupils should be trained in the habit of precise quantitative thinking, which, he maintained, is far more valuable as a basis for university work than mere factual knowledge.

Two consecutive lecture-demonstrations on "A Theoretical and Practical Approach to the Teaching in the M.K.S. System of Electrical Units" were then given by Mr. F. A. Meier, of the University of London Institute of Education. This again had special significance in view of the new Leaving Certificate syllabus, both as regards the M.K.S. system itself and also as regards the approach via electromagnetic induction instead of magnetometry. His demonstrations of home-made apparatus, much of it being designed on original principles, were most impressive. Mr. Meier stressed the point that the new system and approach are far easier than the old, provided we can rid ourselves of our preconceived notions.

In a lecture on "School Astronomy" given at the City Observatory, the director, Mr. N. G. Matthew, asked science masters to try to make time for some astronomy in an admittedly crowded syllabus, and outlined methods by which the subject might be presented. He concluded by explaining a way in which senior pupils in Scotland can join in research by enrolling as members of the team of observers who are reporting on appearances of the aurora borealis. Mr. W. Fulton gave a demonstration of modern methods of sound reproduction, including tape-recorders. He ended by demonstrating a sound-film with a double sound-track—the original optical track, and a magnetic sound-track added later by a special process and giving entirely different sound. This very recent development may have great possibilities for such purposes as the addition of a translated commentary to foreign sound-films.

Prof. G. F. Marrian, professor of chemistry in relation to medicine, University of Edinburgh, gave a lecture on "Careers in Biochemistry". He outlined the history of biochemistry from a borderline-subject to one standing in its own right, and then went on to consider the problem of training, in which he expressed the view that an honours degree in chemistry or in biochemistry is of approximately equal suitability as a start ; but, in addition, several years of research leading to a Ph.D. are practically essential. Prof. Marrian mentioned the openings for biochemists in universities, research units, hospitals and industry, and made a special plea for more biochemists to take up agricultural research in order to help improve the food situation in Great Britain. Finally, he said that the demand for biochemists is limited, the post-war shortage having been filled up ; but for a few students of high standard there is an opportunity of working in a field of science which is developing very rapidly. In a lecture on "Some Recent Developments in Organic Chemistry", Dr. Neil Campbell, of the University of Edinburgh, first dealt with modern sources of organic materials and showed how petroleum is replacing coal-tar as the main source. Then he went on to discuss modern trends in theory and practice, including the theory of orbitals and the use of fluorescence and chromatography.

Other features of the meeting included the annual business meeting, visits to places of interest, exhibitions by members, publishers and manufacturers of scientific apparatus, and a glass-blowing demonstration by Mr. D. Macdonald, chief glass-blower in the Heriot-Watt College. A discussion was also held on "Recent Publications of the Scottish Education Department", which resolved itself largely into an expression of apprehension that the new syllabus in Circular 249 is too long to be covered in the time available at most schools, although it was conceded that the syllabus has great merits in other ways and should be given a fair trial.

# ROTHAMSTED EXPERIMENTAL STATION

## REPORT FOR 1951

THE report of the Rothamsted Experimental Station for 1951 shows that the station has again been the venue of a number of important conferences, that overseas visitors have been even more numerous than in previous years, and that the services of members of the Rothamsted staff continue to be sought by many different countries.

Field work with fertilizers, which has a primary place in the Rothamsted tradition, some of it in conjunction with other centres, is giving indications that some of the newer fertilizers, particularly silicophosphate, are likely to give good results. Nitrophosphates (formed by the action of nitric acid on rock phosphate and subsequent treatment with ammonia) consist essentially of ammonium nitrate and dicalcium phosphate, but there are some chemical and physical differences arising from different ways of production which appear to make some of them a little more effective than others. Two kinds examined at Rothamsted did not on the whole give quite the same yields as the same amounts of nitrogen and phosphate in sulphate of ammonia and superphosphate, but the results suggest that improvements in physical conditions can give a very useful nitrophosphate. Work with the older fertilizers is still giving positive suggestions, and some field results indicate that superphosphate may in some circumstances be used in much smaller dressings than have usually been advocated.

Other work in the Chemistry Department is concerned with the placement of fertilizers and with nutrition problems in forest nurseries.

Consideration of the relation of soils to ions in solution has been based by many workers on Gouy's double-layer theory, and the Physics Department has done very useful work by a critical examination that supports the justification for this use of the Gouy theory. This study is advancing our understanding of the behaviour of the aluminium ion, of the hydrogen-ion concentration in the soil-solution system and of the flocculating and deflocculating effects of salts. The Department is continuing its work on soil cultivation and its investigations in agricultural meteorology.

The study of clay minerals continues in the Pedology Department ; the work has included examination of a number of African soils, and a study of the absorption of organic compounds by clays. Further results of the study of gleying in soils offer some interesting suggestions. The reducing power of fermenting plant material (dealt with in the 1950 report) is much in excess of the iron actually reduced in the soil, and the rate of solution of the ferric oxide seems to be the limiting factor. Mottling with iron rust, so common in many gley layers, is only present in old root channels : elsewhere there is only grey material that is characteristic of the reducing action in gleying.

In the Microbiology Department the important work on nitrification is being continued, and the study of antibiotics secreted by actinomyces is producing some interesting results which may well lead to economic applications. Some of the clay and humic matter acts as an absorbent of the antibiotic, and some organic matter may act as a nutrient to the actinomyces and as an absorbent of its antibiotic. Another interesting piece of work shows that some reductions in soils are not unnecessarily anaerobic, for sulphates can be reduced with the production of hydrogen sulphide by aerobic organisms.

Work in the Botany Department on the uptake of nutrients by roots has been going on for some time, and some of it has recently been published. The uptake of an element seems to depend on the carbohydrate content of the root and the concentration of the particular element concerned, but is not affected by the concentration of other elements in the root cell. These studies are now involving the use of

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* Rothamsted Experimental Station. Report for 1951. Pp. 212. (Harpenden: Rothamsted Experimental Station, 1952.) 7s. 6d.

whole plants, and not merely excised roots, and should throw valuable light on an important and much-discussed subject. Further work on the spraying of leaves with nutrient solutions shows appreciable increase in growth following this treatment and sometimes, but not always, increases the percentage of nitrogen and phosphorus in the dry matter. Some work is being done on the possible replacement of potassium by sodium, and it has been shown, arising out of this work, that the effect of potassium deficiency on carbohydrate production does not account for the decrease in plant growth, since leaves sprayed with sucrose absorb the sugar without any increase in growth.

The Plant Pathology Department has continued its study of viruses and the influence of ultra-violet radiation on their effects. There is much other work on viruses and considerable mycological work, including some important observations on the spreading of spores.

The Biochemistry Department is carrying on the work on nucleoproteins from both normal and infected leaves. Rothamsted is giving up its responsibility in the technological production of leaf protein, which will now be carried on independently by the Grassland Research Station. The oxidation of manganese in certain plants is found to take place by the action of hydrogen peroxide forming in the plant under the influence of a peroxidase. A study of the parts of fungal mycelia that accumulate in soils in a very resistant form will contribute to our knowledge of the structure and properties of soil organic matter.

Different strains of eelworms that attack various crops and weeds are still being investigated in the Nematology Department, and immune varieties of crops are being sought.

Other work includes the study of insect populations, the feeding habits of bees, the effects of insecticides and the influence of insecticides on soil microflora. The Statistics Department continues to design experiments not only for Rothamsted but also for many other centres.

Some of the work (virus diseases in sugar beet, manganese oxidation in plants, and the movement of insects) are the subject of special reviews in this report, and the publication also contains, as usual, a brief report of the Soil Survey of England and Wales and a list of Rothamsted publications.

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## CHECK-LIST OF THE BIRDS OF GREAT BRITAIN AND IRELAND

THE scientific names of British birds have suffered from many changes, which has caused much inconvenience and some confusion. The British Ornithologists' Union has on three separate occasions, between 1883 and 1923, published lists of the birds on the British list with what were considered their correct scientific names. Unfortunately, however, the various authors responsible for these lists did not always pay strict attention to the International Rules of Nomenclature. Six years ago the Union decided that it was time a fresh list was prepared, and a committee was appointed; the new "Check-list of the Birds of Great Britain and Ireland" is the result of its labours*.

The committee had three tasks before it: to decide on the correct scientific names; to investigate the claims of certain rare wanderers to be admitted to the British list; and to examine the twenty-nine races of British birds described since the publication of the previous list. Of these new races, twenty-four were described by one individual, and out of the total the committee has only been able to recognized six.

Most of the changes in scientific nomenclature are already in use, but the committee has made two innovations regarding the use of English names. In the first place, the English name is restricted to the species, and only in a few exceptional cases is one given for a race. The second change is that the name is given by which American birds (either regular visitors or rare wanderers to Britain) are known in Canada or the United States, as well as the recognized British name. For example, the peregrine falcon is called the duck-hawk on the western side of the Atlantic, and the grey phalarope is known as the red phalarope. The general distribution of both species and races is briefly given, and should be very useful to curators and others.

The committee is to be congratulated in bringing its labours to a satisfactory conclusion, and a word of praise is due to the secretary, who, together with the chairman, are the only original members of the committee. The president of the Union, Sir Landsborough Thomson, has written an admirable introduction, which users of the check-list should read carefully.

* Check-List of the Birds of Great Britain and Ireland. (Published by the British Ornithologists' Union.) Prepared by the List Sub-Committee. Pp. xii+106. (London: H. F. and G. Witherby, Ltd., 1952.) 7s. 6d.

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## NATURE OF 'FIELD RESISTANCE' OF THE POTATO TO *PHYTOPHTHORA INFESTANS* DE BARY

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AND

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ALL attempts have hitherto failed to find 'true resistance', that is, resistance by virtue of suprasensitivity (= hypersensitivity), to *Phytophthora infestans* in the European cultivated potato, and there is good reason for thinking that this form of resistance will not be found in any old-established cultivated variety, not even in South America from whence the potato was brought to Europe four hundred years ago. Suprasensitivity, however, to various biological strains of the parasite has been obtained in commercial varieties in recent years by German, British and American breeders, but only by crossing cultivated forms with *Solanum demissum* or other wild *Solanum* species which may possess this type of resistance. Nevertheless, it has been known for a hundred years that considerable variation can be observed among old-established varieties in the reaction to blight under field conditions. This variation of what may be called 'field resistance' is found in the time of the first appearance of the disease and in the speed with which it increases to epidemic proportions within the plot; further, there is correlation between the rhythm of development of the host and the epidemic behaviour of the parasite—the later the variety would mature under disease-free conditions, the later, as a rule, the disease becomes epidemic.

This obvious relation between rhythm of development of the host and epidemic behaviour of the parasite, together with the fact that, under European conditions, blight generally reaches epidemic proportions not earlier than flowering time (therefore 'late' blight) has led many authors to the conclusion that blight is an "age-disease"; they have assumed that a "lowering of efficiency of immune reactions" takes place with increasing age and that this ontogenic change occurs much more quickly in early varieties than in late ones. There is, however, no conclusive experimental proof of such a change; moreover, under different climatic conditions—for example, in Turkey near the Black Sea or in many parts of Chile and in South Africa—blight often appears at epidemic proportions much earlier in the season; long before the plants reach the flowering stage.

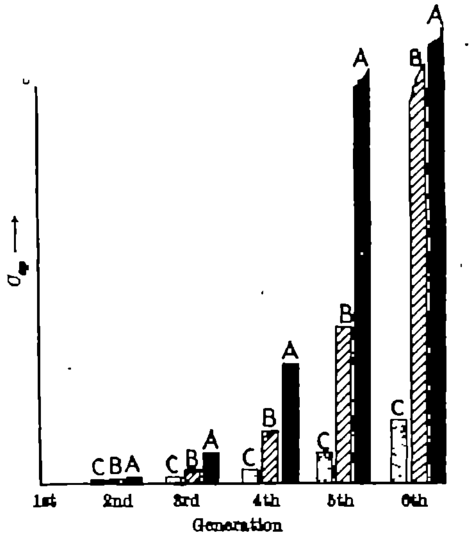
A new attempt to explain the observed facts is based on the following working hypothesis. Potato blight belongs to the group of airborne plant diseases. Under the climatic conditions of the major potato-growing areas of Europe, the parasite has to start at the beginning of each new season from comparatively small foci of infection, and it takes a relatively long time for the disease to reach epidemic proportions (numerous observations of one of us (K. O. M.) indicate that at least five generations of the parasite are necessary to infect a larger plot from a few primary foci of infection). Supposing that the spread of sporangia within the plot is homogeneous and their increase according to geometrical progression, the infestation of a plot is assumed to proceed according to the following formula:

$$C_{ep} = (c.P_I)^n,$$

where $C_{ep}$ is degree of infestation, $P_I$ is "probability of becoming infected per unit area of leaf", $c$ is intensity of fructification per single leaf spot, and $n$ is number of generations of the parasite since the initial infection.

This formula cannot reflect the actual situation within a field-plot; it can only illustrate the principle on which the working hypothesis is based. For example, it assumes that there is only one primary infection and that subsequent spread is internal; the assumption is justified on the grounds of mathematical simplicity by the heuristic character of the equation. Further, all the factors on the right-hand side of the equation are affected by constantly changing environmental conditions, particularly temperature and humidity. Also, since the epidemic effects of differences of $P_I$ will be in inverse ratio to the number of spores hitting the foliage, we may expect the effect to be greater at the beginning of the blight attack than later; and for the same reason, the effect of $P_I$ values on the rate of spread of the disease will vary directly with the distance of the plants from the source of infection.

Nevertheless, assuming that $P_I$ would be the only factor in which three varieties $A$, $B$ and $C$ differ from one another, the differences being in the proportion $A : B : C = 100 : 75 : 50$, and that the density of sporangia sweeping over the plot is homogeneous, then the accompanying diagram illustrates the consequences which would follow from the working hypothesis. It indicates that considerable differences between the $C_{ep}$ values of the varieties concerned are to be expected after four generations of the parasite, and that these differences should increase with increasing age of the plant, so that variety $A$ succumbs much earlier than varieties $B$ or $C$. Conversely, since in early varieties blight usually appears earlier and increases faster to epidemic proportions, these varieties should have greater $P_I$ values than late-maturing ones.



The technique used for testing this working hypothesis will be described in detail in a subsequent paper. Briefly, it consisted of inoculating fresh pieces of leaf of the same size with a weak zoospore suspension which was sprayed on them in dishes by means of an atomizer. The pieces of leaf were examined under the binocular microscope after four or five days and were 'scored' as 'diseased' or 'not diseased'. In the experiments here described a 'common' ($A$) strain of the parasite was used.

The arrangement of the pieces in blocks, with each variety or treatment equally represented and randomized in each block, made possible a statistical analysis of the results of inoculation. The degree of infection, measured for each variety by the number of pieces of leaf attacked (per block), was expressed as a percentage of the number of pieces inoculated (per block), and these percentages were converted by the $\sin^2\theta$ transformation before being subjected to an analysis of variance. These $\sin^2\theta$ figures, referred to as the $R_I$ values, were used as a measure of the $P_I$ values of the varieties. As an example, a test with field plants may be quoted in which there were four varieties: Champion, Stormont Dawn, Home Guard and King Edward. Each variety was represented by forty-four pieces of leaf, arranged in four blocks. Counts were made five days after inoculation and gave the following total numbers of pieces infected: Home Guard, 36; Champion, 14; King Edward, 41; and Stormont Dawn, 14. When the figures which contributed to these totals were expressed as percentages for each block and the percentages converted by the $\sin^2\theta$ transformation, the analysis of variance became possible (Table 1).

Differences are significant at the 1 per cent level and show Champion and Stormont Dawn to be significantly less infected than Home Guard or King Edward.

The essential experiments were carried out with twelve varieties grown at the National Institute of

Agricultural Botany in Cambridge during 1951. Unfortunately, blight appeared at epidemic proportions rather late in the year, the first being observed only in the second half of August. The names and abbreviations, maturity and reaction to blight infection in the field of the varieties used are given in Table 2.

During the period between the end of June and the middle of September, nine series of tests including all these varieties were made on pieces of leaf by the method just described. In Table 3 the results (mean values) of the four laboratory tests carried out between August 1 and 27 are plotted against the reaction of the varieties to blight in the field.

Table 3

| Field observations | | sin² θ (mean values)<br>20·0–24·9 | 25·0–29·9 | 30·0–34·9 | 35·0–39·9 | 40·0–44·9 | 45·0–49·9 |
|---|---|---|---|---|---|---|---|
| Resistant | 1 | OH. | | | | | |
| ↑ | 2 | ST.D. | | | | | |
| | 3 | | | U.S. | K.E. | | |
| | 4 | | A.V. | | | | |
| | 5 | | | | M. | | |
| ↓ | 6 | | | | | U.EM. | |
| Susceptible | 7 | | | | B.H.G.<br>U.CH. | U.EN. | A.P. |

Table 4

| Order of maturity | | sin² θ (mean values)<br>20·0–24·9 | 25·0–29·9 | 30·0–34·9 | 35·0–39·9 | 40·0–44·9 | 45·0–49·9 |
|---|---|---|---|---|---|---|---|
| Early | *A* | | | | U.CH.<br>H.G. | U.EN. | |
| ↑ | *B* | | | | B. | U.EM. | A.P. |
| | *C* | | | | K.E.<br>M. | | |
| ↓ | *D* | OH. | A.V. | | | | |
| Late | *E* | ST.D. | | U.S. | | | |

It will be seen from the table that there is correlation between the 'probability of becoming infected per unit area of foliage' (as measured by $R_I$) and the behaviour of the varieties in the field: the later blight appears and the more slowly it increases to epidemic proportions under field conditions, the smaller are the $R_I$ values obtained in the laboratory. In Table 4 the results are plotted against the varieties arranged in order of maturity in the field, and there is again seen to be an orderly arrangement in which the chance of becoming infected increases with decreasing maturity of the variety.

Of all the varieties under trial, the latest incidence of blight in the field-plot and almost the lowest $R_I$ values in the laboratory were shown by Champion, an old-established British variety which has been known as an outstanding 'blight-resister' for a long time. The results of these tests not only confirmed its field resistance, but also showed that the late incidence of blight in this and similar varieties is by no means the result of a belated lowering of efficiency of immune reactions with increasing age. On the contrary, there are strong indications that an ageing leaf becomes less susceptible to infection. The reason why the disease appears relatively late in the season in these varieties is largely because in them the probability of becoming infected ($P_I$) is relatively low, and in years when the disease occurs only in small proportions, these varieties will often escape severe attack.

Table 1

| Variety | Block 1 | Block 2 | Block 3 | Block 4 | Totals | Mean |
|---|---|---|---|---|---|---|
| Champion | 25·3 | 47·6 | 17·6 | 42·4 | 132·9 | 33·2 |
| Stormont Dawn | 37·1 | 37·1 | 31·5 | 31·5 | 137·2 | 34·3 |
| Home Guard | 64·7 | 72·4 | 64·7 | 58·5 | 260·3 | 65·1 |
| King Edward | 72·4 | 90·0 | 72·4 | 72·4 | 307·2 | 76·8 |
| Totals | 199·5 | 247·1 | 186·2 | 204·8 | 837·6 | 52·3 |

Table 2

| Name | Maturity | | Behaviour to blight | Abbreviations used in Tables 3 and 4 |
|---|---|---|---|---|
| Ulster Ensign | First early | *A* | 7 | U.EN. |
| Ulster Chieftain | ,, ,, | | 7 | U.CH. |
| Home Guard | ,, ,, | | 7 | H.G. |
| Arran Pilot | Second early | *B* | 7 | A.P. |
| Ulster Emblem | ,, ,, | | 6 | U.EM. |
| Bintje | ,, ,, | | 7 | B. |
| Majestic | Early main-crop | *C* | 5 | M. |
| King Edward | ,, ,, | | 3 | K.E. |
| Arran Viking | Main-crop | *D* | 4 | A.V. |
| Champion | ,, | | 1 | CH. |
| Ulster Supreme | Late main-crop | *E* | 3 | U.S. |
| Stormont Dawn | ,, ,, | | 2 | ST.D. |

7 = most early appearance and quick increase of the disease
1 = latest appearance and slow increase at the end of the season

Other experiments, to be described in detail in a subsequent paper, have shown that environmental conditions can affect the $P_I$ value of a plant; for example, plants raised in the greenhouse will usually show a higher degree of infection than plants grown in the field. It has also been found that there are no significant varietal differences of $R_I$ values if the spore suspension is sprayed on to the lower surfaces of the pieces of leaf, indicating, among other things, that natural infection usually takes place on the upper surface of the leaf. Evidence in support of the existence of differences in the factor $c$ in the formula $C_{sp} = (c.P_I)^n$ will also be presented. Finally, the experiments showed that the factor or factors which control the 'chance of becoming infected' are independent of the strain of *Phytophthora* which is used for the determination of $R_I$ values, indicating that such factors are different from those which confer resistance due to suprasensitivity. The potato breeder who wishes to obtain the highest possible degree of blight resistance in his breeding material should therefore combine both qualities by crossing varieties with low $P_I$ values and suitable maturity with those which possess 'true resistance' by virtue of suprasensitivity.

We wish to acknowledge the assistance received from Miss M. Kostrowicka in carrying out numerous $P_I$ tests and in observing the behaviour to blight of the field plots at the National Institute of Agricultural Botany during 1951.

# EFFECT OF NERVOUS STIMULATION ON THE ARTERIO-VENOUS OXYGEN AND CARBON DIOXIDE DIFFERENCES ACROSS THE KIDNEY

By Dr. JOSEPH H. CORT

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THE kidney usually receives about 25 per cent of the cardiac output[1] and thus probably has far more oxygen available than it can extract under ordinary metabolic conditions. This same high rate of tissue-flow greatly dilutes the carbon dioxide returning to the circulation, in relation to other tissues. Normally, therefore, the arterio-venous differences of these gases are small, and any changes produced in them experimentally are even smaller in absolute value. Indeed, attempts to increase the osmotic reabsorptive work of the kidney have produced no measurable change in oxygen utilization[2], and change in oxygen uptake seems to correlate best with blood flow[3]. Consequently, measurable changes in arterio-venous differences may be taken to indicate changes in blood flow rather than tissue oxygen consumption. The work reported here is an attempt to use gaseous differences across the kidney as a measure of the changes in renal blood-flow produced by nervous stimulation.

Fourteen adult cats were used under 'Nembutal' anæsthesia, 30 mgm./kilo administered half intraperitoneally, half intramuscularly. Arterial blood samples were drawn from the femoral artery, while renal blood was collected through a No. 5 or 6 straight cardiac catheter, passed from the internal jugular vein in the neck into the left renal vein with the aid of a fluoroscope. The left renal vein was used because it joins the vena cava at a more acute angle than the right and is longer, thus providing more mechanical security for the catheter position during the experiment. The position of the catheter was verified in each case by post-mortem examination. All blood samples were drawn under oil in heparin-moistened syringes and analysed directly. Urine flow, when measured, was obtained through an in-dwelling catheter in female cats.

Systemic blood pressure was measured with a mercury manometer attached to a carotid cannula.

The portions of the nervous system stimulated were: (*a*) the central end of the severed sciatic, (*b*) peripheral end of the cut splanchnics (exposed by a dorsal approach to the crus of the diaphragm) and (*c*) the supraorbital areas of the cerebral cortex (exposed by superior craniectomy and retraction). The peripheral points were stimulated by means of a thyratron discharge at a frequency of 150/sec.; cortical stimulation was carried out with a 10/sec. square wave of 10 m.sec. pulse-width produced by a multivibrator.

The orbital surface was chosen for cortical stimulation upon the evidence presented by Ward and McCulloch[4] that there are direct unmyelinated connexions from this area to the head ganglia of the sympathetic nervous system in the posterior hypothalamus. The supraorbital surface was just lateral to the posterior third of the olfactory nerve on the concave under-surface of the cat's brain. Renal vein catheterization was completed before craniectomy in every case, so that the effects of the rongeuring of cranial bone could be determined immediately after exposure.

The effects of stimulation on arterio-venous oxygen and carbon dioxide differences are shown in the accompanying table. Oxygen figures are expressed as an arterio-venous difference, while carbon dioxide appears as a venous-arterio difference. The direction of change was the same in every animal with every stimulation, and the figures presented are averages of the differences. The changes are compared with pre-experimental levels determined in triplicate over a half-hour period. The peripheral stimulations were applied for 5 min. continuously. In the case of the sciatic stimulation a drop of about 50 per cent was produced in both gaseous differences. After a period of 10–30 min., the original levels had either been restored or had been exceeded. This phenomenon was easily repeatable in the same preparation, if a rest period of at least 30 min. was allowed between successive stimulations. The figures show that splanchnic stimulation produced a slightly greater change than sciatic stimulation in the same direction. The time relationships of stimulation were also similar. The effects of craniectomy are listed separately: both gaseous differences were depressed slightly, and the depression tended to continue for some time after exposure. This depressed value was taken as the base-line for the subsequent stimulation, which produced a further parallel decrease in both differences of long duration. No significant recovery occurred in most cases by 45 min. after stimulation had ceased.

Urine production completely ceased with the onset of all stimulations and gradually returned during the subsequent period. The restoration of the flow of urine usually coincided with the recovery of gaseous differences. Systemic blood pressure rose sharply in response to peripheral stimulation, but fell again to its original base-line value usually by 30 sec. after stimulation had been initiated. In response to cortical stimulation the rise (20–40 mm. mercury) of systemic blood pressure was slower (1–2 min.) and the decline showed a similar time course.

Supraorbital stimulation, in contradistinction to all the others attempted, produced an effect of long duration, which may be due to continual firing from a hypothalamic circuit, or a cortico-hypothalamic reverberation, or both. It is unlikely that the differences in duration of response are due to end-organ characteristics, since other nervous pathways to the kidney produce a shorter response. Other cortical stimulations[5] have produced similar results.

The respiratory quotient of the kidney remained at about 0·90–1·00 before and after stimulation, so that the kidney appeared to be burning mainly

GASEOUS DIFFERENCES ACROSS THE KIDNEY DURING STIMULATION

| | Gas | *A* | *B* | *C* |
|---|---|---|---|---|
| Sciatic | Oxygen<br>Carbon dioxide | 3·0<br>2·9 | 1·4<br>1·3 | 3·6<br>3·5 |
| Splanchnic | Oxygen<br>Carbon dioxide | 3·3<br>3·5 | 1·2<br>1·8 | 3·8<br>3·5 |
| Craniectomy | Oxygen<br>Carbon dioxide | 4·1<br>3·8 | 3·9<br>3·5 | 3·9<br>3·5 |
| Supra-orbital cortex | Oxygen<br>Carbon dioxide | 3·9<br>3·5 | 2·7<br>2·2 | 2·8<br>2·3 |

*A* = before stimulation; *B* = during stimulation; *C* = after stimulation carbohydrate, and stimulation had little effect on this process.

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The decreases in arterio-venous oxygen and carbon dioxide differences reported here would indicate either an increased total flow, or a decreased distribution of flow, or both. A decreased distribution of flow would be followed by an increased flow in the non-compromised portions, if the total flow remained constant. An example of this is the by-pass described by Trueta *et al.*[6]. Cessation of flow of urine may be attributed to a decreased effective blood supply to glomeruli and tubules by direct afferent arteriolar vasospastic action. Such an afferent arteriolar change would also produce the suggested redistribution or redirection of flow within the vascular network and is in agreement with recent clearance data[7] showing the renal response to stimulation.

I should like to express my gratitude to Profs. D. H. Barron and J. F. Fulton for direction and advice, and to Prof. R. A. McCance, who aided in the preparation of this communication. The fluoroscopy unit was lent by Dr. Samuel Gelfan. This work was financed by a grant from the Therapeutic Research Committee of the American Medical Association.

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# CALCULATION OF ELECTRON-DENSITY DISTRIBUTION IN CRYSTALS WITH THE HELP OF CONVOLUTION OPERATIONS

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THE electron density distribution $\rho_\infty$ of an infinitely large crystal is usually represented by a Fourier series,

$$\rho_\infty(x) = \frac{1}{v_r}\sum_{h}^{\infty} f(b_h)\exp 2\pi i(b_h x), \tag{1}$$

where

$$b_h = h_1 b_1 + h_2 b_2 + h_3 b_3, \tag{2}$$

and

$$b_1 = \frac{[a_2 a_3]}{v_r},\quad b_2 = \frac{[a_3 a_1]}{v_r},\quad b_3 = \frac{[a_1 a_2]}{v_r}$$

and

$$v_r = (a_1 a_2 a_3) = \frac{1}{(b_1 b_2 b_3)}. \tag{3}$$

$a_1$, $a_2$, $a_3$ and $b_1$, $b_2$, $b_3$ are the three fundamental-vectors of lattice cells having the volume $v_r$ in physical space and $1/v_r$ in Fourier space, $(bx)$ denotes the scalar product of radius vectors $x$ and $b$ in physical and reciprocal spaces respectively, the Miller indices $h_1$, $h_2$, $h_3$ are integers and $b_h$ represents the co-ordinate of the reciprocal lattice point $h$. The Fourier coefficients $f(b_h)$ are known as structure amplitudes; they are, in general, dimensionless complex numbers, but are real for $\rho_\infty$ having a centre of symmetry. Only the magnitude $|f(b_h)|$ is obtained experimentally from the integral intensity of the crystal reflexion lying at $b_h$. The difficulty and uncertainty of determining $f(b_h)$ itself from the $|f(b_h)|$ value are well known in classical X-ray crystallography (cf. Hosemann and Bagchi[1]). As in Fourier analysis, here it will also be asumed that the problem of the determination of phases has been satisfactorily solved, and $f(b_h)$ values are known. Even then, the calculation of $\rho_\infty$ with the help of eq. (1) is a laborious task, and various methods and machines have been suggested to lighten this burden (cf. Booth[2] and Nowacki[3]). Moreover, so calculated, $\rho_\infty$ has the following disadvantages.

(*a*) It is very difficult (if at all possible) to discuss the errors involved in the calculated $\rho_\infty$ resulting from errors in measured values of $f(b_h)$.

(*b*) Since experimentally only the reflexions lying within the sphere

$$|b_h| < 2/\lambda \tag{4}$$

can be measured, $\lambda$ being the wave-length of X-rays, the number of terms in eq. (1) would be at most

$$H = \frac{4\pi}{3}\left(\frac{2}{\lambda}\right)^3 v_r. \tag{5}$$

Thus, the calculated

$$\rho_{\text{Abb.}} = \frac{1}{v_r}\sum_{h=0}^{H} f(b_h)\exp 2\pi i(b_h)x \tag{6}$$

shows contour lines of equal electron-density distribution which are different from those of true $\rho_\infty$. This distortion due to the termination of series ('Abbruch effect') cannot be exactly calculated with the help of existing methods. But this is particularly important in view of the fact that the distortion is most marked in the region (as has been shown here) which is likely to offer valuable information about the nature of valence bonds.

(*c*) This 'Abbruch effect' also causes a displacement of the co-ordinates of the atoms, which cannot be exactly calculated.

The following method of calculation overcomes or reduces all these difficulties, since here the major portion of the intensity is treated with the convolution operation to give a $\rho(x)$, and the few remainder terms, when not negligible, can be treated in the usual way of Fourier synthesis.

Let $P^1(b - b_h)$, $P^1(x - x_s)$ denote point functions such that

$$\begin{aligned} P^1(b - b_h) &= 0 \quad \text{for } b \neq b_h \\ P^1(x - x_s) &= 0 \quad \text{for } x \neq x_s \\ \int P^1(b - b_h)\,dv_b &= 1 \\ \int P^1(x - x_s)\,dv_x &= 1, \end{aligned} \tag{7}$$

$dv_b$ and $dv_x$ being elements of volume in Fourier and physical space, respectively.

Further, let the crystal lattice be represented by the lattice peak function $z^1$ and the reciprocal lattice by the lattice peak function $Z^{1/v_r}$ (cf. Ewald[4]), such that

$$Z^{1/v_r}(b) = 1/v_r \sum_{h}^{\infty} P^1(b - b_h)$$

and

$$z^1(x) = \sum_{p}^{\infty} P^1(x - x_p). \tag{8}$$

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$x_p = p_1a_1 + p_2a_2 + p_3a_3$ denotes the position of the middle point of the crystal lattice cell $p$.

Moreover, let $\overbracket{g_1g_2}$ or $\overbracket{G_1G_2}$ denote the convolution (*Faltung*) product of two functions $g_1$ and $g_2$ in physical space or $G_1$ and $G_2$ in reciprocal space, so that

$$\overbracket{g_1g_2}(x) = \int g_1(y)\, g_2(x-y)\, dv_y \tag{9}$$

and

$$\overbracket{G_1G_2}(b) = \int G_1(c)\, G_2(b-c)\, dv_c.$$

For fixed values of $x$ or $b$, the integration is to be extended over all space.

The convolution theorem of Fourier transformations states that

$$\mathcal{F}\, \overbracket{g_1g_2} = G_1G_2$$

and

$$\mathcal{F}\,(g_1g_2) = \overbracket{G_1G_2} \tag{10}$$

where $G_1 = \mathcal{F}\,(g_1)$ ; $G_2 = \mathcal{F}\,(g_2)$.

Now, using eq. (8), the summation (1) can be represented as a Fourier integral $\mathcal{F}^{-1}$, as follows:

$$\rho_{\infty}(x) = \mathcal{F}^{-1}\,(f'Z^{1/v_r}) = \int f'(b)\, Z^{1/v_r}(b) \exp\,[2\pi i(bx)]\, dv_b, \tag{11}$$

where $f'(b)$ is any arbitrary function (requiring only to be partially smooth and free from singularities) in Fourier space, which need only to have the given values of $f(b_h)$ at points $b = b_h$, that is,

$$f'(b) = f(b_h) \text{ at points } b = b_h. \tag{12}$$

In choosing the nature of the function $f'(b)$, one should consider the convenience of further calculation.

The convolution theorem of Fourier transformations (eq. 10) allows eq. (11) to be expressed as

$$\rho_{\infty}(x) = \overbracket{\rho'\, z^1} = \int \rho^1(y)\, z^1(x-y)\, dv_y, \tag{13}$$

where

$$\rho'(x) = \mathcal{F}^{-1}\,(f') = \int f'\,(b) \exp\,[2\pi i(bx)]\, dv_b. \tag{14}$$

The convolution product (13) is independent of the nature of the function $\rho'(x)$ so long as its Fourier transform $f'(b)$ fulfils eq. (12). In Fourier space this is evident from (11), since $f'(b)$ is multiplied by a lattice peak function $Z^{1/v_r}$, which has zero values outside $b = b_h$ (cf. Ewald[4]). In physical space, however, the correctness of (13) and (14) seems at first to be paradoxical, but can be proved as shown below.

The integral (13) can be written as

$$\overbracket{\rho' z^1} = \lim_{b\to 0} \mathcal{F}\,(\rho'(y)\, z^1(x-y)). \tag{15}$$

Using the shift theorem of Fourier transformations, we have

$$\mathcal{F}\,(z^1(x-y)) = \int z^1(x-y) \exp\,[-2\pi i(by)]\, dv_y = Z^{1/v_r} \exp - 2\pi i(bx).$$

Substituting $\rho'$ and $z^1$ for $g_1$ and $g_2$ respectively in eq. (10), we have from (15)

$$\overbracket{\rho' z^1} = \lim_{b\to 0} \overbracket{f'\,(Z^{1/v_r}} \exp - 2\pi i(bx)). \tag{16}$$

Since

$$\lim_{b\to 0} \overbracket{f'\,(P^1\,(b-b_h)} \exp - 2\pi i(bx)) = f'(b_h) \exp 2\pi i(b_hx), \tag{17}$$

the identity

$$\rho_{\infty}(x) = \overbracket{\rho' z^1} = \sum_{p}^{\infty} \rho'(x + x_p), \tag{18}$$

with

$$x_p = p_1a_1 + p_2a_2 + p_3a_3$$

($p_1$, $p_2$, $p_3$ being integers) follows from (16) and (17) as soon as (12) is fulfilled.

As an example, the structure of sodium chloride at room temperature has been analysed in the following steps.

(i) A smooth curve is drawn through all the experimentally obtained values of $f(b_h)$ for $(h_1, h_2, h_3) = (200), (220), (420)$, etc., and another one through the values $f(b_h)$ of (111), (131), (133), etc.

(ii) These curves are extrapolated also for $|\,b\,| > 2/\lambda$, either after Hartree[5] or by plotting $\ln f'$ against $b^2$ and then extrapolating linearly.

(iii) Only in the case of reflexions having different values of $f(b_h)$ for the same $|b| = |b_h|$ is a deviation of $f'(b)$ from spherical symmetry postulated. In that case, either one can interpolate a non-spherically symmetrical curve $f'_n(b)$ or, more conveniently, one interpolates a spherically symmetrical $f'_s(b)$, and the remaining few parameters

$$\Delta_1 f'(b_h) = f'_n(b_h) - f'_s(b_h) \tag{19}$$

are separately treated as correction terms.

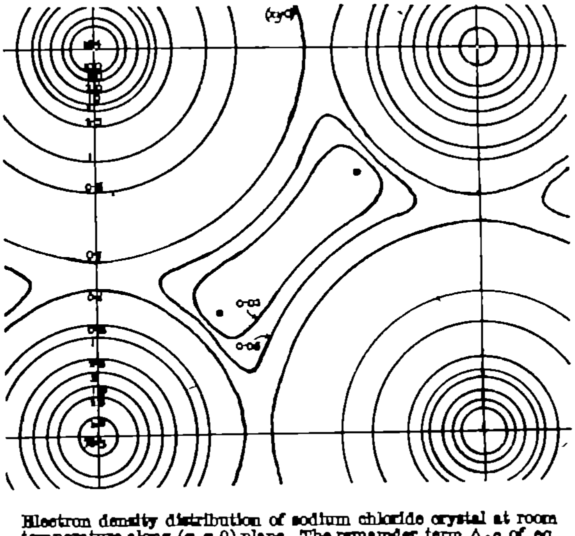
(iv) In spite of the fact that $f(b_h)$ has only one particular value for any constant value of $|b_h|$, a few values of $f|(b_h)|$ may deviate from a conveniently smooth interpolated curve $f'_s(b)$ (that is, a wavy form of $f'(b)$ in the radial direction). In this case also, one can either interpolate this wavy function $f'_w(|b|)$ or, again more conveniently, take the smooth curve $f'_s(b)$ and introduce the deviations

$$\Delta_2 f'(b_h) = f'_w(b_h) - f'_s(b_h) \tag{20}$$

as correction terms.

The spherically symmetrical $f'_s(b)$ function, when transformed into physical space, gives spherically symmetrical density distributions $\rho'_s$ around certain points $x_s$ in the crystal cell, which are determined by the special structure of the crystal.

The overlapping of the spherically symmetrical distributions $\rho'_s(x - x_s)$ around such adjacent lattice



Electron density distribution of sodium chloride crystal at room temperature along $(p_1p_2 0)$ plane. The remainder term $\Delta_2\rho$ of eq. (20) affects only the contour lines $\not< 0{\cdot}03$ electrons/Å.$^3$

points $x_n$, if any, causes a deviation from spherical symmetry inside the lattice cell. Actually, such deviations were found in the case of sodium chloride (see diagram), though $f'$-values were spherically symmetrical.

(v) The advantage of deciding in favour of a spherically symmetrical function $f'_s(b)$ is that it can easily be transformed by one-dimensional Fourier analysis:

$$\rho'_s(r) = \frac{4\pi}{r}\int_0^\infty |b|\, f'_s(|b|) \sin 2\pi r|b|\, d|b|\,;\quad r = |x|. \quad (21)$$

(vi) The advantage of using a smooth function $f'_g(b)$ lies in the fact that it can be resolved into a few Gaussian curves $G(b)$ the Fourier transforms of which can be calculated directly. Thus

$$f'_g(b) = \sum_{n=1}^{N} A_n\, G_n(b)$$

with

$$G_n = \pi^{3/2}\, c_r c_s c_t \exp - \pi^2 (c_r^2 b_r^2 + c_s^2 b_s^2 + c_t^2 b_t^2) \quad (22)$$

and

$$\rho'_g(x) = \sum_{n=1}^{N} A_n\, g_n(x)$$

$$g_n(x) = \exp(-x_r^2/c_r^2 - x_s^2/c_s^2 - x_t^2/c_t^2), \quad (23)$$

where $b_r$, $b_s$, $b_t$ and $x_r$, $x_s$, $x_t$ are orthogonal components of $b$ and $x$, and $c_r = c_s = c_t$ in the case of spherical symmetry.

(vii) The required electron density distribution is then given by

$$\rho_\infty(x) = \rho'_{gs} \sqcap z^1 + \Delta\rho(x), \quad (24)$$

where the Fourier transform of $\rho'_{gs}$ is smooth as well as spherically symmetrical, and the remainder term $\Delta\rho$ can be easily calculated, since

$$\Delta\rho(x) = \frac{1}{v_r}\sum_{h}^{H} (\Delta_1 + \Delta_2)\, f(b_h) \exp 2\pi i(bx). \quad (25)$$

In the case of sodium chloride the electron-density distribution is given by

$$\rho_\infty(x) = \left(\frac{\rho'_1 + \rho'_2}{2}\right) \sqcap z''(x) + \left(\frac{\rho'_1 - \rho'_2}{2}\right) \sqcap z''\left(x - \frac{a_1}{2}\right) + \Delta_2\rho, \quad (26)$$

where the Fourier transforms of $\rho'_1$ and $\rho'_2$ are smooth and spherically symmetrical, $z''(x)$ is a face-centred lattice and $z''(x - a_1/2)$ is the same lattice with its origin shifted to $a_1/2$. $\Delta_1\rho = 0$, because every $|b_h|$ has one and only one value of $f(b_h)$ and $\Delta_2\rho$ is negligible almost in the whole of the lattice cell.

The electron-density distributions calculated from equation (26) along (100), after taking into account respectively Hartree's linear extrapolation for $|b| > 2/\lambda$ (ref. 5) and the logarithmic method mentioned above, show a discrepancy which is less than 4 electrons/A.³ near the centres of Na+ and Cl− ions and negligible outside the region $r = 0{\cdot}3$ A. from the centre of each ion (the difference is less than 0·001 electrons/A.³).

On the contrary, if it is taken that $f(b_h) = 0$ for all $|b| \geqslant 2/\lambda$, as is generally assumed in usual Fourier synthesis, the 'Abbruch effect' is not negligible outside $r = 0{\cdot}3$ A.; in the case of molybdenum $K\alpha$-radiation the contour lines are distorted by $\Delta\rho_{\rm Abb}$-waves of length ∼ 0·4 A. and amplitudes ∼ 0·5 electrons/A.³, lying at the outer shells of the atoms, and ∼ 0·1 electrons/A.³ in the centre of neighbouring ions. This causes the well-known displacement of the centres.

This 'Abbruch effect' can also be calculated with the help of convolution operations. Since

$$f'(b)_{\rm Abb.} = f' \cdot S\,;\quad \rho'_{\rm Abb.} = \rho' \sqcap s, \quad (27)$$

S($b$), the Abbruch-shape function in Fourier space, is a sphere of radius

$$|b| = 2/\lambda = B, \quad (28)$$

and of density unity. Since

$$s(r) = \mathcal{J}^{-1}(S) = \frac{4\pi}{3} B^3 . 3\, \frac{\sin 2\pi Br - 2\pi Br \cos 2\pi Br}{(2\pi Br)^3}, \quad (29)$$

$\rho'(r)_{\rm Abb.}$ shows according to (27) subsidiary maxima at distances of about $r \sim 1/B = 0{\cdot}36$ A. for molybdenum $K\alpha$-radiation. The diagram represents $\rho_\infty(x)$ along $(p_1 p_2 0)$ planes, which is obtained by using the logarithmic method of extrapolation. $\Delta_2\rho$ only causes a correction (see eq. 25) of less than 0·02 electrons/A.³ and affects only the region of the small island in the diagram between two adjacent chlorine ions.

The maximum possible errors in the calculated values of $\rho_\infty$ can also be easily determined. $\rho_{\rm Na^+}$ and $\rho'_{\rm Cl^-}$ can be calculated sufficiently accurately from curves of $\ln f'/b^2$ with the help of eq. (23) and (26). They are composed of two and three $g_n(r)$, respectively.

Given the type of structure (eq. 26) and the lattice edge $|a_1| = |a_2| = |a_3| = 5{\cdot}618$ A., the whole of the sodium chloride structure at room temperature can be described by the ten following parameters only (cf. eq. 23):

| $n$ | | $A_n$ (electrons/A.³) | $c_n$ (A.) |
|---|---|---|---|
| $\rho'_{\rm Na^+}$ | 1 | 13·2 ± 0·6 | 0·449 ± 0·006 |
| | 2 | 57·0 ± 3·0 | 0·220 ± 0·003 |
| $\rho'_{\rm Cl^-}$ | 1 | 1·8 ± 0·2 | 0·89 ± 0·02 |
| | 2 | 4·9 ± 0·6 | 0·46 ± 0·02 |
| | 3 | 167 ± 8 | 0·210 ± 0·002 |

It is very interesting to note that Na+ with two electron shells can be described by the summation of two, and Cl− with three, electron shells by means of three Gaussian curves $A_n g_n(r)$ (cf. eq. 23); this may not be merely an accident.

We wish to thank Prof. H. Witte and Dr. E. Wölfel (Institut für chemische und physikalische Röntgenkunde, Darmstadt) for placing their experimental data of $f(b_h)$ at our disposal (cf. Wölfel[6]). The calculations necessary to give the results shown in the table were carried out by F. Motzkus and G. Schoknecht in two days without the help of any machine, for which also our thanks are due. It is hoped to publish this work in full in the near future.

[Dec. 19.

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# LETTERS TO THE EDITORS

*The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications*

## Quaternary Derivatives of Benzoyltropine and Benzoyl-ψ-tropine with Anticholinergic and Local Anæsthetic Properties

In the course of experiments dealing with correlations between structure and effect of cholinergic-blocking (antimuscarine, antinicotinic) actions[1,2], it has been found that in the case of compounds with tropeine structure the influence exerted on the effects by different quaternary groups shows great variations. Quaternary derivatives of tropeines possessing local anæsthetic properties, for example, benzoyltropine (= benzoyl-anti-tropine)[3], as well as benzoyl-ψ-tropine (= benzoyl-syn-tropine), have been prepared and studied[4], special consideration being given to the correlations between stereo-structure and pharmacological effect. Antimuscarine, ganglionic-blocking, curare-like, as well as local anæsthetic actions have been investigated. The effects of the individual compounds are shown in the accompanying table.

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Benzoyltropine HCl | 0·01 | < 0·1 | — | 1·5 | |
| ,, $CH_3I$ | 0·025 | 2·1 | 0·15 | 0·6 | |
| ,, $C_2H_5Br$ | 0·02 | 3·0 | 0·25 | 1·4 | |
| ,, $n$-$C_3H_7Br$ | 0·02 | 2·8 | < 0·10 | 1·2 | |
| ,, $n$-$C_4H_9Br$ | 0·005 | 6·0 | 0·25 | 0·6 | |
| ,, benzyl Br | 0·01 | 3·0 | 0·10 | 1·2 | |
| Benzoyl-ψ-tropine HCl | 0·003 | < 0·1 | — | 2·2 | 2·6 |
| ,, $CH_3I$ | 0·002 | < 0·2* | < 0·06 | 0·25 | 0·4 |
| ,, $C_2H_5Br$ | 0·005 | 6·7 | 0·15 | 0·58 | 2·8 |
| ,, $n$-$C_3H_7Br$ | 0·003 | 6·0 | 0·10 | 0·80 | 3·0 |
| ,, $n$-$C_4H_9Br$ | 0·005 | 4·6 | 0·25 | 1·50 | 3·2 |
| ,, $i$-$C_5H_{11}I$ | 0·003 | 2·8 | 0·20 | 1·55 | 4·3 |
| ,, benzyl Br | 0·005 | 0·5 | 0·10 | 2·20 | 2·0 |

1. Antimuscarine effect on isolated rabbit and guinea pig intestine; atropine = 1.
2. Ganglionic blocking effect on nictitating membrane of the cat; TEA = 1.
3. Curare effect in the frog; *d*-tubocurarine = 1·0.
4. Infiltration anæsthesia on the skin of the abdomen in the rat (ref. 4); procaine = 1·0.
5. Conduction anæsthesia (frog plexus anæsthesia); procaine = 1·0.

* Ganglionic stimulating effect can also be observed.

In the case of tropeines with different stereo-structures, cholinergic-blocking effects undergo entirely different changes when quaternary groups are altered. In our opinion, when measuring anæsthetic action upon conduction, it does not suffice to use methods by means of which the motor response alone can be studied in the case of substances possessing curare activity. The derivatives we used, however, show marked activity from the point of view of infiltration anæsthetic action as well. Thus the higher alkyl, as well as aralkyl, quaternaries show activities similar to those of tertiary compounds. This effect could be observed in the case of other tropeines and other aralkyl quaternaries—for example, α-naphthylmethyl, 1-4-xylylene, as well[5]. This means that the generally accepted view, according to which local anæsthetic action of amines is confined to compounds containing secondary or tertiary amino groups, is not valid. The above view gained general acceptance most probably owing to the fact that it was mainly methyl quaternary compounds that had been studied. The methyl quaternaries have proved to be relatively inactive in the present investigations.

In our opinion, the syn- or anti-position of the OH group of tropine and the aromatic ester group bound to it[3], as well as the character of the quaternary groups, interact to influence the total stereo-structure of the compound, and thus secure the optimal molecular structure required for the different pharmacological effects[5].

Local anæsthetic action of quaternary tropeines showing anticholinergic effect suggests that the local anæsthetic action (using the term in a general sense) should be considered to be an anticholinergic effect.

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Sept. 13.

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## Synthesis of Quaternary Compounds possessing Lasting Local Anæsthetic Action

It has been found that, when compounds with local anæsthetic action containing tertiary nitrogen and belonging to different types of compounds are transformed into alkyl-, but especially into aralkyl-, quaternary derivatives, then the new compounds invariably exhibit a slowly developing local anæsthetic action that, however, is of very long duration. Nádor and Gyermek have found that ganglionic blocking[1] and curare-like action[2] of quaternary compounds are to a great extent dependent upon the type of chain the nitrogen is quaternarized with; therefore alkyl- and aralkyl-quaternary compounds have been used in our experiments.

Synthesis of quaternary compounds has been carried out in the following way. The tertiary compound is brought into reaction in benzene or acetone with the proper alkyl- or aralkyl-halogenide; the reaction proceeds smoothly, but care must be taken to exclude even traces of humidity. In this way, among others, diethyl-benzyl-4-(amino-benzoyl)-β-oxyethyl-ammonium bromide, that is, procaine-brombenzylate, was obtained by the reaction of *p*-amino-benzoic acid-β-diethylaminoethylester and benzyl bromide; melting point, about 120° indefinite; markedly hygroscopic. $C_{20}H_{27}O_2N_2Br$ requires C, 59·65; H, 6·68; N, 6·87; Br, 19·62 per cent; found: C, 59·32; H, 6·66; N, 6·74; Br, 19·60 per cent.

Similar methods have been used for the preparation of pantocaine-brombenzylate from methanol-ether (melting point, 168–70°), and nupercaine-brombenzylate from ethanol-ether (melting point, 183–85°).

Methyl-quaternary derivatives were prepared in the same way. The compounds dissolve readily in water and are stable. Novocaine-brombenzylate decomposes in water, a small amount of benzyl bromide being set free when exposed to prolonged standing.

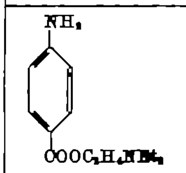
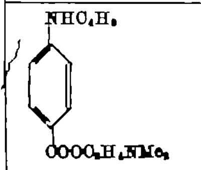
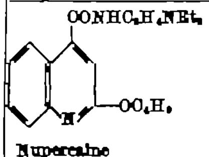
Compounds have been synthesized in other ways as well, and thus evidence has been obtained that the quaternarizing alkyl or aralkyl chain was invariably added to the β-dialkyl-aminoalkyl side-chain. For example, the *p*-nitrobenzoic acid-β-bromethylester, obtained by means of esterizing glycolbromhydrine with benzoylchloride, gave with diethylbenzylamine the quaternary *p*-nitrobenzoyl ester, which, when hydrogenized in ethanol, resulted in a compound identical with the novocaine-brombenzylate already mentioned.

Further evidence of the general validity of the phenomenon is to be seen also in the fact that not only the typical local anæsthetics mentioned, but also compounds of other types as well, completely follow in their quaternary derivatives the local anæsthetics. The latter compounds, to which belong, for example, the parasympathetic blocking agents atropine and diphenylpiperidino acetamide[3], and also pyribenzamine possessing antihistaminic effect, were found to exert, in addition to the effects mentioned, also more or less marked local anæsthetic action in their tertiary forms. These compounds have been produced by the method already described.

The experiments have been extended to a variety of different alkyl, cycloalkyl and aralkyl derivatives, as well as to local anæsthetics of different types. Synthesis of these compounds is being carried out.

According to views accepted generally hitherto[4], tertiary local anæsthetics would lose their local anæsthetic effect following quaternarization. In the case of quaternary compounds the effect usually develops only after a period of about 30 min. (obviously this is the reason why these compounds have been considered to be ineffective); but in numerous cases it is 12–16 hr. before the effect develops. Methyl-quaternary derivatives are generally less effective than are corresponding tertiary compounds; but even the latter are sometimes surpassed by aralkyl derivatives.

Local anæsthetic effect as determined by means of pharmacological investigations[5] of a few characteristic compounds from among the numerous quaternary derivatives are shown in the accompanying table.

| Compounds | | Conduction | Infiltration |
|---|---|---|---|
| | | Local anæsthetic action | |
|  <br>Procaine | tertiary | 1 | 1 |
| | methyl-quaternary | 0·9 | 0·9 |
| | benzyl-quaternary | 2·4 | 6·5 |
|  <br>Pantocaine | tertiary | 6·4 | 8·6 |
| | methyl-quaternary | 2·8 | 7·5 |
| | benzyl-quaternary | 5·1 | 27·0 |
|  <br>Nupercaine | tertiary | 16·0 | 21·4 |
| | methyl-quaternary | 8·1 | 14·9 |
| | benzyl-quaternary | 11·7 | 15·6 |

Details of this investigation will be published in *Acta Chimica Hungarica*. We are grateful to the Hungarian Academy of Sciences for substantial aid and to Miss Magda Markó for assistance with the experiments.

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## An Olfactometer for observing the Behaviour of Small Animals

ONE of the earliest olfactometers was the *Y*-tube type devised by Barrows in 1907[1]. Illustrations of several modifications to this basic design of apparatus are given by Dethier[2]. A difficulty arises in the use of these designs because of the sharp line of demarcation between the odours[3] at the junction of the two arms. On reaching this point, the animal is suddenly confronted with a choice, and has little chance of rectifying a 'mistake' as it is confined to a short narrow tube, at the end of which it is trapped. The relative attractiveness of two odours is estimated by observing the numbers of animals which choose each arm of the *Y*, and there is little or no opportunity for studying other changes in behaviour initiated by the odours.

Thorpe *et al.*[4] studied the chemotropic responses of wireworms in a chamber partly filled with sand over which a stream of air was passed. A longitudinal partition reaching almost to the level of the sand divided the air in the upper part of the chamber into two sides which could each be given a characteristic smell. Although there was little mixing of the gases, the wireworms could pass freely from one side to the other, and their response was judged by counting the number which burrowed into the sand on each side. This is, in effect, a choice chamber in which only the end result is observed.

A new and very simple olfactometer has been designed which consists of a wide flat glass chamber, through which is passed a current of air. The flatness of the chamber minimizes turbulent mixing, and a known part of the air stream can be contaminated with the odour to be tested. The animal's movements and behaviour can be observed and timed as it wanders freely across a known gradient.

Six narrow strips of plate-glass were arranged to form the walls of a hexagonal chamber between two sheets of plate-glass. For the study of the behaviour of the blow-fly parasite *Mormoniella vitripennis* (Walk.) (Hymenoptera, Chalcidoidea), which is about 2·5 mm. in length, a chamber 40 cm. × 16 cm. was used (Fig. 1). The insects were introduced through one arm of a *T*-shaped entrance tube. A rate of flow of approximately 60 cm./min. was used, and smoke trails showed that the airstreams down

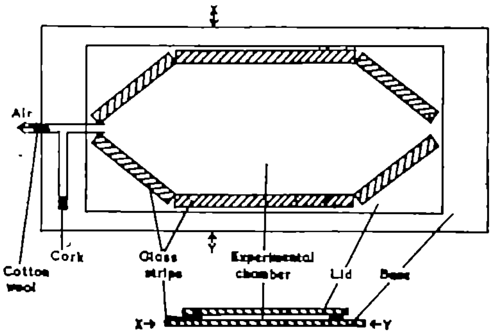

Fig. 1. Plan of the olfactometer, and a cross-section through *XY*

the broadest part of the apparatus were then parallel. The effects of diffusion were observed by drawing ammonia fumes over a smear of hydrochloric acid placed on the shaded square in Fig. 2. The limits of the area covered by the ammonium chloride are shown by the dotted line.

The odoriferous substance to be tested was placed on the shaded square and a single insect introduced through the entrance tube. The track taken by the insect was recorded on a piece of squared paper, arrow-heads being marked at 15-sec. intervals. Each experiment was continued for five minutes or until the insect walked out of the apparatus, whichever occurred first.

In the control experiments, when no odour was present, female *Mormoniella* walked straight through the apparatus. When subjected to the odour of liver on which blow-fly larvæ had been feeding, they remained in the contaminated area and followed a twisting path which frequently led them to the source of the odour. There was no evidence that the insects received a directed stimulus, apart from the tendency to walk upwind which they displayed even when no odour was present (Fig. 2). Once within the area of contamination, the insects remained there, making frequent short-radius turns, which were, however, not confined to the margins of the contaminated area (Fig. 3). Such turns were never observed on control runs, and are to be regarded as a behaviour response to the odour of the hosts' environment.

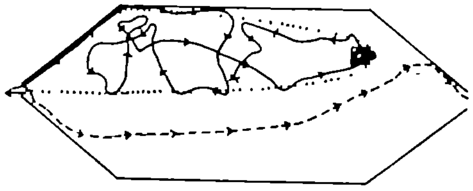

Fig. 2. Track of a *Mormoniella* female when subjected to the odour of liver on which blow-fly larvæ have fed. The dotted line shows the extent of the contaminated area; the broken line shows the track of the female during a control run, when no odour was present

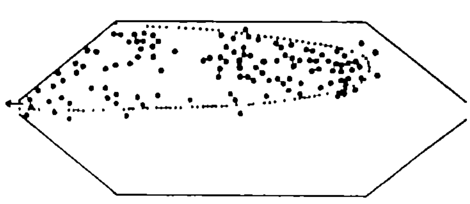

Fig. 3. Points at which *Mormoniella* females executed short-radius turns when subjected to the odour of liver on which blow-fly larvæ have fed. Dotted line shows the extent of the contaminated area. (Results from 14 experimental runs superimposed)

This type of olfactometer has the advantage of easy construction, and it can be very easily cleaned or modified. The animal's behaviour can readily be observed, and movement is less restricted than in other types of apparatus. It should be simple to modify such an apparatus for the study of aquatic animals.

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## Occurrence of Vitamin E in Cod and Other Fish-liver Oils

It has been found with many different animal species that, if the diet is low in vitamin E and is supplemented with cod-liver oil, signs of vitamin E-deficiency result[1]. This observation has sometimes led to the assumption that vitamin E is not present in the oil; but the assumption has not always been confirmed by biological and chemical assays of the oil, although both methods have led to conflicting reports[2]. The following experiments were made in an attempt to clarify the situation.

Preliminary examination of three samples of cod-liver oil by the Emmerie–Engel method indicated the presence of 25·6, 30·2 and 32·2 mgm. total tocopherols in 100 gm. of the oils. Since this method is not specific for tocopherols, a fuller examination was then carried out. The unsaponifiable material, obtained from the oils by alkaline hydrolysis in the presence of pyrogallol, was freed from carotenoids, vitamin A and sterols. Chromatography of the concentrate on 'Vaseline'-coated paper, using 75 per cent ethanol or 90 per cent acetic acid as the developing solvent[3], or on silicone-impregnated paper using 70 per cent ethanol, followed by spraying with $\alpha\alpha'$-dipyridyl and ferric chloride, revealed the presence of a substance which had the same $R_F$ value as α-tocopherol under the variety of conditions described. In addition, a mixture of α-tocopherol and the concentrate gave only one spot on the developed chromatograms.

In view of these results with cod-liver oil, and the observations by Robeson and Baxter[4] that α-tocopherol occurs in two different shark-liver oils, dogfish and Californian jewfish, five other fish-liver oils have been similarly examined. The tocopherol contents are shown in the accompanying table. For each oil, examination of the paper chromatogram revealed the presence of α-tocopherol, and no other substance reducing ferric chloride was found in the concentrates. It is probable, therefore, that α-tocopherol is a normal constituent of fish-liver oils and may act as a natural antioxidant in these oils as well as in vegetable oils.

The results for cod-liver oil confirm the observations of Dam[5] and Blaxter[6] that the typical signs of vitaα-TOCOPHEROL CONTENT OF FISH-LIVER OILS

| Liver oil | α-Tocopherol (mgm./100 gm. oil) |
|---|---|
| Cod | 25·6 ; 30·2 ; 32·2 |
| Angler fish | 31·9 |
| Blue skate | 25·3 |
| Haddock | 18·0 |
| Ling | 27·2 |
| Turbot | 45·0 |

min E-deficiency produced in animals given a ration containing the oil are not due to a deficiency of the vitamin in the diet so much as to the presence of the highly unsaturated acids of the oil.

I am grateful to Dr. J. A. Lovern, of the Torry Research Station, Aberdeen, for the samples of oils.

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## Rapid Production of Malignant Hepatomas by Simultaneous Administration of Tannic Acid and 2-Acetylaminofluorene

IN previous experiments we have proved the cirrhogenic[1] and carcinogenic[2] activity of tannic acid administered parenterally, and that this activity can be influenced by the protein content of the diet[3]. It seemed of interest to examine whether the simultaneous administration of another hepatic carcinogen has an influence on the carcinogenic activity of the tannic acid.

The experiment was made on fifty-six young rats of 115 gm. average body-weight divided into two groups, each group containing identical numbers of males and females. The animals of group 1 were given tannic acid solution subcutaneously once weekly (four doses of 200 mgm. per kgm. 2 per cent aqueous solution, or else 250 mgm. per kgm. 2·5 per cent aqueous solution). The diet of both groups consisted of casein 10 per cent, sunflower oil 10 per cent, cod liver oil 1 per cent, yeast 3 per cent, salt mixture 4 per cent, dextrin 22 per cent, maize grits 50 per cent. To this were added 2·5 mgm. in the first four weeks and then 3 mgm. daily per animal of acetylaminofluorene.

Of group 1 (tannic acid + acetylaminofluorene) thirteen rats died before the 160th day, of group 2 (acetylaminofluorene only) five animals died during the same period and five were killed at different times. The surviving rats were killed on the 180th day of the experiment. Primary tumours occurred only in the liver. The tumours produced could be grouped as follows : group 1, preliminary changes (that is, some changes, at most pinhead-sized nodes) ; group 2, explicit changes (tumours of 2–6 mm. diameter) ; group 3, largest growths (Table 1).

Table 1

|  | No. of rats | Rats with liver tumours (1) | (2) | (3) | Total | Per cent |
|---|---|---|---|---|---|---|
| Tannic acid and acetylaminofluorene | 28 | 7 | 15 | 4 | 26 | 92 8 |
| Acetylaminofluorene | 28 | 6 | 2 | – | 8 | 28·5 |

The largest tumour produced was 5 cm. × 3·6 cm. × 3·6 cm. in size, weighing 27·45 gm. ; this rat died on the 166th day of the experiment. The tumour proved histologically to be an anaplastic malignant hepatoma. Metastases were present in the regional lymph nodes.

It is well known that hepatomas due to the effect of 2-acetylaminofluorene administration[4] occur more frequently in males than in females. In this experiment, however, as a result of the simultaneous administration of tannic acid and 2-acetylaminofluorene, hepatomas developed in all the males and in twelve of the females, whereas acetylaminofluorene alone produced hepatomas in four male and four female rats.

The results for the simultaneous occurrence of hepatomas and cirrhosis are shown in Table 2.

Table 2

|  | Early cirrhosis | Developed cirrhosis | Total | Tumour and cirrhosis |
|---|---|---|---|---|
| Tannic acid and acetylaminofluorene | 7 | 11 | 18 | 17 |
| Acetylaminofluorene | 5 | — | 5 | 1 |

This experiment suggests that : (1) simultaneous administration of tannic acid and 2-acetylaminofluorene greatly increases the carcinogenic activity of these substances on the liver ; (2) liver cirrhosis is an important promoting factor in liver carcinogenesis.

This work will be published in detail in the *Acta Morphologica Hungarica*.

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## Doubling of Chromosomes Induced by Gloriosine isolated from *Gloriosa superba*, Linn.

THE usefulness of colchicine as a chemical in doubling chromosomes in plants was first reported by Blakeslee[1], who obtained polyploids in *Datura stramonium* by treating its seeds with this alkaloid. Since then, colchicine has been extensively used for inducing polyploidy in many species of plants. In announcing an Indian source for colchicine, Parthasarathy[2] reported that, if fresh extract of tubers of *Gloriosa superba* is applied to maize seed before sowing, the developing roots show tetraploid sectors. This confirmed the polyploidizing influence of the alkaloid colchicine present in these tubers, the isolation of which had been reported by Clewer, Green and Tutin[3] in 1915.

Some months ago, tubers of *G. superba* collected from the Deccan and coastal areas of Bombay State were supplied to the National Chemical Laboratory, Poona, for extracting colchicine which was required for cytogenetic and plant-breeding work in this laboratory. During the extraction, Subbaratnam[4] reported the isolation of a new alkaloid allied to colchicine which has provisionally been named 'gloriosine'. Very small quantities of the alkaloids colchicine and gloriosine extracted from *G. superba* were made available for testing their influence in inducing polyploidy. A comparison was therefore made by testing these with colchicine obtained from *Colchicum autumnale*. 0·3 per cent aqueous solutions of the three alkaloids were prepared, and plumules of germinated seedlings of two pure varieties of sann hemp (*Crotalaria juncea*) were kept immersed in the solutions for four hours and were later washed and planted out. When the plants were in flower their ploidy was determined.

Swelling and retarded growth of seedlings treated with colchicine from *C. autumnale* and gloriosine showed that polyploidy had been induced. The percentage of polyploids obtained from each of the alkaloids is given in the accompanying table.

| Source of alkaloid | No. of seedlings treated | Polyploids | |
|---|---|---|---|
| | | Tetraploid | Octoploid |
| Colchicine from *C. autumnale* | 15 | 8 | — |
| Colchicine from *G. superba* | 15 | 5 | 1* |
| Gloriosine from *G. superba* | 15 | 11 | — |

* The ploidy of some plants in this lot has yet to be determined.

The results of the test clearly indicate that both colchicine and gloriosine from *G. superba* have a polyploidizing effect, and that gloriosine promises to be even more effective than colchicine in inducing polyploidy. Further tests on gloriosine are in progress.

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## Identification of 4-Methyl-D-glucuronic Acid in *Eucalyptus regnans* Wood

MANY workers have identified the hexuronic acid components of pectins, gums and mucilages[1]. However, the uronic acid components of wood hemicelluloses have proved difficult to identify. O'Dwyer[2] and Yaramori and Tachi[3] have shown that glucuronic acid is present in the hemicelluloses of beech wood and of elm wood respectively. O'Dwyer[4,5] has obtained, from oak wood, an aldobiuronic acid containing one methoxyl group per uronic acid residue. Also, Sands and Gary[6] have obtained an aldobiuronic acid from mesquite wood hemicellulose: they demonstrated that the aldobiuronic acid contained a methoxyl group and, because of the difficulty encountered in the identification of the uronic acid (viewed in the light of the experience of Anderson and Otis[7]), suggested that the methoxyl group was attached directly to the uronic acid residue.

White[8] and Smith[9] have shown, by different methods, that the acid hydrolysate from mesquite gum (an exudate from mesquite wood) contains 4-methyl-D-glucuronic acid residues.

It has now been demonstrated that the acid hydrolysate from *Eucalyptus regnans* F. v. M. wood also contains 4-methyl-D-glucuronic acid residues. *E. regnans* shavings were hydrolysed with *N* sulphuric acid and the hydrolysate was neutralized with barium carbonate, filtered and concentrated. The barium salts (consisting chiefly of barium aldobiuronate) were isolated by repeated precipitation from aqueous ethanol, and the crude product (Ba, 16 per cent; uronic acid anhydride, 38 per cent; $OCH_3$, 6 per cent) was refluxed for 20 hr. with 8 per cent methanolic hydrogen chloride. The resulting crude methyl glucuronoside syrup (b.p. 132°–136° (bath temp. 185°)/0·1 mm., $n_D^{25}$ 1·48, $[\alpha]_D^{20} + 88°$ in methanol (*c*, 2·8), 29·2 per cent $OCH_3$) was then treated according to Smith[9] to give the amides of 4-methyl methyl-α- and -β-D-glucuronosides. (α-form, m.p. 232°, $[\alpha]_D^{22} + 152°$ in water (*c*, 0 36): β-form, m.p. 228°, $[\alpha]_D^{21} - 62°$ in water (*c*, 0·25).) The mixed α- and β-forms, on analysis, gave: C, 43·37; H, 6·75; O, 42·8; N, 6·51; $OCH_3$, 27·46 per cent; $C_8H_{15}O_6N$ requires C, 43·46; H, 6·84; O, 43·40; N, 6·33; $OCH_3$, 28·06 per cent. Both forms of the amide gave X-ray powder diffraction diagrams the lines of which were identical with those of samples obtained through the courtesy of Dr. F. Smith.

In addition, it was shown that D-xylose (characterized as its dibenzylidene dimethyl acetal, m.p. 211° not depressed on admixture with a sample prepared from authentic D-xylose) was also present in the mother liquors resulting from the crystallization of the mixed amides and, further, that the crude barium aldobiuronate contained no glucosidic methoxyl groups. Hence it is probable that the non-resistant carbohydrate fraction of *E. regnans* wood contains residues of the aldobiuronic acid, 4-(4-methyl-D-glucuronosyl)-D-xylose.

Since this work was completed, our attention has been directed to a paper by Jones and Wise[10], who have shown that the acid hydrolysate from aspen wood contains 4-methyl-D-glucuronic acid.

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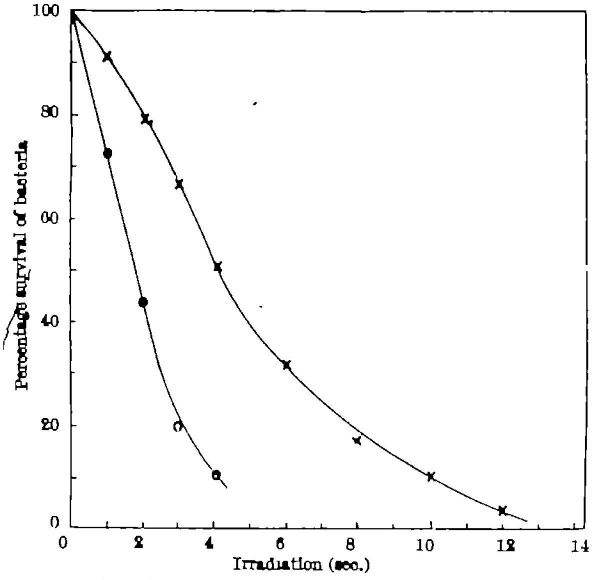
## Susceptibility of Catalase-negative Bacteria to Ultra-violet Irradiation

In the tribe Lactobacteriaceae there are two closely related genera—*Lactobacillus*, which are catalase-negative, and *Microbacterium*, which are catalase-positive. Representative members of these genera were selected, namely, *Lactobacillus pastorianus* (ATC 8291) as the catalase-negative bacteria and *Microbacterium flavum* (ATC 10340) as the catalase-positive bacteria. Both species form distinct colonies and have an optimum temperature near 30° C. The bacteria were reared on Difco's stock culture broth media and buffered with calcium carbonate, and incubated for seven to nine days at 30° C. *L. pastorianus* was diluted 1–10,000 and *M. flavum* 1–50,000 with physiological salt solution, and 1 ml. of the solution placed in the centre of a sterile Petri plate. The aliquot was exposed to ultra-violet radiation from a 40-watt tube, model HUVM-30 (American Sterilizer Co., Erie, Pa.), with about 90 per cent of the radiation at 2537 A. The distance from the tube to the bacteria was 43 cm. and time of exposure was at various intervals from 1 to 14 sec. Thirty plates were run for each time of irradiation, and average results are presented in the accompanying graph. Immediately after irradiation, 15–20 ml. of tomato agar was added to the plate and agitated to distribute the bacteria uniformly around the plate. The plates are incubated for seven days at 30° C. and the colonies counted. Controls were those bacteria which were not exposed to ultra-violet radiation.

The catalase-positive bacteria, *M. flavum*, is more resistant to ultra-violet radiation than the catalase-negative, *L. pastorianus*. Note in the graph that, after 4 sec. exposure to ultra-violet light, 50 per cent of *M. flavum* survive while only 10 per cent of *L. pastorianus* are viable.

Even after 1 sec. exposure there is a 20 per cent difference in survival, with *L. pastorianus* being more susceptible. These results would indicate that catalase does afford some protection from death by irradiation by decomposing the harmful peroxides which are produced, for the chief difference between the species is the presence or absence of catalase. The negative rate of change of the slope of the curve for *M. flavum* in the graph indicates that an enzymatic reaction of the second order is influencing the survival-rate.



×—×—, *Microbacterium flavum* ; ○—○—, *Lactobacillus pastorianus*

Survival-rates of catalase-negative *Lactobacillus pastorianus* and the catalase-positive *Microbacterium flavum* for similar periods of irradiation

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## Mitochondrial Distribution in Saccharomyces

Genetical experiments by Ephrussi and co-workers[1] have adequately demonstrated the existence of extra-chromosomal factors determining the cytochrome oxidase and succino-dehydrogenase activities of yeast clones analysed by them. A particulate nature was ascribed to these factors, and their identity with the mitochondria was suggested in view of the well-known association of the enzymes concerned with these bodies; however, no direct observations on the behaviour of the mitochondria during cell divisions were reported.

In spite of their very small size, the mitochondria of actively dividing yeast constitute the most prominently visible entities of the cytoplasm and are, moreover, not obscured by any other cytoplasmic inclusions. They are recognized by their extraordinarily uniform diameters, their ability to react with the 'Nadi' reagent and with tetrazolium, and by their staining with janus green *B*. Phase-contrast microscopy reveals them with unusual clarity in the living cell, making their behaviour and distribution in budding cells amenable to direct analysis. Table 1 indicates the frequencies of mitochondria in single haploid cells, of monosporic derivation, observed in the microscope field at random. The mitochondrial counts were made under bright contrast with Kohler method illumination and a yellow-green filter. All levels within the cell were carefully focused in succession to ensure a precise count.

The variation in frequency from 1 to 18 per haploid cell bore no relation to the differences in sizes of cells normally occurring in any actively proliferating culture. Thus, for example, small single

Table 1

| No. of mitochondria per cell | No of cells counted | Percentage of cells |
|---|---|---|
| 1 | 22 | 3 8 |
| 2 | 40 | 6·9 |
| 3 | 42 | 7 3 |
| 4 | 80 | 13 9 |
| 5 | 36 | 6 3 |
| 6 | 164 | 20 8 |
| 7 | 26 | 4 5 |
| 8 | 78 | 13·5 |
| 9 | 10 | 1·8 |
| 10 | 26 | 4 5 |
| 11 | 6 | 1 0 |
| 12 | 16 | 2 8 |
| 13 | 2 | 0 3 |
| 14 | 28 | 4 9 |
| 15 | 4 | 0 7 |
| 16 | 4 | 0·7 |
| 17 | 0 | 0 |
| 18 | 2 | 0 3 |
|  | 576 | 100 |

cells (apparently buds that separated early from the mother cell) possessed one to four mitochondria; similarly, larger single cells possessing only one mitochondrion were not uncommon. It will be noted that the number most commonly encountered is six per cell and that cells with four and eight mitochondria occur in equal frequencies, constituting half the percentage of those containing six per cell; also, that even numbers of mitochondria are more frequently encountered than odd numbers, indicating that binary divisions occur once the mitochondria enter the bud.

Direct observation of the migration of mitochondria during budding is possible with phase contrast when cells are mounted in nutrient fluid. A single mitochondrion, invariably found in the mother cell at the point of attachment of the incipient bud, enters the bud at a very early stage after performing energetic movements (usually at 10 min.). This may be followed by the entry of additional mitochondria as the bud grows, but divisions of mitochondria in the mother cell to supply the bud have not been observed though such undoubtedly occur. Fusions between mitochondria have not been observed. Table 2 indicates the distribution of mitochondria between mother cells and attached buds at various stages of bud growth. The sizes of buds relative to the mother cell are arbitrarily determined as ¼, ½, ¾ and equal. Only a few representative cases among many observed are shown.

Table 2

| No. of mitochondria in mother cell | No. of mitochondria in bud (or buds) | Size of bud (or buds) |
|---|---|---|
| 6 | 1 | ¼ |
| 14 | 4 | ½ |
| 6 | 4, 3 | ¼, ¼ |
| 6 | 1 | equal |
| 8 | 1, 1 | ¼, ½ |
| 6 | 2 | ½ |
| 3 | 2 | equal |
| 4 | 3, 1 | ¼, ½ |
| 6 | 6 | equal |
| 6 | 1 | equal |
| 2 | 1 | equal |
| 10 | 1 | equal |
| 2 | 3, 1 | ¾, ¼ |
| 12 | 3, 1 | ¾, ½ |
| 8 | 4, 4 | ¾, ½ |

It will be seen that there is no necessary correlation between the mitochondrial count and the relative size of the bud, or between that of the bud and mother cell. For example, a mother cell with six mitochondria may have only one mitochondrion, or may have six in its bud of equal size; or, a cell with ten mitochondria may have only one in its bud of equal size. These observations suggest that buds become detached at maturity or prematurely from the mother cell with inconstant, frequently low, even single mitochondrial complements, to yield the heterogeneous clones shown in Table 1.

A simple, directly observable explanation is thus provided for the origin from normal cells of occasional clones deficient in a cytoplasmic factor which is restorable on out-crossing to normal cells. It is reasonable to assume that distribution of mitochondria to the bud is random, and would not involve a preferential migration should the mother cell possess mitochondria of aberrant constitution. Indeed, instances of abnormal mitochondria have been reported in higher plants[2,3] and in yeast[4]. The present observations indicate that buds breaking away from the mother cell with only a single, 'mutant' mitochondrion, or without any 'normal' mitochondria, will be expected, as a consequence, to yield clones of 'vegetative mutants' breeding true to type such as the respiratory mutants encountered by Ephrussi. In view of the localization of a variety of enzymes in the mitochondria[5], this mechanism of the origin of vegetative mutants would explain irregularities in terminal genetical characters that are determined through the mediation of mitochondrial enzymes unless alternate pathways due directly to gene products become substituted for these deficiencies.

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## Microbiological Decomposition of Litter

THE decomposition of tree litter has been the object of extensive chemical investigations; but the organisms involved in this process have attracted much less attention. Nevertheless, it appeared of interest to investigate which is the organism opening the attack on dead leaves falling from, or having fallen from, different trees in autumn.

Realizing the possibility that many kinds of organisms might be involved, we were prepared to use agar plates of different compositions; but we were surprised to find that the microflora of the leaves is much more uniform than might be anticipated. We proceeded as follows: from different trees we collected yellowed leaves, some on the point of falling, and others which had just fallen, using sterile tubes and sterile forceps. Without delay the leaves were shaken for several minutes in sterile tap water and a few loops were plated on malt agar. Using leaves of *Forsythia*, *Amelanchier*, oak, beech, apple and peach and many others, soon a very uniform growth appeared, consisting nearly exclusively of white colonies of a yeast-like organism, which proved to be *Pullularia* (*Dematium*) *pullulans* (de Bary et Low) Berkhout[1] (see photograph). A number of strains were isolated which proved to be varieties of this organism, differing somewhat in the rate of colour production (from brown-red to black) but identical in all other respects. In leaves picked up from the soil, secondary infection is not infrequent and often bacteria and moulds are numerous.

*Pullularia pullulans* from decaying litter

*Pullularia* attacks pectin strongly, and accordingly the above suspensions of leaves were also plated on pectin agar[2]. Nearly all the pectin-splitting colonies again were those of *Pullularia*, and only a few colonies of bacteria developed. When freshly collected leaves were kept between two sterile sheets of filter paper moistened with sterile water, the number of *Pullularia* increased considerably during the first two days, and many hundreds were found where only a few were present previously; other organisms were not found to increase in numbers. Hence it appears that not only does the overwhelming majority of the micropopulation of dead leaves of many trees consist of *Pullularia pullulans*, but also that this organism is the first one to develop under conditions similar to those in newly fallen litter. This suggests that the pectin of yellowed leaves is decomposed and thus the path is cleared for other organisms to penetrate into deeper layers; but further investigation is required.

Experiments with litter in a more advanced state of decomposition showed that *Pullularia* tends to disappear and is replaced by other organisms, among which bacteria and a few moulds prevail. Investigations on this secondary flora are in progress.

Meanwhile, it occurred to us that it might be worth while to investigate the microflora of leaves at the moment of budding, and so in early spring we made the same experiments with small green leaves, just after their appearance and also at a time when they were merely green buds. Again, among the pectin-splitting organisms *Pullularia* was frequent. In a quantitative experiment, 1 gm. of fresh leaves (*Amelanchier*) was shaken with 100 ml. of water for 5 min. and 0·1 ml. was plated. Four splitting colonies were found, three being *Pullularia*, or 3,000 per gm. of leaf. When the leaves were kept between moist filter paper for three days the number had increased to 287,000 per gm. Young leaves of beech were positive for *Pullularia*; oak and fir showed only fungi, some of which were pectin-splitting varieties. But again, after a few days between moist filter paper, the number of the pectin-splitting fungi had increased so abundantly that counting in 0·001 ml. was impossible. Hence decomposition of pectin by a small number of micro-organisms appears to be of very early occurrence in the decomposition of fallen litter.

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## Effect of Added Primer on Lima Bean Phosphorylase

FORMATION of an amylose-type polysaccharide from glucose-1-phosphate by the action of phosphorylase does not take place unless a small amount of starch, glycogen or dextrin is added as the priming agent. The primer, which is sometimes called activator, is required presumably because the enzyme is unable to cause the condensation of glucose-1-phosphate, but acts only by transferring glucose units from glucose-1-phosphate to the non-reducing end of an already existing polysaccharide chain[1]. There have been reported, however, two exceptions which were claimed to require no added primer in this reaction; one is purified phosphorylase of lima bean, as reported by Green and Stumpf[2], and the other is that of sweet potato, as reported by Inoue and Onodera[3]. In both cases, according to these authors, the addition of different types of primers in various amounts had little or no effect on the initial velocity of this reaction catalysed by respective enzymes. In the case of purified lima bean phosphorylase, the possibility that the enzyme preparation might be contaminated with polysaccharide was excluded, since this preparation could not serve as a source of a polyhexose catalyst for purified potato enzyme.

In an earlier study[4] of the inhibition of phosphorylase by β-amylase, such as that found in crude extracts of sweet potato, barley or wheat, it was concluded that this inhibition might be due to destruction of added primer by the action of β-amylase to give limit dextrins, which had no priming effect on phosphorylase. Addition of appropriate amounts of mercuric compounds to these extracts, so as to inhibit selectively the β-amylase activity, enables phosphorylase in these extracts to utilize the added primer, and in this way phosphorylase activity can be detected in the presence of β-amylase[5]. It was found later[6] that purified potato phosphorylase, although still contaminated with a small amount of β-amylase, actually required the added primer in the synthesis of starch from glucose-1-phosphate.

Lima bean phosphorylase was purified by the method of Green and Stumpf[2]. The purest preparation thus far obtained after eight fractionations with ammonium sulphate with frequent dialyses had a specific activity (enzyme activity in units (37°)/mgm. protein) of 0·62, thus indicating that this preparation was much inferior in purity to purified potato enzyme, the specific activity of which was usually 2·5–3·0 after four fractionations. No further purification could be attained by the use of various procedures.

Nevertheless, this preparation required an added primer in the synthesis of starch from glucose-1-phosphate, as can be seen in a typical experiment represented in Fig. 1. From this and other similar experiments, the enzyme–primer dissociation constant was calculated by the graphical method of Lineweaver and Burk[7]. The value of $Ks$ thus obtained was 1·05 mgm. Lintner's soluble starch per 3·5 ml., or approximately 30 mgm. soluble starch per 100 ml. This is comparable with the values previously obtained for potato phosphorylase (41 mgm. Lintner's soluble starch per 100 ml.[8]; 97 mgm. Zulkowski's soluble starch per 100 ml.[9]) and for crystalline muscle phosphorylase[10] (20 mgm. glycogen per 100 ml.). The iodine colour reaction of the products of this reaction, using a small amount of dextrin (Merck; iodine colour, red) as the source of primer, changed from red-purple via purple to deep blue, indicating the formation of an amylose-type polysaccharide.

The purest enzyme preparation used in the above experiment still contained a trace of primer polysaccharide, as can be seen in a typical experiment represented in Fig. 2. Treatment of the boiled lima bean enzyme with purified sweet potato β-amylase was effective in removing the contaminating primer, which is a further proof of its polysaccharide nature. The exact amount contained in the purified lima bean preparation was not determined, but a simple calculation shows that the amount is far less than 2 mgm. soluble starch per ml. enzyme preparation, which is enough to give a half-maximal activity to the potato enzyme in the experiment of Fig. 2. This amount of polysaccharide, which corresponds to 0·05 mgm. soluble starch contaminated in the lima bean enzyme used in the experiment of Fig. 1, will give an error of approximately 5 per cent in the determination of the $Ks$ value; an error of this order is permissible in experiments of this nature.

Although I cannot account for the results obtained by Green and Stumpf, it can now be said that, without exception, phosphorylase requires an already existing polysaccharide primer in the synthesis of starch from glucose-1-phosphate.

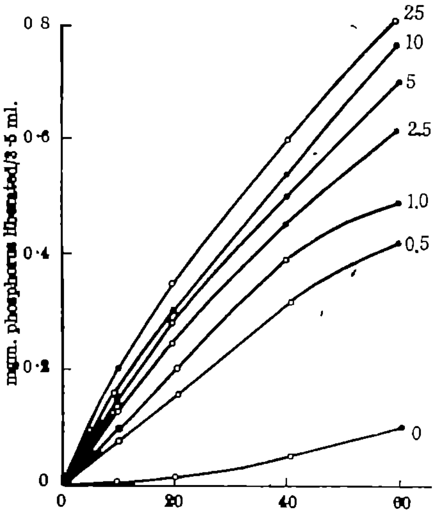

Fig. 1

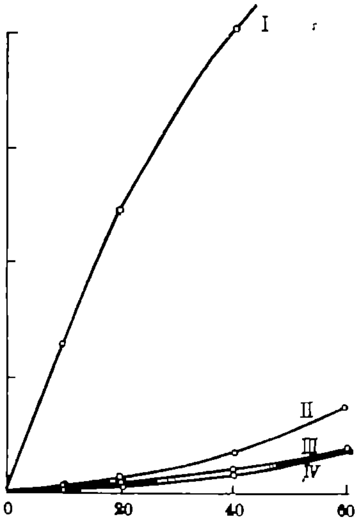

Fig. 2

Fig. 1. Effect of added primer on purified lima bean phosphorylase in the synthesis of starch from glucose-1-phosphate. The reaction mixture contained 1 ml. 0·5 *M* acetate buffer ($p$H 6·0), 0·5 ml. purified lima bean phosphorylase (prep. *LB.B8*; 1/20 diluted), 1 ml. 0·1 *M* glucose-1-phosphate, and various amounts of Lintner's soluble starch as indicated on the curves. Total volume, 3·5 ml. Incubation temperature, 37 ± 0·1°. At intervals, samples were withdrawn from the digests, deproteinized with 5 per cent perchloric acid, and tested for inorganic phosphorus

Fig. 2. Effect of primer polysaccharide in purified lima bean phosphorylase. The standard digest (curve IV) contained 1 ml. 0·5 *M* acetate buffer ($p$H 6·0), purified potato phosphorylase, and 1 ml. 0·1 *M* glucose-1-phosphate. Other digests contained in addition: curve I, 25 mgm. Lintner's soluble starch, curve II, 0·5 ml boiled lima bean enzyme (prep. *LB.B8*); curve III, 0·5 ml. boiled lima bean enzyme, treated with purified sweet potato β-amylase, and heat-inactivated. Total volume of each digest: 3·5 ml. Incubation temperature: 37 ± 0·1°. At intervals samples were withdrawn, deproteinized with 5 per cent perchloric acid, and tested for inorganic phosphorus

The lima bean used in this study was a commercial product (Baby lima beans from Chester B. Brown Co., Morrill, Nebr., U.S.A.), made available by the courtesy of Messrs. S. Wada and N. Yamada, to whom I wish to express my thanks.

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# Experimental Dissociation of Cells from Chick Embryos

DURING the development of an embryo, a very important part is probably played by the forces of attachment between cells. Weiss[1] in particular has emphasized the importance of interactions between cell surfaces in the processes leading to tissue differentiation. Holtfreter[2,3] has shown that the cells of the young amphibian embryo can be dissociated experimentally by alkali-treatment, and Mookerjee *et al.*[4] has made a comparative study of the firmness of cell-attachment both in different species of Urodele and during the course of differentiation of one particular organ, the notochord. A similar type of cell-dissociation has now been shown to occur in the chick embryo.

Whole embryos, or parts of them, at the primitive streak stage, are placed in chick Ringer solution the $p$H of which had been brought to 9–9·2. Within a few minutes the cells fall apart either singly or in small groups. The cells are at first rounded, but may later become elongated or flattened, with irregular outlines. An intake of water clearly occurs, and an ectoplasmic layer may be lifted off from the endoplasmic interior. The ectoplasm may assume the form of a lobular pseudopodium, which can appear at any point on the cell surface. With increasing imbibition of water the ectoplasm may be lifted away from the endoplasm over the whole surface of the cell. Churning movements are visible within the endoplasm. Over-exposure to alkaline media renders the cell surface so permeable that large visible particles may leak out through the membrane, which eventually may take on a crenated appearance shortly before the death and complete disintegration of the cell. Except in the final stages, these cell changes are quickly reversible by alteration of the $p$H to the acid side. The general picture is thus extremely similar to that seen in the tissues of early amphibian embryos.

After the experiments reported here were concluded, Moscona and Moscona[5] have published observations on the dissociation of tissues of later stages of the chick embryo.

The work described here was carried out while I held an I.C.I. Research Fellowship of the National Institute of Sciences, India. Thanks are due to Dr. Subodh Mittra, director of the Chittaranjan Cancer Hospital, for the provision of laboratory facilities.

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## Rapid Specific Preventive Action of Tetanus Toxoid

KRECH[1] has found that mice infected with tetanus spores could be saved by toxoid alone, an antitoxin not being used, whereas the control animals died. He also gave toxoid in two doses 24 and 48 hr. before a lethal dose of toxin. The eight mice injected with toxoid survived while the two control animals died on the sixth and ninth day respectively. He concluded that these effects were due to the rapid formation of antibodies. Lemétayer[2], also using toxoid, was able to produce a retardation of the onset of the signs of tetanus if he gave it one day before the toxin.

Raynaud *et al.*[3], using larger doses of toxoid, given one day before, were able to prevent all signs and lethal effect of 1 minimum lethal dose (m.l.d.) of toxin. These results were obtained by subcutaneous injections into the hind limbs, and there was the possibility that these effects could be either local or non-specific. Again, the effect may only have been produced if the toxin and toxoid were made from a filtrate produced by one strain of organism.

In the experiment described below, an attempt was made to overcome these objections. The toxoid was given intravenously, a toxoid from another laboratory was used, and an extra control group of mice was given diphtheria toxoid.

Table 1. MICE WERE GIVEN 1 M.L.D. OF TETANUS TOXIN SUBCUTANEOUSLY. SOME HAD RECEIVED VARIOUS TOXOIDS INTRAVENOUSLY 24 HR. EARLIER

| Type and dose of toxoid | No. of mice used | No. of animals dying of tetanus in less than 6 days | Remarks |
|---|---|---|---|
| Tetanus (Copenhagen) 500 Lf | 6 | 0 | None died or showed local tetanus* |
| Diphtheria (Copenhagen) | 6 | 6 | All showed local tetanus on second day after toxin |
| Tetanus (Pasteur) 700 Lf | 6 | 0 | None died or showed local tetanus* |
| Nil | 6 | 6 | All showed local tetanus on second day after toxin |

* Observed for 20 days.

The results in Table 1 show that tetanus toxoid given intravenously completely prevents the onset of local tetanus and death from 1 m.l.d. of toxin given subcutaneously 24 hr. later. The amount of toxoid used was very large when compared with the amount of toxin, for as 1 Lf of toxin is approximately equivalent to 10,000 mouse m.l.d. of toxin, the toxoid/toxin ratio in these experiments is approximately $5 \times 10^6$ to $7 \times 10^6$.

In another experiment it was found that 200 Lf of toxoid gave complete protection against 1 m.l.d. of toxin but not against 4 m.l.d. Using this smaller dose of toxoid, 1 m.l.d. of toxin was given to groups of mice at increasing intervals after the toxoid (see Table 2). These results show that the protection lasts only a short time, for even when the toxin was given two days after the toxoid few animals survived. When the interval was six days no protection was found.

Krech's suggestion that this phenomenon is due to rapid formation of antibody appears to be untrue, as no antibodies have been detected during the first days after administration of toxoid (unpublished work). The most probable explanation of the action of toxoid would appear to be either a prior blocking of the hypothetical receptor substance in the central nervous system, similar to an interference phenomenon, or a competitive inhibition of the action of the toxin.

Table 2. TETANUS TOXOID (200 LF) WAS INJECTED INTRAVENOUSLY INTO MICE AND 1 M.L.D. OF TOXIN WAS GIVEN SUBCUTANEOUSLY 1–6 DAYS LATER

| Intervals between giving toxoid and toxin (days) | No. of animals in each group | Number of animals surviving at various times after the injection of toxin (days) | | | |
|---|---|---|---|---|---|
| | | 4th | 8th | 12th | 16th |
| 1 | 6 | 6 | 6 | 6 | 6 |
| 2 | 6 | 6 | 4 | 2 | 1 |
| 3 | 6 | 6 | 4 | 2 | 2 |
| 4 | 6 | 6 | 3 | 2 | 1 |
| 5 | 6 | 4 | 3 | 2 | 1 |
| 6 | 6 | 3 | 2 | 1 | 0 |

The phenomenon is being investigated to determine which of the two probable explanations is correct, and also to find out if other toxoids can protect animals from their analogous toxins.

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## Isotope Curves in Red Blood Cell Studies

WHEN iron-55 or a carbon-14—or nitrogen-15—labelled substrate is fed to an individual, a portion of the isotope is incorporated in red cell hæmoglobin[1-4]. Curves of subsequent changes in the amount of isotopic excess can be explained and used for calculating the survival curve of red cells, as well as their average time of utilizing the incorporated substance.

A schematic curve is shown in Fig. 1 over a time scale marked at about 30-day intervals. The tagging during the first month reflects mitosis and maturation in the bone marrow, while the plateau of the second month shows completion of the isotopic uptake. Mollison[5] and Rimington[6] gave qualitative descriptions of the reutilization represented by the singly hatched area of Fig. 1.

To get the average cell life $L$, the reutilization fraction $r$, and the average material utilization time $T$, consider Fig. 1 with total hatched area $A$, cross-hatched area $A'$, and $B$ and $H$ as shown. A convenient method of determining these areas consists of plotting them on paper of known and uniform mass per unit area, cutting out and weighing the outlined areas, and calculating them from their masses. Then $T = A/H \doteqdot A'/(H-B)$ and $L \doteqdot A'/H$ and

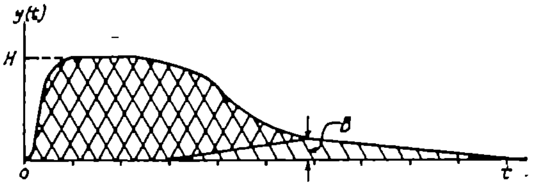

Fig. 1. Schematic curve of isotopic tagging of red-cell hæm

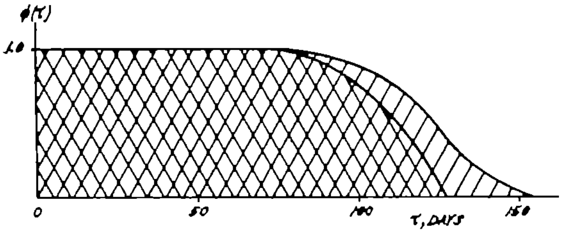

**Fig. 2.** Approximate survival curve of animal red cells (ref. 1) including designation of the wearing fraction

$r = l - L/T \doteqdot B/H$. In normal cases[1-3,7], $L$ is 100–130 days, $T$ is between 125 and 145 days for nitrogen and carbon and between 390 and 580 days for iron, while $r$ is 0·1–0·25 for nitrogen and carbon and 0·65–0·8 for iron.

To determine the fraction of red cells surviving to each age of $\tau$ days, or $\varphi = \varphi(\tau)$, let $y_0 = y_0(t)$ represent the height of the cross-hatched area above time $t$. With this correction for reutilization, apply equation (16) of ref. 1 in the form

$$\varphi(\tau) = y_0(\tau+\tau_0)/H - \frac{dy_0(\tau+\tau_0)}{d\tau}\Big/ bH,$$

which allows a correction of a couple of days, $\tau_0$, for averaging out any prolongation of the feeding time and for deducting the initial lag of about a day in the release of tagged cells—the $b$ of this equation is the fraction (empirical) of previously unreleased tagging that is released each day. To obtain further detail in the description of red cell survival, consider the two sequential stages in the lives of circulating red cells[8]. These are (i) a period of wearing and (ii) a subsequent random breakdown of worn cells. Evidence of these two stages is found in Ashby curves discussed in an earlier communication[8]. If $k$ is the rate of random breakdown, or $\max_{\tau}\left(\frac{d\varphi(\tau)}{d\tau}\Big/\varphi(\tau)\right)$, and if $\varphi_1(\tau)$ is the fraction of cells still undergoing wearing at time $\tau$, then $\varphi_1 = \varphi_1(\tau) = \varphi(\tau) - \frac{d\varphi(\tau)}{d\tau}\Big/k$. The result of applying the equations for $\varphi$ and $\varphi_1$ to a normal case[1] is shown in Fig. 2, in which $\varphi$ covers the total hatched area and $\varphi_1$ covers the cross-hatched area. Because of the reutilization correction, these results are an improvement on those of Shemin and Rittenberg[1], while the addition of $\varphi_1$ is a motivated extension.

The $\varphi$ used here is the same as that of Callender, Powell and Witts[9], but its determination is more direct in the isotope studies than in the Ashby studies. The case of Fig. 2 shows a wider spread in the times of declining $\varphi$ than do their Ashby cases.

The proper value of $L$ is given by $L = \int_0^\infty \varphi(\tau)d\tau$, and this agrees with the above expressions for $L$. These estimates of $L$ are more accurate than the earlier assumption of symmetry of $\frac{d\varphi(\tau)}{d\tau}$ about $\tau = L$[1,7]—although the latter procedure tends to compensate for the lack of the reutilization correction.

Diseases like sickle cell anaemia[7], which involve relatively short values of $L$, are still incompletely analysed.

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## Red-Cell Survival and Ashby Curves

Callender, Powell and Witts[1] gave an expression for the determination of the fraction of red cells surviving to age $\tau$, or $\varphi = \varphi(\tau)$, from the Ashby curve[2] of $Y = Y(t)$, which is the number of transfused red cells surviving in the recipient at time $t$. Their equation is, with average red-cell life $L = \int_0^\infty \varphi(\tau)d\tau$, $\varphi(\tau) = -L\frac{dY(\tau)}{d\tau}\Big/Y_0$, where $Y_0$ is the number of red cells transfused (these are assumed to be a representative steady-state population). The importance of this result has not previously been fully realized.

The application of the above expression for $\varphi$ should be extended considerably when it has been supplemented with a good method of determining the scale factor $L/Y_0$. The determination of $L$ in this factor appears to require previous knowledge of $\varphi$.

However, $\varphi(0) = 1{\cdot}0$, so that $L/Y_0 = -1\Big/\frac{dY(0)}{dt}$, and thus the difficulty can be solved by getting a good value for the initial Ashby slope, $dY(0)/dt$, at least whenever the curve is not complicated by donor-recipient differences. In the latter cases $dY(0)/dt$ can be determined by extrapolation from later times on a preliminary plot. Ashby curves showing rapid cell destruction are essentially exponential, whereas those showing the slower normal destruction are roughly linear, so the preliminary plots of $dY(t)/dt$ should be made on semilog and linear paper, respectively, for those two types of $Y$ curves. With this judiciously chosen (possibly extrapolated) value of $dY(0)/dt$, the final result is

$$\varphi(\tau) = -\frac{dY(\tau)}{d\tau}\Big/\frac{dY(0)}{d\tau}.$$

According to the motivated interpretation of Ashby curves[3], the circulating red cells undergo two successive stages in their life-history: (i) a period of wearing the duration of which depends on the donor, except in recipients having acquired anæmia, and (ii) a period of subjection to a first-order random breakdown at a rate that depends on the surrounding environment and which can therefore differ between donor and recipient. This interpretation agrees with Callender, Powell and Witts's result, and it further shows that if $\int_0^\infty \varphi(\tau)d\tau$ is calculated from the $\varphi$ observed in the recipient, it will give the $L$ for the donor (except with recipients having acquired anæmia) because of a compensation between the effects of donor-recipient differences at the two ends of the observed curve.

Fig. 1 illustrates the result of applying this treatment to a curve of normal cells in a recipient with idiopathic hypochromic anæmia[4]. For this case $L$ is about 85 days. It shows a greater spread in the times of declining $\varphi$ than do the curves of Callender, Powell and Witts[1]. In that regard it resembles more closely the normal survival curve determined by the more direct and therefore more accurate method of isotopic tagging[5,6].

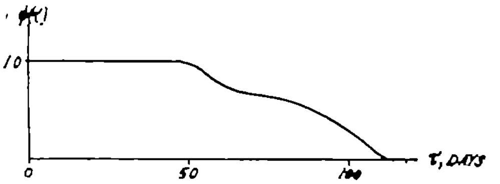

Fig. 1. Approximate survival curve of normal cells in a recipient with idiopathic hypochromic anæmia (ref. 4)

However, the results of isotopic tagging in cases like sickle cell anæmia, which involve short values of $L$, are not yet fully explained[7]. On the other hand, Fig. 2 shows $\varphi$ for sickle cell anæmia as calculated by the above method from an Ashby curve of Callender, Nickel, Moore and Powell[8]. For this case $L$ is about six or seven days. The $\varphi$ curve is evidence of wide gradation between a large fraction of cells that die rapidly and a much smaller fraction with much longer survival times. In particular, the original Ashby curve is represented approximately by the equation $Y(t) = 0{\cdot}35\,(\exp - 0{\cdot}25t) + 0{\cdot}29\,(\exp - 0{\cdot}035t)$, so that empirically about $0{\cdot}35 \times 0{\cdot}25/(0{\cdot}35 \times 0{\cdot}25 + 0{\cdot}29 \times 0{\cdot}035)$, or 0·9 of the cells may have an average life of about 1/0·25 or four days, while the rest may have an average life of about 1/0·035 or thirty days. This result should aid the eventual elucidation of such cases.

This investigation was sponsored by the Veterans Administration and is published with approval of the Chief Medical Director. The statements and conclusions published by the authors are the result of their own study and do not necessarily reflect the opinion or policy of the Veterans Administration.

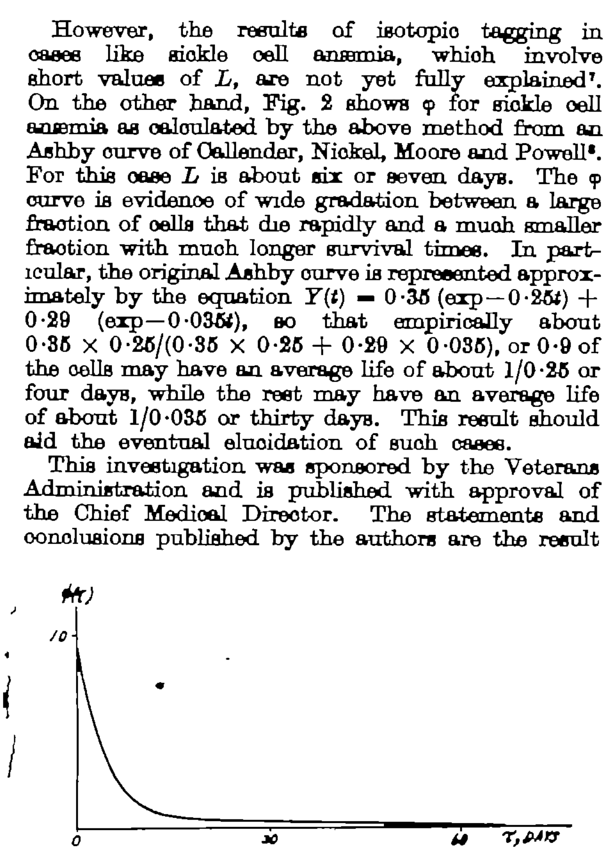

Fig. 2. Approximate survival curve of cells from a donor having sickle cell anæmia (ref. 8)

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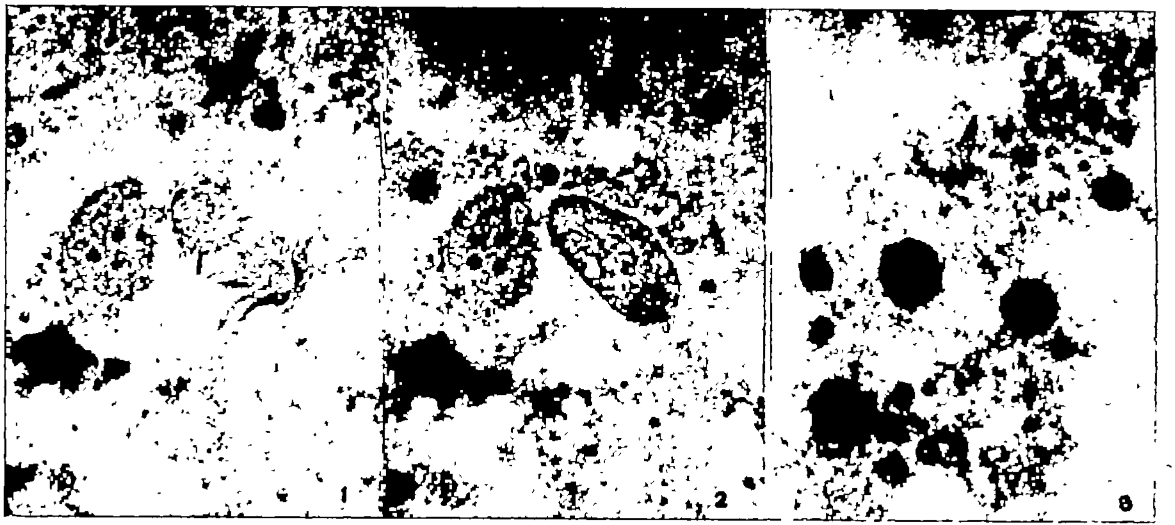
## Dividing Nuclei in Coconut Milk

Cutter, Dubé and Wilson[1] have published some interesting information regarding the growth and development of the coconut fruit. Apart from physiological studies on the growth and development of the endosperm tissue, they have detected the presence of free nuclei suspended in the milk, and by slowly centrifuging the milk they have successfully isolated such nuclei in the living state. The present observations have resulted from an attempt to follow up that work to see whether the fruit with its exposed nuclei can be used as a living receptacle for testing the direct effect of antibiotics and other substances on chromosomes. Hitherto, such studies have been confined to onion root tips, which can be made to grow in water.

Coconuts of graded size were collected from the experimental station of the Bose Institute and stored in the cold room (25° ± 2° C.) for a week. Fruit were cut open every day to observe (1) in which stage the free nuclei appeared, (2) whether growth of tissue took place by somatic divisions, and (3) whether division could continue in fruit after they had been picked from the tree. The solid or semi-solid endosperm and drops of the liquid milk were fixed in acetic alcohol and aceto-carmine, or Feulgen squashes were afterwards prepared. As observed by Cutter *et al.*, the tissue is at first a syncitium but later becomes walled. It will be seen from the accompanying photographs that the nuclei are of different sizes, in the present instance varying in diameter from 16·6 μ to 72·2 μ. The meristem of the endosperm creeps along the inner face of the endocarp, starting from the micropylar end towards the other side and covering the walls completely as it progresses. The endosperm grows also in thickness; but due to the large size of the embryo sac, the inner cavity is never completely filled up, and there is a little water containing free nuclei right up to the end of development in the mature fruit. This type of embryo sac is unknown in other families and cannot be classified under any of the types of Maheshwari[2] or Johansen[3].

A drop of milk mounted without fixation or staining may be seen to carry many of these free nuclei, some of which may even be in the dividing state, with large spindle, chromosomes and perhaps an



Photographs from a drop of water mounted straight from the fruit. (1) Two free nuclei, one in resting condition and the other at late telophase. There are fragments of cytoplasm and some bacteria in the field. All are suspended in the water or 'milk'. (2) The same two nuclei photographed 10 min. later. The one at telophase has reverted to one nucleus, conditions being unfavourable for the progress of division. (3) Nuclei of various sizes embedded in a floating mass of cytoplasm. Nuclei have taken up the vital dye, acridine orange. × 3,500

adhering film of cytoplasm. Chromosomes may be visible under high power (× 400) only. Regular somatic division figures, however, have been seen in free nuclei adhering to the tissue, in those inside the syncitium and in those in the walled tissue. Chromosome counts have been obtained from stained material. They vary from $32(2n)$, $48(3n)$ to $160(10n)$. The meristematic syncitium of the fruit may show abundant division figures after being stored in the cold room for as long a period as eight days, but not if kept in the refrigerator for even six hours. At the latter temperature (5° C.), nuclei pass into the 'resting' stage.

Cutter, Dubé and Wilson were not able to detect any division figures in the endosperm and concluded that the tissue perhaps divides 'amitotically'. Present observations do not support this view. These authors also mention that free nuclei are found in the milk before endosperm development begins, and they think that development of the endosperm is initiated by deposition of these nuclei on the walls of the embryo sac. My observations, however, show that the free nuclei do not appear in the water until a little of the endosperm, if only the barest film, has begun to form. It appears more likely that these free nuclei become detached from the loose jelly of the syncitium and become suspended in the water. Otherwise, their origin is difficult to visualize.

Further cytological and experimental work is being carried out with this very promising material, which yields such large numbers of chromosomes almost directly exposed in the water, unbounded by cytoplasm or cell wall. Preliminary observations have been made on the fruit of the betel nut (*Areca catechu*, Linn.), which resembles the coconut fruit in appearance and development, starting with the large embryo sac cavity filled with water, although about a twentieth the size of the coconut fruit. In this case the little cavity, containing not more than 2 c.c. of water, finally becomes completely filled by growth of the endosperm, and the edible nut is actually formed of the hardened endosperm. In a drop of the water mounted under the microscope, the same type of free nuclei can be seen, some of them dividing, with the large spindle figure and chromosomes discernible under high power. The chromosomes are smaller than those of the coconut.

Coconuts and allied fruits are therefore not only good sources for obtaining measurable quantities of free nuclei, as found by Cutter, Dubé and Wilson, but may also be observed for chromosomes as well. They are easily accessible, yield a great deal of material and may be stored for days without deterioration.

Thanks are due to Dr. D. M. Bose, director of the Bose Institute, for his encouragement in the work, and to Sri K. L. Chaudhuri of the Institute for the photomicrographs.

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## Occurrence of *Verticillium* in Potato Tubers in India

*Verticillium* wilt of vascular plants has been reported from various countries. In India it has been recorded by Patel, Qureshi and Bhide on egg plants (*Solanum melongena*)[1]. Though very common in potatoes, it has not been noticed in India until now.

In September 1952, while collecting potato tubers from different cultivated crops in the Bhowali–Naini Tal area, we came across several diseased tubers, one of which yielded species of *Fusarium* and *Verticillium*. This species of *Verticillium* closely resembles *V. albo-atrum* R. and B.

On potato dextrose agar its characters are as follows: conidia ellipsoidal, unicellular 4–8 × 1·5–3 μ; primary whorl of branches, 2–7 in number and 32–48 μ apart, bearing secondary branches; conidiophores, 120–230 μ in length. The terminal branch of the conidiophore is 16–24 μ in length. Conidia are sometimes collected in heads on the sterigmata tips.

This is the first report of *Verticillium* attacking potatoes in India. Presumably it causes considerable damage to potato crops here. Further work on the morphology, cultural characters and pathogenicity is being studied in detail.

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## A Cinematographic Technique, using Ultra-violet Illumination, for Amphibian Blood Circulation

EVER since Marey[1] used cinematographic techniques in 1892 for recording the circulation in a tortoise's heart, many biologists have found the ciné camera a useful instrument for the registration of cardiac movements. Many details of amphibian circulation are, however, not yet fully agreed upon, and in a series of recent papers, Foxon[2] revived the controversy about the selective or non-selective distribution of the oxygenated and de-oxygenated blood to the arterial arches in the heart of the frog, *Rana temporaria*. While Foxon claimed to have established a non-selective distribution by means of direct X-ray cinematography, the present work shows that, in *Hyla cærulea* at least, the blood is sometimes distributed in the manner postulated by the classical theory of Brucke and Sabatier; that is, the streams of deoxygenated and oxygenated blood are kept distinct and distributed selectively to the arterial arches.

Direct X-ray cinematography has always suffered from the necessity of moving comparatively large masses of sensitive material and of using lead-shutters, and has thereby restricted the frequency and total duration of exposure. Foxon was able to obtain only fifteen pictures for each experiment at 3 frames per sec. recording two to three cardiac cycles during the 5 sec. of his total exposure. The present technique consisted in the direct recording, at 16 frames per sec., of the exposed amphibian heart on colour film, using a source of illumination rich in the ultra-violet region of the spectrum and showing up blood circulation by the injection of fluorescein.

After opening the abdominal cavity of an anæsthetized frog, *Hyla cærulea*, about 1 c.c. of frog-Ringer solution containing 0·005 gm. of fluorescein per ml. was injected slowly into either the anterior abdominal or the left jugular vein. The source of illumination was a 500-W. D.C. high-pressure mercury vapour lamp, and in order to eliminate most of the visible light, a Corning filter, No. 5113, having a transmission of 45 per cent at 4050 A., was interposed. Similarly, to absorb any reflected ultra-violet radiation, a Corning filter, No. 3421, was placed between the amphibian heart and the lens of the ciné camera. A Ciné Kodak Special I, with a 63-mm. lens, *f* 2·7, and 50-mm. extension tube, was used and records of considerable contrast resulted. Due to the heavy absorption of the filter No. 5113, the colour balance of the Kodachrome, type *A*, was materially upset and produced bright yellow blood-vessels on an under-exposed blue background, a highly desirable and not unpleasing effect. Evaluation of the films was carried out by preliminary loop-projection and later by detailed frame analysis.

Apart from immediate visual inspections on thirty other frogs by one of us (J. R. S.), a total of eight cinematographic records were made with the above technique, six of which showed a non-selective distribution of the blood and two a highly selective distribution in which the dyed venous blood passing out from the ventricle was sent to the pulmo-cutaneous and systemic arches but not to the carotid arch. In one of these two films the dye is seen clearly entering the pulmo-cutaneous arch before it appears in the systemic arch. This type of distribution conforms so closely to that postulated by the classical theory that we consider Foxon's categorical statement: "the classical hypothesis is, quite frankly, wrong" to be untenable as a general statement, and that in certain circumstances the blood is distributed as Brucke and Sabatier have postulated.

Further work is proceeding in order to determine what the exact circumstances are which bring about this selective distribution; but in the meantime it is hoped that the cinematographic technique, described above, might prove useful to other workers in this and other biological investigations.

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Jan. 29.

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THE method described by Simons and Michaelis for the study of the amphibian circulation seems to promise to be useful, and full results should be most interesting.

Before, however, I can begin comparing the results of Simons and Michaelis on *Hyla cærulea* with my own and those of other workers who have used *Rana temporaria* and *Bufo bufo*, it seems desirable that we should agree as to what precisely the term 'classical hypothesis' denotes. My own view has been that it is a hypothesis concerning the mode of action of the anuran heart which accounts for a selective distribution of the blood from the two auricles (I do not call it 'oxygenated' and 'deoxygenated' blood, for in *Rana* there is no evidence that the degree of oxygenation of the blood in the two auricles is constantly different). The real basis of the 'classical hypothesis' is differences in pressure in various vessels, which cause the blood leaving the ventricle during different phases of systole to be directed in various ways, causing differences in the time of movement of the blood in the principal arteries. Also, blood is supposed to flow at one time up one side of the spiral valve of the conus and another time up the other side. Vandervael[1] stated that these time differences were not to be seen in frogs in which the heart and arteries were viewed by trans-illumination. I confirmed[2] his results using similar methods; thus the evidence that the heart of the frog *Rana temporaria* does not function in the manner of the classical hypothesis has nothing to do with injection studies of any kind. The classical hypothesis of the mode of action of the heart is, I believe, not correct. This, however, as I[2] pointed out, does not preclude a selective mechanism of distribution of blood brought about by the anatomical arrangements of the heart. Vandervael[1], by the injection of indian ink in *Rana*, concluded that mixing of the blood from the two auricles was complete, and I[2] have said that the mixing of the indian ink was considerable; Savolin[3], working on *Bufo bufo*, also found that mixing was considerable, although there might be some selection whereby the carotid arteries received slightly less of the blood from the right auricle than did the systemic and pulmo-cutaneous arches.

The radiographic studies referred to by Simons and Michaelis have been undertaken mainly as an illustration of the results achieved by indian ink injections. It was hoped that perhaps the densities of the shadows might have allowed of some evaluation of the degree of mixing taking place, but this has not been possible. I have never claimed to have demonstrated complete mixing; however, I believe mixing to be considerable.

I believe that in Anura we see a group of animals which have become greatly modified in many respects, not least in regard to skin respiration. In correlation with skin respiration we see also a highly modified heart, for I think it likely that in early Amphibia the division of the heart into two sides was more complete than in modern members of the group. If this is so, we are seeing a loss of division in the heart, and, in fact, it is well known that more aquatic amphibians show great reduction of the spiral valve and fenestration of the inter-auricular septum (see Noble[4]). It is therefore to be expected that certain Anura have a more selective circulation than others, and it is probable that *Hyla cœrulea* is one of these. What is new is the suggestion that this selective circulation can be switched on or off according to circumstances. I shall await further reports with interest, particularly those of the actual mechanism by which selection is accomplished.

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[1] *Arch. Biol. Paris*, 44, 577 (1933).

[2] *Proc. Zool. Soc. Lond.*, 116, 565 (1947)

[3] *Comment. biol., Helsin.*, 10, No. 4, 1 (1948).

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## Pharmacology of the Alkaloids of *Aspidosperma oblongum* A.DC.

A PRELIMINARY pharmacological investigation of the total alkaloids of *Aspidosperma oblongum* A.DC. obtained by classical methods has been carried out. A 6 per cent solution of the hydrochlorides in an appropriate isotonic saline at *p*H 6·8 was used.

The solution caused relaxation and loss of tone when applied to the isolated ileum of the rabbit and rat. Peristalsis was inhibited in proportion to the dose given. The characteristic actions of acetylcholine and barium chloride were antagonized. The antagonism to acetyl-choline bore a linear relationship to the dose given. The characteristic effects of histamine and acetyl-choline on the guinea pig ileum were antagonized, the antagonism bearing a linear relationship to the dose given.

The normal movements of the isolated uterus of the rabbit, guinea pig and rat were inhibited and the actions of acetyl-choline and barium chloride strongly antagonized.

Antagonism to the action of adrenaline on smooth muscle was demonstrated on the isolated rabbit uterus.

In the frog rectus abdominis muscle preparation, a linear relationship between dose of the alkaloids and extent of inhibition of the action of acetylcholine was demonstrated. About one-tenth of the activity of curarine chloride was shown in this respect.

In the frog gastrocnemius sciatic nerve preparation, a curare-like neuro-muscular blocking action reversible by physostigmine was demonstrated.

When tested by Sollmann's frog plexus anæsthesia method[1] as modified by Bulbring and Wajda[2], a graded local anæsthetic action was shown.

In the isolated and *in situ* frog-heart preparations the rate and amplitude of the contractions were reduced by a small dose (0·06 mgm.). A larger dose (0·6 mgm.) caused irreversible stoppage. Prior atropinization did not modify these effects. Electrical stimulation of the vagus in the latter preparation did not produce its characteristic effects.

In Langendorff heart preparations of the cat, rabbit, guinea pig and rat, the alkaloids caused a reduction in rate and amplitude followed by a well-marked auriculo-ventricular block, unmodified by previous atropinization. The block was reversible.

In the rabbit and the rat electrocardiogram, doses which caused marked slowing of the heart were seen considerably to reduce the amplitude of the *P* wave, to invert the *QRS* wave and to prolong and increase the amplitude of the *T* wave. The *PT* interval was almost doubled.

Intravenous administration of small doses to nembutal-anæsthetized rabbits and cats lowered the blood pressure and slowed the heart.

Doses of 6–30 mgm. were injected into the ventral lymph sacs of frogs. Complete paralysis was exhibited within a few minutes. The higher dose caused death within thirty minutes; at lower dose-levels there was occasional recovery.

In mice and rats parenteral administration of sublethal doses of the alkaloids caused the animals to become quiet and their movements sluggish. The eyelids were closed and there was an appearance of drowsiness. The limbs were extended, the heart slow and irregular. Complete recovery took about two hours. Lethal doses caused slowing and irregularity of the heart followed by violent clonic convulsions. Convulsive episodes alternated with periods of exhaustion. Death was due to heart failure.

Our investigations point to the presence of a potent cardioactive substance which antagonizes acetyl-choline or is associated with substances having this property. Studies on the chemistry and pharmacology of this substance are in progress.

We thank Mr. D. B. Fanshaw, conservator of forests, British Guiana, for the barks; Major J. Buchanan, of Messrs. A. C. Cossor, Ltd., for technical advice with the Cossor 1314, E.C.G., and Mr. G. E. Trease, director of pharmaceutical studies in the University of Nottingham, for permission to publish this communication.

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University, Nottingham. Dec. 4.

[1] Sollmann, T., *J. Pharmacol. Exp. Ther.*, 11, 1 (1918).

[2] Bulbring, E., and Wajda, I., *J. Pharmacol. Exp. Therap.*, 85, 78 (1945).

# FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

## Monday, May 4

Royal Geographical Society (at 1 Kensington Gore, London, S.W.7), at 5 p.m.—Prof. P. de Béthune. "Appalachian Relief".

British Society for the History of Science (in the Lecture Theatre, Science Museum, Exhibition Road, London, S.W.7), at 5.30 p.m.—Annual General Meeting, with Presidential Address.

Society of Engineers (at the Geological Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Mr. W. E. P. Johnson: "Gas Turbines in Retrospect and Prospect".

## Tuesday, May 5

University of London (at King's College, Strand, London, W.C.2), at 5.30 p.m.—Prof. D. M. MacKinnon: "On the Notion of a Philosophy of History".*

University of London (in the Chemistry Lecture Theatre, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Dr. R. W. G. Wyckoff, For.Mem.R.S.: "The Structure of some Biologically Important Solids".*

## Wednesday, May 6

University of London (at the School of Pharmacy, 17 Bloomsbury Square, London, W.C.1), at 5.30 p.m.—Dr. W. O. James, F.R.S. "The Formation of Alkaloids in Plants".* (Further Lecture on May 7.)

British Institution of Radio Engineers, London Section (at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 6.30 p.m.—Mr. G. I. Hitchcox: "Recent Advances in the Application of Electronics to Chemical Instrumentation".

Society of Public Analysts and Other Analytical Chemists (joint meeting of the Microchemistry Group and the Scottish Section, in the Chemistry Department, The University, Glasgow), at 7.15 p.m.—Scientific Papers.

Society for Visiting Scientists (at 5 Old Burlington Street, London, W.1), at 7.30 p.m.—Discussion on "The Nature and Constitution of Viruses" (Chairman: Dr. A. S. McFarlane; Speakers: Dr. P. R. Lépine, Dr. R. W. G. Wyckoff, For.Mem.R.S., Mr. F. C. Bawden, F.R.S.).

## Thursday, May 7

Royal Society (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Prof. N. F. Mott, F.R.S.: "Dislocations, Plastic Flow and Creep in Metals" (Bakerian Lecture).

Linnean Society of London (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Mr. John Gilmour, Dr. J. Ramsbottom, Dr. T. A. Sprague and Mr. W. T. Stearn: Papers to commemorate the Bicentenary of the publication of the "Species Plantarum".

Institution of Electrical Engineers, Utilization Section (at Savoy Place, Victoria Embankment, London, W.C.2), at 5.30 p.m.—Mr. L. J. Davies: "Research in the Electrical Manufacturing Industry".

Chemical Society (at Burlington House, Piccadilly, London, W.1), at 7.30 p.m.—Scientific Papers.

## Friday, May 8

Royal Astronomical Society (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Scientific Papers.

Royal Institution (at 21 Albemarle Street, London, W.1), at 9 p.m.—Prof. A. J. S. Pippard: "The Civil Engineer in the Laboratory".

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# APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Assistant Lecturer in Mathematics—The Registrar, The University, Reading (May 9).

Colville Fellowship tenable in the Department of Chemistry—The Professor of Chemistry, Royal Technical College, George Street, Glasgow (May 9).

Engineer to control, under Assistant Director, large engineering workshop making wide range experimental apparatus at the Ministry of Supply, Harwell—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting C.193/53A (May 9).

Lecturer (Grade B) in the Department of Mathematics—The Clerk to the Governing Body, Battersea Polytechnic, Battersea, London, S.W.11 (May 9).

Plant Physiologist in the Botany Department—The Secretary, Edinburgh and East of Scotland College of Agriculture, 13 George Street, Edinburgh (May 9).

Assistant Biochemist (Basic Grade) (with a university degree or equivalent)—The Group Pathologist, Group Pathological Laboratory, Lakin Road, Warwick (May 11).

Reader in Civil Engineering at the Imperial College of Science and Technology—The Academic Registrar, University of London, Senate House, London, W.C.1 (May 11).

Senior Lecturer or Lecturer in Civil Engineering, a Senior Lecturer or Lecturer in Electrical Engineering, two Senior Lecturers or Lecturers in Mathematics, two Senior Lecturers or Lecturers in Chemistry, a Senior Lecturer or Lecturer in Physics, and a Senior Lecturer or Lecturer in Zoology, at the Nigerian College of Arts, Science and Technology—The Secretary, Advisory Council on Colonial Colleges, 15 Victoria Street, London, S.W.1 (May 11).

Assistant Lecturer in Chemistry—The Principal, Royal Holloway College, Englefield Green, Surrey (May 15).

Leverhulme Studentships in Chemical Engineering—The Registrar, University College, Gower Street, London, W.C.1 (May 15)

Senior Lecturer in Veterinary Medicine—The Secretary of University Court, The University, Glasgow (May 15).

Electrical Engineers and Physicists (Scientific Officer grade—Ref. A.92/53A; Experimental Officer or Assistant Experimental Officer grade—Ref. A.337/52A) for interesting research or development work on radar equipment for Forces, in the Ministry of Supply at Malvern—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting the appropriate Ref. No. (May 16).

Esso Research Studentship in Chemistry—The Professor of Chemistry, The University, Southampton (May 16).

Lecturer in Zoology (with special interest in entomology)—The Secretary, Birkbeck College, Malet Street, London, W.C.1 (May 16).

Lecturers (2) in Engineering (with special qualifications in mechanical engineering with particular interest in one or more of the following: fluid mechanics and heat transfer, thermodynamics applied to heat engines, theory of machines, the engineering of chemical processes)—The Registrar, The University, Manchester 13 (May 16).

Physicist in a Ministry of Supply Establishment in S.E. London, to assist in work involving application of electron microscopy to explosives and metallurgical problems—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting A.93/53A (May 16).

Professor or Reader in Theoretical Physics, a Professor or Reader in Applied Mathematics, a Reader or Senior Lecturer in Civil Engineering, and a Reader or Lecturer (Grade I) in Metallurgy—The Registrar, The University, Nottingham (May 16).

Research Assistant in Biochemistry, to work on enzymes in connexion with genetics of micro-organisms—The Registrar, University College, Leicester (May 16).

Scientific Officers (with first- or second-class honours degree or equivalent in engineering, physics or mathematics) in the Ministry of Supply, as resident technical representatives at aircraft contractors' works in England—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting C.213/53A (May 16).

Assistant Lecturer in Physics—The Registrar, Queen Mary College, Mile End Road, London, E.1 (May 18).

Chair of Geography in the University of Ceylon—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (May 18).

Biologist (with a first- or second-class degree) in the Generation Operation Branch at Headquarters in London, to study the effects of power station operation upon the life of rivers and other waterways, in general and in relation to specific power stations—The Director of Establishments, British Electricity Authority, Winsley Street, London, W.1 (May 19).

Head of the Department of Metallurgy, County Technical College, Wednesbury—The Director of Education, Department F.E. County Education Offices, Stafford (May 20).

Lecturer in Pure Mathematics—The Registrar, King's College, Strand, London, W.C.2 (May 22).

Assistant Chemist—The Chief Engineer, Middlesex County Council, Main Drainage Department, Mogden Works, Isleworth, quoting L.951T (May 23).

Lecturer or an Assistant Lecturer in Biochemistry—The Registrar, The University, Leeds 2 (May 25).

Chair of Agriculture in University College, Ibadan, Nigeria—The Secretary, Inter-University Council for Higher Education in the Colonies, 1 Gordon Square, London, W.C.1 (May 30).

Lecturers in Statistics and Applied Mathematics at the University of Cape Town—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (May 30).

Lecturer or Assistant Lecturer in Mathematics at University College of the West Indies—The Secretary, Inter-University Council for Higher Education in the Colonies, 1 Gordon Square, London, W.C.1 (May 30).

Senior Lecturer in Physics, and Lecturers in Botany, Physical Chemistry, Geology, Zoology, at the University College of the Gold Coast—The Secretary, Inter-University Council for Higher Education in the Colonies, 1 Gordon Square, London, W.C.1 (May 30).

Lecturer in Economics at the University of Hong Kong—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (May 31).

Lecturer in Psychology (preferably with qualifications and research interests in social psychology), a Lecturer in Geography (experience in cartography and field techniques an advantage), a Lecturer in Zoology (preferably with interest in vertebrate zoology or comparative physiology), a Lecturer in Civil Engineering (preferably with interests in hydraulics and soil mechanics), a Lecturer in Biochemistry (preferably with interests in protein chemistry), and a Lecturer in Philosophy, at the University of Adelaide—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (Adelaide, May 31).

Lecturer in Veterinary Pathology—The Registrar and Secretary, The University, Bristol (May 31).

Coke Research Fellowship for research in the Department of Fuel Technology, Ellison Research Fellowships (3) for research in Chemistry or Physics, and C. G. Carlisle Research Scholarship for research in Metallurgy—The Registrar, The University, Sheffield (June 1).

Lecturer or Assistant Lecturer in Pathology—The Secretary, Royal Veterinary College and Hospital, Royal College Street, London, N.W.1 (June 1).

Assistant Lecturer (with an honours or special degree in geology) in the Department of Geology—The Secretary, Bedford College, Regent's Park, London, N.W.1 (June 5).

Senior Lecturer in the Department of Chemistry at University College of the West Indies—The Secretary, Inter-University Council for Higher Education in the Colonies, 1 Gordon Square, London, W.C.1 (June 13).

PHYSICISTS to work on nuclear induction and in related fields—The Academic Secretary, Weizmann Institute of Science, Rehovoth, Israel (June 15).

RESEARCH STUDENTSHIPS IN SCIENCE—The Registrar, The University, Manchester 13 (July 1).

BIOCHEMIST (senior grade, non-medical)—The Physician Superintendent, Crichton Royal Mental Hospital, Dumfries.

EXPERIMENTAL OFFICER or ASSISTANT EXPERIMENTAL OFFICER at Royal Greenwich Observatory, Herstmonceux, for recording of cosmic ray intensity and development of photoelectric instruments—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting A.101/53A.

HUGH WOOD MEMORIAL FELLOWSHIP IN MINING—The Registrar, The University, Leeds 2.

RESEARCH FELLOWSHIP IN MECHANICAL ENGINEERING—The Registrar, The University, Nottingham.

SCIENTIFIC OFFICER (with first- or second-class honours degree or equivalent in metallurgy) in a Ministry of Supply Establishment, South-East London, for physical metallurgical research—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting F.159/53A.

SENIOR LECTURER with qualifications and experience IN CHEMICAL ENGINEERING at Bradford Technical College—The Director of Education, Town Hall, Bradford.

# REPORTS and other PUBLICATIONS

*(not included in the monthly Books Supplement*

## Great Britain and Ireland

Proceedings of the Royal Irish Academy. Vol. 55, Section A, No. 4: Solar Eclipses visible in Ireland between A.D. 400 and A.D. 1000. By F. J. O'Connor. Pp. 61–72. 1*s.* 6*d.* Vol. 55, Section A, No. 5: A New Quaternion Approach to Meson Theory. By C. W. Kilmister. Pp. 73–100. 4*s.* 6*d.* Vol. 55, Section A, No. 6: Note on the Production of Pseudo-scalar Mesons. By Rev. J. McConnell. Pp. 101–108. 1*s.* 6*d.* (Dublin: Hodges, Figgis and Co., Ltd., 1952–1953.) [53

Proceedings of the Royal Irish Academy. Vol. 55, Section B, No. 3: Revision of certain Ordovician Fossils from County Tyrone. By F. Cowper Reed. Pp. 29–136+5 plates. 11*s.* Vol. 55, Section B, No. 4: Antituberculous Substances, 9, Long-chain Aliphatic Bases. By Vincent C. Barry, M. L. Conalty and Dermot Twomey. Pp. 137–148. 2*s.* Vol. 55, Section B, Nos. 5, 6: Antituberculous Substances, 10, Oxidation Products of Derivatives of *o*-Phenylene Diamine, by Vincent C. Barry and J. G. Belton; Antituberculous Substances, 11, Some Further Phenazine Pigments derived by Oxidation of *o*-Phenylene Diamine Derivatives, by Vincent C. Barry, J. G. Belton, J. F. Chambers, M. L. Conalty, Rose Kelly and D. Twomey. Pp. 149–164. 2*s.* Vol. 55, Section B, No. 7: The Application of the Barry Degradation to Snail Galactogen. By Proinnsias O'Colla. Pp. 165–170. 1*s.* (Dublin: Hodges, Figgis and Co., Ltd., 1952–1953.) [53

Macaulay Institute for Soil Research. Annual Report, 1951–1952. Pp. 52+2 plates. (Aberdeen: Macaulay Institute for Soil Research, 1953.) [53

Carnegie Trust for the Universities of Scotland. Fifty-first Annual Report (for the Year 1951–52) submitted by the Executive Committee to the Trustees on 23rd February 1953. Pp. iv+80. (Edinburgh: Carnegie Trust for the Universities of Scotland, 1953.) [53

Books for Young People. Group 2: Eleven to Thirteen plus, Annotated and Classified. Compiled by the North Midland and Yorkshire Branches of the Library Association under the editorship of Edgar Osborne. Pp. 123. (London: Library Association, 1953). 10*s.*; 7*s.* 6*d.* to members. [53

Contributions of Science to Peace (Alex Wood Memorial Lecture 1953 delivered in Friends House, London, February 18th, 1953.) By Prof. Charles A. Coulson. Pp. 28. (London: Fellowship of Reconciliation, 1953.) 1*s.* 6*d.* [53

John Innes Leaflet No. 12: Soil Blocks. Pp. 8. (Edinburgh and London: Oliver and Boyd, Ltd., 1953.) 9*d.* [53

University of London: University College. Annual Report, 1951–1952. Pp. 140. (London: University College, 1953.) [53

Department of Scientific and Industrial Research: Radio Research. Special Report No. 25: Selected Problems in the Preparation, Properties and Application of Materials for Radio Purposes. Pp. iv+24. (London: H.M. Stationery Office, 1953.) 1*s.* 6*d.* net. [53

Negretti and Zambra, Ltd. Seventh Annual Report and Accounts for the Year ended 30th September 1952. Pp. 16. (London: Negretti and Zambra, Ltd., 1953.) [53

## Other Countries

Conseil International des Unions Scientifiques: Union Géodésique et Géophysique Internationale. Association de Séismologie et de Physique de l'Intérieur de la Terre. Comptes rendus des séances de la neuvième Conférence réunie à Bruxelles du 20 Août au 1er Septembre 1951. Rédigés par J. P. Rothé. Pp. xii+288. (Strasbourg: Association de Séismologie et de Physique de l'Intérieur de la Terre, 1952.) [43

Forest Research in India, 1947–48. Part 2. Reports for Burma and Indian Provinces. Pp. iii+75. (Delhi: Manager of Publications, 1952.) 5.4 rupees; 8*s.* 3*d.* [43

Indian Forest Records (New Series). Chemistry and Minor Forest Products, Vol. 1, No. 2: The Vegetable Tanning Materials of India and Burma. By M. V. Edwards, R. L. Badhwar and A. C. Dey. Pp. x+191. (Delhi: Manager of Publications, 1952.) 6 rupees; 9*s.* 6*d.* [43

Bulletin of the Museum of Comparative Zoology. Vol. 107, No. 8: Airplane Observations of Homing Pigeons. By Donald R. Griffin. Pp. 409–440. (Cambridge, Mass.: Harvard College, 1952.) [43

National Research Council: Division of Geology and Geography. Publication 245: Report of the Committee on the Measurement of Geologic Time, 1951–1952. Pp. iii+151. (Washington, D.C.: National Academy of Sciences, 1953.) 1.50 dollars. [43

Fieldiana. Zoology, Vol. 33, No. 2: Mammals. By Colin Campbell Sanborn. (Philippine Zoological Expedition, 1946–1947.) Pp. 87–158. 1.50 dollars. Zoology, Vol. 34, No. 8: On the Mollusk Fauna of the Landlocked Waters of Bermuda. By Fritz Haas. Pp. 101–106. 10 cents. Zoology, Vol. 34, No. 9. South American Non-Marine Shells; Further Remarks and Descriptions. By Fritz Haas. Pp. 107–132. 60 cents. (Chicago: Chicago Natural History Museum, 1952.) [43

Bulletin of the American Museum of Natural History. Vol. 100, Article 3: Avian Systematics and Evolution in the Gulf of Guinea. (J. G. Correia Collection.) By Dean Amadon. Pp. 393–452+4 plates (New York: American Museum of Natural History, 1953.) 1 dollar. [43

Acta Psychiatrica et Neurologica Scandinavica. Supplementum 77: Cerebral Changes following Electrically Induced Convulsions; an Experimental Study on Cats. By Hans Hartelius. Translated from the Swedish by Erika Odelberg. Pp. 128. (Copenhagen: Ejnar Munksgaard, 1952.) 20 Swedish crowns. [43

University of Illinois Engineering Experiment Station. Bulletin Series No. 400: Almost Sinusoidal Oscillations in Nonlinear Systems. Part 2: Synchronization. By Johannes S. Schaffner. Pp. 32. 25 cents. Bulletin Series No. 401: Comparative Performances of a Warm-Air Ceiling Panel System and a Convection System. By Prof. Robert W. Roose, Morris E. Childs, George H. Green and Prof. Seichi Konzo. Pp. 92. 80 cents. Bulletin Series No. 402: A Study of the Practical Efficiency under Static Loading of Riveted Joints connecting Plates. By Prof. Wilbur M. Wilson, Prof. William H. Munse and M. A. Cayol. Pp. 76. 75 cents. Reprint Series No. 49. Progress Reports of Investigation of Railroad Rails and Joint Bars. By R. E. Cramer and R. S. Jensen. Pp. 36. 30 cents. (Urbana: University of Illinois, 1952) [43

University of Helsinki: Institute of Meteorology. Paper No. 71. Theory of the Lag Coefficient of Hygroscopic Hygrometers. By Vilho Väisälä. Pp. 10. (Helsinki: University of Helsinki, 1952.) [43

Beach Erosion Board: Corps of Engineers. Technical Memorandum No. 29. Artificially Nourished and Constructed Beaches. By Jay V. Hall, Jr. Pp. ii+25. (Washington, D.C.: Government Printing Office, 1952.) [43

Fieldiana. Anthropology, Vol. 40: Mogollon Cultural Continuity and Change; the Stratigraphic Analysis of Tularosa and Cordova Caves. By Paul S. Martin, John B. Rinaldo, Elaine Bluhm, Hugh C. Cutler and Roger Grange, Jr. Pp. 528. (Chicago: Chicago Natural History Museum, 1952.) 8 dollars. [43

Copan Ceramics: a Study of Southeastern Maya Pottery. By John M. Longyear, III. (Publication 597.) Pp. xiii+114+72 plates. (Washington, D.C.: Carnegie Institution, 1952.) 5.25 dollars [43

Second Annual Report of the National Science Foundation, Fiscal Year 1952. Pp. viii+77. (Washington, D.C.: Government Printing Office, 1953.) 30 cents. [43

Mauritius Institute Bulletin. Vol. 3, Part 3: Catalogue of the Birds of Mauritius. By F. R. G. Rountree, R. Guérin, S. Pelte and J. Vinson. Pp. 155–217. (Port Louis: Mauritius Institute, 1952.) 5 rupees; 7*s.* 6*d.* [43

Smithsonian Institution. Report of the Secretary and the Financial Report of the Executive Committee of the Board of Regents for the Year ended June 30, 1952. (Publication 4102.) Pp. ix+175. (Washington, D.C.: Government Printing Office, 1953.) [43

Annals of the New York Academy of Sciences. Vol. 55, Art. 6: Use of Antibiotics in Tropical Diseases. By H. W. Brown and 50 other Authors. Pp. 967–1284. (New York: New York Academy of Sciences, 1952.) 3.50 dollars. [43

Académie Royale de Belgique: Classe des Sciences. Mémoires, Tome 27, Fasc. 7: Recherches sur les surfaces algébriques irrégulières. Par A. Andreotti. Pp. 36. 40 francs. Mémoires, Tome 27, Fasc. 8. La tectonique kundelunguienne. Par A. Beugnies. Pp. 128+3 plates. 150 francs. (Bruxelles: Académie Royale de Belgique, 1952.) [43

Union of South Africa: Department of Mines. Geological Series, Bulletin No. 21: Waterberg Coalfield; Records of Boreholes 41 to 100 drilled for the Department of Mines. Pp. 381. (Pretoria: Government Printer, 1951.) 7*s.* 6*d.* [43

Union of South Africa: Department of Agriculture. Science Bulletin No. 305 (Chemistry Series No. 181): Water Requirements of Alluvial Karroo Soil with reference to the Minimum Requirements of Winter Cereals under Irrigation. By M. M. Walters. Pp. iv+35. 6*d.* Science Bulletin No. 313 (Chemistry Series No. 180): The Crude Fibre Content of Sifted and Unsifted Maize Meal. By C. P. Naudé, P. v. d. M. Bruwer and W. P. Pretorius. Pp. 12. 3*d.* Science Bulletin No. 326 (Chemistry Series No. 183): The Toxicity of Pastures after Treatment with Locust Poison. By Dr. C. P. Naudé and Dr. J. P. Van Zijl. Pp. 22. 3*d.* Science Bulletin No. 327 (Chemistry Series No. 184): Meat-marking Inks. By C. H. G. Shutte. Pp. ii+11. 3*d.* Science Bulletin No. 328 (Chemistry Series No. 185): The Use of Brak Water for Irrigation. By H. Klintworth. Pp. 14. 3*d.* Science Bulletin No. 330 (Chemistry Series No. 182): The Effect of Seasons and Years on the Nutrient Content of Spineless Cactus-leaves ([illegible]) picked for Feeding Purposes. By M. M. Walters. Pp. 34. 6*d.* (Pretoria: Government Printer, 1951–1952.) [43

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# ROLE OF UNIVERSITIES IN ADULT EDUCATION

WE have already discussed (*Nature*, May 2, p. 759) some general aspects of adult education in Great Britain, and suggested that the time has now come for fresh thinking on the subject. A shrewd contribution to that end has been made by Dr. H. P. Rickman, of the Department of Adult Education in the University College of Hull, in the March issue of *The Fortnightly*. Dr. Rickman is convinced that adult education is the very life-blood of democracy, and believes that the Workers' Educational Association can provide an unbiased liberal education to enrich personalities and produce better citizens. It cannot at the same time, however, extol one social class and claim itself to be its representative, and Dr. Rickman believes that that part of Prof. R. H. Tawney's summons for a return to strong working-class membership of the Workers' Educational Association is mistaken. Objective teaching cannot be based on class education, but should aim at bringing together, rather than separating, the different sections of the community.

The changed character of the Workers' Educational Association, on this view, is an asset and not a drawback. It fits the Association to supplement the educational system of Great Britain without class distinction, which we are beginning to achieve, by providing adult education on the widest possible basis, and in doing so to offer some correction to the deadening uniformity which some quarters are seeking to impose. Dr. Rickman challenges boldly the doctrinaire and flimsy reasons for stressing the narrower 'workers' conception of the movement, and points the way to a fresh advance through bringing imagination, courage and critical thinking to bear on the new problems.

Dr. Rickman's views find some support in the Unesco Survey, "Universities in Adult Education"*, particularly in Prof. S. E. Raybould's study and in the admirable introduction by Mr. C. O. Houle. The latter attempts to bring out the common features and the underlying principles of policy which emerge in Prof. Raybould's account of British experience, Dr. E. A. Corbett's account of university extension education in Canada and that by B. M. Woods and Helen V. Hammarberg of university extension education in the United States of America, which constitute the rest of the book. Dr. Corbett gives us little more than a long list of Canadian activities in this field, with some historical notes. Mr. Woods and Miss Hammarberg make more effort to distil the lessons of American experience; but on the whole it is the diversity of experience and the differences in practice in the three countries that are most manifest from the three separate studies.

Mr. Houle's introduction gives something more than unity to the book: it brings out the relevance at a time when, particularly in Great Britain, the purpose and methods of adult education demand re-examination of the study of foreign institutions in order to determine the basic principles which underlie their effective operation. Although Dr. Corbett's survey does not indicate the cultural differences and historical associations of which full account must be taken in arriving at any such principles, the other two surveys at least offer a tentative approach. Indeed, Prof. Raybould quite as much as Mr. Houle stresses the need for investigation not only into the history of adult education institutions, but also into the nature of the educational process in mature persons. In doing so, moreover, he recognizes the promise which such developments hold—particularly perhaps inquiry into history, psychology, methods and comparative study—for a fuller understanding of the essential nature of adult education, its special problems, and the contribution it may make to the development of democratic societies.

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* Universities in Adult Education. (Problems in Education, 4.) Pp. 172. (Paris: Unesco; London: H.M. Stationery Office, 1952.) 8s. 0d. net.

To some extent the need for such inquiries has been recognized in the United States also; but, at least in Britain, Prof. Raybould is right in suggesting that along such lines the extra-mural departments of universities may become university departments of adult education in fact as well as in name; while the research itself provides a framework of theory in which the experiments in the training of tutors that most such departments have conducted become an established part of the service rendered by universities to adult education in general. Nor is this the only direction in which Prof. Raybould thinks that the universities could in the future make a distinctive and important contribution. He places first, in fact, the provision, through extension committees, of facilities for students of a different educational and occupational background from that of many Workers' Educational Association students.

In suggesting that this is a field of work for extra-mural departments to cultivate independently of the Workers' Educational Association, and that extension committees, as distinct from joint committees with the Workers' Educational Association, may in future find their chief sphere of activity among the professional classes, Prof. Raybould seems to be ignoring Dr. Rickman's warning and exposing the Workers' Educational Association to further danger of class distinction. Apart, however, from this, it would be a mistaken policy for the universities to concentrate exclusively in their extra-mural work on post-graduate courses of the refresher type. However valuable such courses may be, and although they are undoubtedly proper for a university to provide, such activities should not be undertaken without regard to the other responsibilities of a university towards its region. Selection and discrimination are essential, and it is, above all, important that the universities should not dissipate their available resources by endeavouring to meet all demands made upon them for the provision of adult education.

Mr. Houle, in his introduction to the Unesco publication, formulates five rules which he suggests should guide the universities here. First, the universities should restrict themselves to complex subject-matter: other agencies he considers are better equipped to handle the simpler and rudimentary subjects. Then they should be pioneers, daring in experiment and ready to attempt the pilot study, or in other words to undertake the tasks which voluntary bodies are pre-eminently equipped to attempt. They should provide here, as in other fields, the growing points of society. With these Mr. Houle links the task of training leaders and providing a broad base of leadership at every level of society and in every sphere of activity.

This is clearly a task which in the changed context of the education system of Britain must increasingly fall to the lot of the universities, and accordingly it is important that they should collaborate with the many other agencies in society which provide adult education. An intelligent co-ordination of effort will mean both that the university can illustrate and assist the work of the other agencies, and that it can avoid doing the things which it should not do. Finally, like Prof. Raybould, Mr. Houle suggests that the universities should master adult education as a field of knowledge. The development of research here and the training of leaders will, he recognizes, draw upon and integrate the interests of departments other than education; above all, a dynamic programme of this character demands original thinking and a genuine attempt to re-assess the practices of the past and to adapt them both in relation to the needs of to-day and the resources available.

The universities may well be called upon to make such an effort, and if the recent alarm in regard to the grants for adult education stimulates them to undertake it with some urgency, no harm will have been done. Harm will, however, be done if the stability or the continuance of the extra-mural activities of the universities are endangered, or their planning and development as an essential part of normal university work are hindered. Here, as elsewhere in the universities' work, economy must be practised and retrenchment effected, not on a short-term financial basis, but in relation to the long-term view which alone can avert the disruption and waste caused by sudden and arbitrary cuts.

If, however, the universities are required to consider afresh their precise responsibilities and functions in adult education in view of the widening purpose and growing importance of adult education in general and of the new conditions of to-day, critical thinking and clear vision are equally demanded of the Workers' Educational Association. The Association, moreover, has to reconsider its functions and purpose in the new context, and must face the challenge implicit in the criticism of Dr. Rickman and others. Similarly, we must also expect from the Minister of Education administrative ability, in order to avoid waste of resources and the continuance of means no longer appropriate. Still more, the Minister must have the vision and grasp of essential issues which alone can provide the basis for firm decisions. The committee which is being appointed to make recommendations for the Minister's guidance has a wide field to cover, and the recent discussions will have indicated some of the pitfalls which the formulation of a national policy is likely to meet.

# HISTORY OF SCIENCE

## A Guide to the History of Science

A First Guide for the Study of the History of Science, with Introductory Essays on Science and Tradition. By Prof. George Sarton. Pp. xviii + 316. (Waltham, Mass.: Chronica Botanica Co.; London: Wm. Dawson and Sons, Ltd., 1952.) 7.50 dollars.

## A History of Science

Ancient Science through the Golden Age of Greece. By George Sarton. Pp. xxvi + 646. (London: Oxford University Press, 1953.) 63*s*. net.

STUDENTS of the history of science must sooner or later come across the name of George Sarton, either as an author or in his capacity as editor of the international quarterly *Isis*, one of the most widely read periodicals dealing with the subject. *Isis* was founded by Dr. Sarton, and has been edited by him continuously since it first appeared in 1913 until the end of last year. As well as being a prolific writer, Sarton has lectured on his subject at Harvard almost continuously from 1916 until 1951. In fact, he is one of the select few who have been able to make the study of the history of science their life-work. The publication, almost simultaneously, of two new works from his pen is therefore an event of especial interest.

The first of these works, Sarton would like to be known, for citation purposes, as "Horus", an allusion to the fact that Horus is the son of Isis and Osiris, the latter, of course, being the title of the occasional publication closely associated with *Isis*. Certainly, it can be claimed that "Horus" is, in the literary sense, an offspring of these two publications. This new work serves two purposes. The author first seeks to justify his claim that the history of science as a whole, and not simply that of one or other of the individual sciences, should be more widely studied as a major academic discipline. This thesis is elaborated in three introductory essays, in which, also, he indicates the steps he considers necessary to foster and carry out the teaching of this discipline. The essays are followed by an extensive bibliography, covering the subject in the wide sense indicated.

To deal with the bibliography first, the works listed are placed under four major headings, as follows: *A*, History; *B*, Science; *C*, History of Science; and *D*, Organization of the Study and Teaching of the History of Science. The titles under each of these headings are again divided into sub-headings totalling, in all, twenty-six; and finally each of the secondary headings is further sub-divided. Of the secondary headings, we may mention, as examples, under (*A*), historical methods; under (*B*), scientific methods and the philosophy of science, catalogues of scientific literature, general scientific journals, and national academies and scientific societies; under (*C*), treatises and handbooks on the history of science, history of science in special countries, history of special sciences, journals and serials concerning the history and philosophy of science (with a useful addendum of "Misleading Titles"); and, under (*D*), national societies devoted to the history of science, and the teaching of the history of science. A short introductory note precedes each of the twenty-six main sub-divisions, and many of the individual entries are annotated. Further assistance to users of the bibliography is given by an author index containing upwards of 1,500 names. It is expected that the book will be used mainly by English-reading students, and their needs are given priority by listing suitable books in English, or in English translations, whenever possible. If such are not available, then, in the case of texts in the less familiar languages, French or German translations have been given preference over the originals. The author has refrained almost entirely from the temptation to add remarks critical of particular entries, but has, wherever possible, given references to the critical reviews or short notices published in *Isis*, a course which is probably more satisfactory from the student's point of view.

The bibliography is based primarily on the author's own library, and is supplemented from the bibliographies regularly published in *Isis* (which, by now, it is claimed, must include some 75,000 entries). Some idea of its scope can be gained from the fact that it occupies about 250 pages, and that the number of titles approaches 2,000. At the same time, no claim is made that it is exhaustive, and readers familiar with the subject in general, or specialists in the history of particular sciences, will doubtless call to mind some works that, in their opinion, might deservedly have been included. The author disarms criticism on these grounds with the statement that a general bibliography of this sort cannot do more than assist a scholar; and adds the sound advice that, though every investigation should begin with a bibliography, it ought to end with a better one.

It is regrettable that the author has found it necessary, on the score of labour and expense, to exclude biographies of scientists. These often provide valuable material for students. Users of the bibliography are advised to make their own lists, but this is not an easy task for the inexperienced, particularly if living out of reach of a first-class reference library. Apart from this criticism, the book admirably fulfils the purpose expressed in its full title. It is an excellent guide to the history of science, and is believed to be the only book of its kind. To obtain the information here compressed between the covers of one conveniently sized book, it would be necessary to search the pages of *Isis* for the past forty years. It should prove extremely valuable to students, research workers, teachers, librarians, and in fact to all in any way interested in the history of science, or some special branch of science.

A notice of "Horus" would not be complete without some further reference to the three introductory essays that occupy the first sixty pages or so. These are based on three lectures delivered by the author in Europe, with the express object of explaining the meaning and purpose of the history of science. In the first, entitled "Science and Tradition", Sarton discusses the revolutionary change that has resulted from the major scientific discoveries, not only in our way of life, as a result of their practical application, but also in our outlook on the world as a whole, and on the universe around us. The change, he states, though it has taken place slowly, is one from a science ancillary to theology, or divine revelation, to the modern conception of science as the search for truth irrespective of its consequences. Sarton's fear is that, accompanying this change, the destruction of good traditions is taking place concurrently with the elimination of the bad ones. He is apprehensive that we are passing into an age in which the rule of technocrats rather than that of true scientists is in the ascendant. He concludes this lecture by pointing out that, while most educated people realize the need for the study of history for political purposes, they do not yet realize its function in the reconciliation of science with the humanities, or for the humanization of science.

The second lecture has a somewhat misleading title, "The Tradition of Ancient and Mediæval Science", and might more aptly be called "The Transmission of Ancient Science through the Ages". In it the author discusses the fragmentary and incomplete state of our knowledge of the science of the ancients, that is, broadly speaking, of science as it existed before the invention of printing stimulated the accurate recording and wide distribution of knowledge. Much has been lost, but it is still possible that our knowledge of this early period may yet be enlarged through the patient study of old manuscripts and inscriptions by philologists and archæologists.

Sarton hopes, by means of his first two lectures, to persuade his readers that it is worth while teaching the history of science; but he admits that acceptance of this view will not be universal, and may not be general. In his third lecture he discusses whether, in fact, it really is possible to teach the history of science, as a whole, as distinct from the histories of particular sciences, which, not surprisingly, have a much wider appeal. He indicates the nature of the opposition likely to be encountered. There are, first of all, those who reject the past as something not worth worrying about, being permanently finished. Secondly, there are those scientists who realize the importance of political and social history, but are not interested in the history of science, because the scientific ideas of the past are definitely inferior to those of the present, and therefore would not repay the effort of studying them. They are concerned only in the perfectibility of science. These two groups, Sarton feels, are historically blind, and there is no hope of overcoming their lack of interest.

Into a third group Sarton places those ignorant, and therefore dangerous friends, men of science. perhaps a majority, who admit an interest in, and may even be enthusiastic about, the history of science, but scarcely realize the necessity of studying it. They regard it as a relatively simple matter, and uncritically accept as good any book on the subject (how they can do otherwise without making a special study of the subject is not stated). This latter class, Sarton claims, quite fails to realize the difficulties in the way of arriving at truth in historical matters; or that, though history may be easy to read, it does not follow that it is easy to write. Sarton thinks they will only too readily answer that it is possible to teach the history of science, but will dismiss it as a task so easy that it can safely be left to inferior minds.

Sarton's thesis is that historians of science must know both science and history, and that the most perfect knowledge of one is insufficient without some understanding of the other. He claims that a historian of culture is not qualified to discuss the history of science if he lacks any kind of scientific training and, similarly, that even the most distinguished men of science are not qualified to discuss the history of their subject if they lack historical sense. Good intentions are not enough, and, Sarton states, there are few historians of science fully qualified for the task of teaching their subject. It is all a matter of training; but the training, if different from that ordinarily required for a historian or a scientist, is not necessarily more difficult. Nevertheless, if it is to be taken seriously, there can be no doubt that the history of science as a whole must be regarded as a major discipline.

This is the counsel of perfection, but it is a thesis that ought ultimately to receive universal acceptance, as general interest in and knowledge of the history of science grows, and there are encouraging signs that it is growing, even among professional historians.

Sarton's other, his latest, work on the history of science goes back to the Golden Age of Greece, when philosophers had more time to think, talk and speculate. Those who know the author's earlier three-volume "Introduction to the History of Science" will, no doubt, wish to know what is the relation of the latter to this new product of his pen. The "Introduction", a work covering the period from antiquity up to A.D. 1400, is an elaborate treatise and bibliography, a reference work not intended as a book to be read straight through. The new work, on the other hand, is intended to meet the needs of students and general readers, rather than those of the research worker. It contains the essence of the course lectures given by Sarton at Harvard during the past thirty years or so. Though complete in itself, it is only the first of a series of eight volumes in which the author intends to take his reader up to the present day, and covers, in time, only the period from the dawn of history until the end of the fourth century B.C. It specifically excludes any special study of early Hindu and Chinese science, not because these are without importance, but on the ground that they lack significance for Western scientists, whose thinking has been influenced mainly by Hebrew and Greek thought, and scarcely at all by that of the Chinese and the Hindus.

This book cannot be noticed in detail here, but the name of the author is sufficient guarantee that perusal will be rewarding; and industrious readers will no doubt look forward to the appearance of the further volumes promised. They will form a fitting monument to Sarton's life-work.

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# BIOCHEMISTRY OF PHOSPHORUS COMPOUNDS

## Phosphorus Metabolism

A Symposium on the Role of Phosphorus in the Metabolism of Plants and Animals. Vol. 1. Sponsored by the McCollum–Pratt Institute of the Johns Hopkins University. Edited by William D. McElroy and Bentley Glass. (Contribution No. 23 of the McCollum–Pratt Institute.) Pp. xv+762. (Baltimore, Md.: Johns Hopkins Press; London: Oxford University Press, 1951.) 80s. net.

EVEN the briefest account of major advances in biochemistry during the past two decades could not fail to include the developments in the chemistry and physiology of phosphorus compounds; for in this field we have witnessed truly spectacular progress. Looking back, however, one cannot but be impressed by the successive changes in the attitude of biochemists towards the role and the mode of action of phosphorus compounds in Nature. Thus, for example, about 1930, it was popular to discuss the concept of 'energy linkage' ('energetische Koppelung'); this notion, while it attributed to a phosphorus-containing coenzyme such as adenosine-triphosphate the position of an agent which plays a part in energy exchange, did not, however, provide any material basis for the actual mechanism of this process. From 1934 onwards that somewhat vague idea of 'energy linkage' acquired a new meaning with the discovery of the 'Lohmann reaction' and 'Parnas reaction', when it was demonstrated for the first time that adenosinetriphosphate is involved in a direct intermolecular shift of phosphate groups, from the phosphorylated intermediary products of glycogenolysis to creatine. For some years following these findings the term 'energy linkage' was largely abandoned in favour of the concept of 'chemical linkage'; before long, however, it emerged again (1941), this time in an entirely new guise, with emphasis on the phosphate bonds in adenosinetriphosphate as the site at which the free energy is stored, and whence it can be dispensed in response to the demands of metabolic processes.

Another significant change concerning the phosphorus-containing coenzymes, which began to take shape more recently, has been the growing awareness that the function of these substances is by no means restricted to the metabolism of carbohydrates, but that they are instrumental also in the decarboxylation and transmethylation of amino-acids, the synthesis of peptide bonds, carbon dioxide fixation, photosynthesis, oxidation of fatty acids, formation of acetylcholine and certain other acetyl-transfer reactions. In fact, with discoveries in the field of phosphorus compounds and phosphorylations following each other at an ever-increasing pace, there remains scarcely a branch of biological chemistry which could claim to have escaped their impact. Nothing can illustrate the above statement in a more realistic and convincing manner than the symposium on phosphorus metabolism held in June 1951 at the McCollum–Pratt Institute in Baltimore, the proceedings of which have now appeared as a book containing no fewer than fifty papers dealing with different aspects of phosphorus metabolism in plants and animals. These are by no means conventional review articles. They are surveys by specialists who were recruited from among active investigators intent on reporting and discussing not so much what was being done by others, but rather the results of their own original research. Each subject is introduced on a broad basis by one speaker, and then elaborated further by additional contributions of several other investigators.

The subjects thus covered include the metabolism of polysaccharides and disaccharides (Hassid, Doudoroff, Hehre, Sutherland), fructose (Slein, Taylor), hexosephosphates (Leloir, Cohen, Lipmann), triosephosphates, pentosephosphates (Horecker, Racker, Dische) and nucleosides (Lampen, Schlenk); the biochemistry of inorganic pyrophosphates and metaphosphates (Schmidt), coenzyme A (Novelli), pyridoxal phosphate (Gunsalus) and uridine pyrophosphate compounds (Park); the metabolism of phosphorus-containing coenzymes (Kornberg); the role of inorganic ions in phosphorylations (Lardy, Najjar); thermodynamics of phosphate bonds (Lipmann, Oesper, Koshland); a series of articles on acetyl-transfer reactions (introduced by Barker), and another on oxidative phosphorylations (Hunter, Green, Lehninger and others); and finally, a number of particularly interesting papers grouped together under the title of "Utilization of Phosphate Bond Energy in Biological Systems", which includes contributions on muscular contraction, bioelectricity, bioluminescence, synthesis of peptide bonds, carbon dioxide fixation and transmethylations.

The symposium exhibits several commendable features; in particular, it deserves praise for the skilful avoidance of overlapping in the treatment of the various subjects, and the care with which it has been edited and published; the inclusion *in extenso* of the discussions greatly enhances its value, especially to those actively engaged in this or in allied fields. It can be said without exaggeration that in its peculiar collective form it is one of the most comprehensive treatises on the subject of phosphorus metabolism available at present. T. MANN

# CLIMATOLOGICAL MAPS FOR THE BRITISH ISLES

## Climatological Atlas of the British Isles

(Air Ministry: Meteorological Office. M.O. 488.) Pp. vii+139. (London: H.M. Stationery Office, 1952.) 52*s.* 6*d.* net.

A COMPREHENSIVE climatological atlas of the British Isles has long been awaited, for, since the days of Buchan, Mill and Bartholomew, a steadily growing mass of standardized observations has arisen to satisfy the public need. In this atlas the incidence and distribution of ten major climatic elements—pressure, wind, temperature, rainfall, snow, thunder, humidity, sunshine, visibility with fog, and cloud—are very thoroughly delineated in upwards of a hundred and fifty maps and diagrams, printed with clarity and effective colouring. A folding orographical map can be opened for comparison with those of climate, which abound in material for discussion. There is, for example, a splendid set of maps of average means of relative humidity at 13.00 hr. whereon the moist atmosphere of eastern Ireland gives food for thought. Likewise, the unpleasing frequency of winter fog on the Great North Road from Newark to Ferrybridge is sternly revealed.

Climatological mapping for islands so diversified is not easy; on the whole, the compromise here adopted is effective. Yet the drawing of isopleths among an irregular scatter of observations subject to numerous environmental variables is a geographer's technique which is not everywhere evident. Many readers will turn with interest to some of the smaller maps—for example, the enterprising effort to show the average date of the first and last screen frost (p. 48). Misapprehensions may arise here; air masses being what they are, the chances of early and late frosts in the potato country of south Lancashire are, in my opinion, unlikely to be represented by the isopleths here given. Scrutiny of recent data from Strathy or Kettins will soon show that the bleak pastures of Caithness or the broad ploughlands of Strathmore are not given fair representation by the map on p. 49, which shows them receiving less than half the number of frosty nights ascribed to the Eden valley. Maps showing absolute extremes (p. 47) are open to similar criticisms; they might reasonably have been extended to include more stations over a longer period.

Representative temperature data are, however, difficult to choose and map, and the like applies to other climatic elements; moreover, caveats are entered in the text (for example, pp. 31 and 128). Future editions might include diagrams giving approximate corrections for altitude or site factors, as the effects of the latter are tolerably constant. Some further representation of the variability of monthly rainfall would be welcome.

Among minor points, on p. 29 the November extreme up to 1940 should be given as 70° F.; on p. 117 the choice of Cullompton's 1,101 hours of sunshine in 1912 as "lowest on record" is odd when in the same year many stations had both lower totals and lower percentages. On p. 133 the same order of tints has been used to grade both visibility and fog. Misprints, for example Marton on p. 80, are very rare.

The success of the many maps must be set against the few open to criticism. Numerous detailed maps and tables—for example, those showing exceptional rainfalls, sea-breeze effects, and frequency of low cloud and sunny days—are welcome and opportune. Admirable informative notes and useful references are added. The diversity and clarity of the material thus officially presented render this atlas not only indispensable as a reference but also good value; minor points can easily be remedied in a second edition. Such an atlas provides a lively stimulus to all who would discuss the future welfare of Great Britain.

GORDON MANLEY

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# INDIAN VIEWS ON PLURAL SOCIETY

## Caste and Class in India

By Prof. G. S. Ghurye. Pp. vii+246. (Bombay: Popular Book Depot, 1950.) 15 rupees.

## Group Prejudices in India

A Symposium. Edited by Sir Manilal B. Nanavati and C. N. Vakil. Pp. 223. (Bombay: Vora and Co., Ltd., 1951.) 17*s*. 6*d*.

PROF. G. S. GHURYE'S "Caste and Class in India" is in effect a second edition of his "Caste and Race in India", published in the "History of Civilization" series in 1932. The chapter (5) on "Race and Caste" in that first edition, and the appendixes which related to it, have been, wisely on the whole, omitted in the present volume, and hence no doubt a change has been necessary in the title. Chapters 8 and 9 in the first edition, called there "Caste: Recent and Contemporary" and "Conclusion", are expanded into Chapters 7, "Caste and British Rule", and 8, "Caste and Nationalism", a ninth chapter being added on "Class, its Role", while there are some other additions in earlier chapters. The first four chapters still constitute an excellent conspectus of the caste system, which Prof. Ghurye is admirably qualified to give, and these form the most valuable part of the book. On the elements of caste outside India he is not quite so happy, as his insistences on parallels with Rome and with medieval Europe, for example, are not really valid. Class distinctions are world wide and have not infrequently involved some restriction of, or even prohibition of, intermarriage between classes; it is the peculiarly Indian element of taboo involving pollution and consequential purification which distinguishes caste from mere class. Prof. Ghurye correctly states that Anglo-Saxon laws laid down a rule of endogamy, but there is very good reason to suppose that 'laws' of that kind merely laid down what the lawgiver regarded as an ideal of behaviour; and, in any event, to go on to say that "by the fifteenth century in England this rule of endogamy had almost vanished" gives a very false impression of English society from the time of King Alfred onwards, to say nothing of any changes due to the Norman Conquest, when Anglo-Saxon laws were superseded by Norman. When dealing with the origin of the caste system, Prof. Ghurye seems to lay too much emphasis on the racial factor, which by itself would no more have given rise to a caste system in India than it has done anywhere else.

In his chapter on "Caste and British Rule", the author indicts the British for not having taken more effective measures to abolish caste and for not having ignored caste in its recruitment to Government service, a policy which, if pursued, would have filled the southern Indian services, at any rate, with Brahmans to the virtual exclusion of other castes. But discriminative recruitment was probably an inevitable corollary of abstention from anti-caste legislation, and that is a measure which, in view of the religious sanctions of caste-observance, would have been contrary to the pledge given by the Crown in 1858, and could in any event only be successful if undertaken by Indians themselves, since caste is still an integral factor in Hindu society, and very strongly entrenched there. When Prof. Ghurye states that ever since the Indian Mutiny "the Indian Army has been studiously purged of the higher castes", he is making a flat misstatement, since many Rajputs and some Brahmans have continuously played an important part in the composition of the Indian Army. Actually lower- (not higher-) caste Hindus had been eliminated from the Bengal Army by 1893, when the 'class' system of recruiting was restored, so that whole regiments consisted uniformly of Brahmans, or of Rajputs, etc. The final chapters amount in effect to an exhortation to abolish caste, and the author is to be commended for realizing that an attempt to return to the four *varna* of the Vedic age, as recommended by Mahatma Gandhi, would be no less detrimental if achieved than it is actually in practice impossible. But he should be more careful in his use of authorities at second hand; a failure to verify his references has led him to ascribe to Sir F. Bartlett words which, though doubtless he would agree with their content, he most certainly never expressed.

Prof. Ghurye is also one of the thirty-one contributors to "Group Prejudices in India: a Symposium", edited by Sir Manilal Nanavati and C. N. Vakil. This volume has the very commendable purpose of focusing the attention of the Indian public on the causes of tension, rivalry, and antipathy between cultural, religious, and economic groups so numerous in Indian society. The contributors are divided into six sections: culture and prejudices, religions and prejudices, social prejudices, politics and prejudices, minorities and prejudices, and miscellaneous. Unfortunately, the contributions are extremely uneven and, together with a few objective and useful contributions to the study of, and therefore towards the elimination of, prejudice, there is some sermonizing, a good deal of rather frothy platitude, and some sheer fustian. Generally speaking, the contributors blame Great Britain for encouraging group antagonism by a deliberate policy of 'divide and rule', and although the editors point out that the political unity of the Indian peninsula was first brought about by British rule, one contributor goes so far as to accuse the British of having deliberately created in 1917 the non-Brahman versus Brahman antagonism in south India, which had become vocal at least as early as 1840. Writers seeking to eliminate prejudice would carry more weight and sound more convincing if they refused to be blinded by it themselves.

J. H. HUTTON

## Wörterbuch der mathematischen Wissenschaften

Band 1: Deutsch–Englisch. Von Dr. Leo Herland. Pp. 235. (London: Hafner Publishing Co., Ltd., 1951.) 24*s*.

THIS book is a first attempt to fill a need long felt by mathematicians for a specialized technical dictionary. It will be of considerable help to research students who, with little previous knowledge of German, are faced with the task of reading a good deal of mathematics in German, such as the "yellow-backs" or "Ergebnisse" tracts. The book is well produced. A large type has been used in the printing, and this makes for unusual clarity. Numerous cross-references are given under many of the key words which occur in widely differing branches of the subject, and altogether the author has produced a commendable and relatively complete work.

However, there are some serious omissions, such as the following. The words *Verband*, *schlicht*, *Zelle* and *Spaltung*, all commonly occurring in non-specialized branches of mathematics, are missing. In geometry, which the author curiously emphasizes by separating it from the main stream of mathematics, the omissions are particularly serious. Examples are *Hauptdreikant*, *Doppelgeschlecht*, *Leitkurve* and *Restschnitt*. It would help a geometer if, under cross-referencing, the words *Konstantenzahl*, *Hullflache* and *adjungierte Fläche* appeared. And what about *abzählende Geometrie*? This does not appear under *Geometrie*, and for *abzählen* the meanings given are 'count, denumerate', but not the usual translation 'enumerate'. Incidentally, I cannot find the verb 'denumerate' in the "Oxford Concise Dictionary", so this translation of *abzählen* is not to be recommended on the grounds of common usage. Another word, *Auflösung*, is used in algebraic geometry to refer to the 'resolution' of singularities, but no cross-reference to this is made. Apart from omissions such as these, there are some incorrect translations: *perfekt* (algebra) should be 'complete', and *mehrdeutig* in function theory is, literally, 'many-valued' and not 'ambiguous'.

If these omissions and errors can be rectified in a second edition, the book should be in great demand among mathematicians. L. S. GODDARD

## Physics as a Career

By Norman Clarke. Pp. 70+9 plates. (London: Institute of Physics, 1952.) 6*s*. net.

THE author of this book, Mr. Norman Clarke, is the deputy secretary of the Institute of Physics and he has spent most of the past seven years, as he reminds the reader in the preface, talking, writing and listening to physicists, intending physicists and employers of physicists; this fact should be sufficient to commend the book as a useful and authoritative guide to those seeking a career in physics. In addition, as many members of the Institute can testify, particularly those who have consulted Mr. Clarke with regard to problems concerning salaries, conditions of employment and training, and in connexion with applications for posts as physicists, his sound advice and wide experience have been invaluable. His knowledge with regard to these matters is now made available to a wider public, and it is to be hoped that it may stimulate those who have the talents to study and take up professional careers in physics.

The author deals briefly, in separate sections, with physics and its applications, professional education and qualifications, posts in industry, the universities, government service, technical colleges, schools, research associations and work as hospital physicists. Details of the salaries and prospects of promotion in these various posts are clearly stated. In the four appendixes, useful factual information regarding technical colleges recognized by the Institute of Physics as training centres, and the various research associations of the Department of Scientific and Industrial Research, is given, in addition to a short bibliography of books about science, and the addresses of the various physical societies and associations of physicists. The illustrations are interesting and lend tone to the book, but are superfluous to the text.

## Under the Red Sea

By Hans Hass. Translated from the German by James Cleugh. Pp. 208+47 plates. (London: Jarrolds Publishers (London), Ltd., 1952.) 16*s*. net.

CONSIDERABLE publicity is being given in the popular press to the possibilities of leaving this earth to explore worlds beyond our own. Much more accessible than Mars or the moon, however, is a world on which man has still barely set foot: the world beneath the seas, where "the surface of the water is the sky . . . and the waves are its clouds". The fascination and enchantment of it can be judged from some of the superlative photographs which liberally illustrate this book by Dr. Hans Hass. Outstanding are a series of nine pictures of the manta, *Manta birostris* Walbaum. Very great credit, too, must be given to the author's courage and considerable swimming skill in obtaining these.

Unfortunately, it is the photographs alone which commend "Under the Red Sea" to the serious attention of biologists. The text contains little of scientific worth and presents, for the most part, a rather trite and superficial account of the author's brief acquaintance with the Sudan, the Sudanese and its British officials. Quite unexpectedly, however, there are here and there passages of vividly descriptive writing, as when he portrays some exquisite coral land- (or sea-?) scape, or in describing the sensations of being alone in this underwater world with a myriad of animals of unknown habits. At such times he writes with a passion for this environment as great as that of a countryman writing of the countryside he loves. ALAN J. BROOK

## Les négritos de l'Ile de Luçon (Philippines)

Par Dr. E. Genet-Varcin. (Ouvrage publié sous les auspices de la Société d'Anthropologie de Paris.) Pp. 260. (Paris: Masson et Cie., 1951.) 1200 francs.

THIS is a study of the pygmy skeleton, with special reference to material from the Philippine island of Luzon. The material consists of the remains of fifteen adult males, fourteen females, two adolescents and five infants and is probably the most complete collection of Negrito skeletons yet made, or ever likely to be made. It is a great pity, therefore, that the measurements of the individual crania and other bones have not been included, as this omission makes the publication useless for comparative studies making use of modern biometrical techniques. Mean measurements when based on such a small sample can be very misleading, and this criticism applies even more strongly when they are compared with means relating to other groups of pygmies where the numbers on which the means are based are even more inadequate—in some cases merely a single specimen. Any conclusions derived from this study must therefore be regarded as hypothetical until they can be supported by more complete data.

G. I. JONES

# SCIENTIFIC INSTRUMENTS FOR RESEARCH AND INDUSTRY

## PHYSICAL SOCIETY'S EXHIBITION, 1953

THE thirty-seventh annual exhibition of scientific instruments, organized by the Physical Society, was opened by the president of the Society, Prof. R. Whiddington, on April 13. After thanking the governors and heads of departments of the Imperial College of Science and Technology, London, for continuing to allow the use of the College for the purposes of the exhibition, he remarked, "I feel certain that those whose hospitality we enjoy feel, with the Council of the Physical Society, that this exhibition not only meets a need but also does a most useful service to the community which we are all in our several ways trying to serve. . . . Whenever, in recent years, I look through the Handbook, I am reminded of the time when, as a young man, forty years ago I started research at the Cavendish Laboratory, Cambridge, on a topic to do with electrons. I was warned by certain well-meaning friends of the serious mistake I was making in entering a field destined in the near future to become arid, dull and uninteresting. How wrong they were ! In looking through the 300 or more pages of our Handbook, what a large number of exhibitors are connected in one way or another with applications of particle physics, in particular electron physics. This is not the time or place for me to compare the work of the modern electron physicist with that of his forbear in physics of the last century, though it is interesting to reflect even for a moment, as I hasten to say we are now doing, on the many similar principles used in both eras. The results to-day are really staggering, whether you look at the university laboratory devoted in the main to research for its own sake, or the industrial and service research laboratories where equal fun and interest is to be found, but where applications are made more directly to human amenities and defence. I firmly believe, and I am sure that all with knowledge of the position will agree with me, that this exhibition does much to show the scientific world what apparatus and instruments are available—and what books are available—to help in the great work".

The exhibition was open for five days, April 13–17 inclusive. The numbers attending amounted to twenty thousand, their entry being automatically recorded as 'persons per minute' during every minute while the exhibition was open, that is, from 10 a.m. to 8 p.m. including the lunch hour. This time only one exhibit was housed in the Huxley Buildings, the main exhibition being staged in the Imperial College.

Three discourses were delivered by eminent scientific authorities : (1) "Seismic Study of the Ocean Basins", by Dr. E. C. Bullard, director of the National Physical Laboratory, Teddington ; (2) "Particles, Pellicles ; Pigments, Paints and Physics", by Dr. L. A. Jordan, director of the Paint Research Station, Teddington ; and (3) "Scintillation Counting and its Medical Applications", by Prof. W. V. Mayneord, head of the Department of Physics, Royal Cancer Hospital, Fulham Road, London.

Dr. Bullard's discourse was given on Tuesday evening, April 14. After referring to geological methods used in studying the solid earth above sea-level, he pointed out that direct information about the geological structure of the floor of the deep oceans is necessarily meagre. The rocks are not only hidden under several miles of water, but are usually also covered by several thousand feet of sediments. Oceanic geology has therefore to be carried on by indirect methods, and conclusions drawn from the frequently ambiguous indications of gravity, magnetic and seismic measurements. Of these, the seismic give the most detailed information. The first marine seismic observations were made before the Second World War in the relatively shallow seas covering the continental shelf on both sides of the Atlantic. Since the War the work has been extended to the deep oceans, and results of great interest for geology have been obtained. In shallow water the instruments can lie on the bottom, but in deep water this becomes impracticable and a method is used in which both the explosive and the receiving device are suspended at a depth of only a few hundred feet from the surface. The receivers are hydrophones hung beneath buoys fitted with radio-transmitters. Results have been obtained up to distances of 80 miles using only a few hundred pounds of explosive. They show the structure of the greater part of the oceans to be quite different from that of the continents. The discontinuity which occurs at about 35 km. under the continents, and represents the base of the earth's crust, is only about 5 km. below the floor of the oceans. The sediments in the oceans are not so thick as had been generally supposed and are usually less than 3,000 ft. in thickness, as compared with 8,000–16,000 ft. over the continental shelf. From the measurements of velocity in the various layers below the ocean, the 5-km. layer of rock underlying the sediments is supposed to be basalt (velocity 6·5 km./sec.), whereas the deeper-lying basic rock, having a higher velocity of sound (8·1 km./sec.), is probably olivine. The results at present available represent only a few points scattered over a vast area, but nevertheless are of great significance for geological theory.

The second discourse, by Dr. L. A. Jordan, was given on Wednesday evening, April 15. He illustrated the importance of physical considerations in research applied to paint technology, by noting the transition from the general particle to the particular pigment in terms of crystalline nature and structure, and the effects of refractive index and other physical conditions on colour and special properties as well as on general behaviour. Similarly, considerations of the media used in paint technology were shown to bring in rheological considerations and other aspects of classical physics. It was shown that particle size has a profound effect on the colour shade of a pigment, and that large apparent variations of colour can be produced as the colour of the background is varied. Dr. Jordan directed attention to the infra-red and ultra-violet reflexion from paints and referred to the importance of these factors on the painting of tanks exposed to desert heat, and to ships' camouflage. Viscous and elastic properties of paints can be measured by a torsion pendulum method, and the weathering properties were illustrated by electron microscope photographs. In considering the flow properties of paints, it was pointed out that they are non-Newtonian fluids showing thixotropic behaviour. The conjunction of pigment and medium, constituting paint, brings notable forces into play. Examples were shown of carbon black in oil forming equispaced parallel 'diffraction' lines, mottling effects during flotation, and the effects of temperature gradients during flotation. Pigment flotation in paints regarded as a dynamic phenomenon has been the subject of special study at the Paint Research Station. A cinematograph film illustrating this work was shown. A striking effect 'like oil on troubled waters' was shown when a trace of silicone fluid was introduced into the surface of a pigment–oil mixture, all trace of cell formation (mottling) being immediately destroyed.

Prof. W. V. Mayneord delivered the third discourse on Thursday evening, April 16. He pointed out that the use of crystalline and liquid scintillating media in conjunction with electron multipliers has now become an important technique in modern physics. He outlined the development of the subject and discussed the underlying physical principles. The high sensitivity of the system for a detector of small linear dimensions makes the method applicable to a number of important problems. As a proportional counting system, the scintillation method has applications in gamma-ray and particle spectroscopy. Prof. Mayneord described applications of scintillation counting to the detection and measurement of radioactive isotopes introduced into the human body, including recent attempts to form visual and photographic images of the spatial distribution of radioactive materials. The importance of such applications to cancer research is obvious.

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Details of the exhibits and demonstrations staged by about 150 exhibitors are to be found in the Physical Society's "Handbook of Scientific Instruments and Apparatus, 1953"[*]. This handbook is essentially a reference book, well printed on art paper and profusely illustrated by half-tone reproductions, valuable to all those interested in the use of scientific instruments in industrial, 'service', or academic research and in the teaching of science in schools and technical colleges. The exhibits cover the whole field of scientific instruments and the materials used in their construction; the exhibitors include a large number of industrial firms, the government research laboratories and some university laboratories.

On this occasion a tour of the exhibition revealed a welcome increase in the number of 'dynamic' exhibits (that is, demonstrations, or working models) relative to 'static' (that is, not functioning) exhibits. Although there is, of course, much of interest in static exhibits, a simple demonstration is always more attractive and often more convincing. With such a large number of interesting exhibits it is not possible in this brief review to mention more than a few, picked more or less at random. Inventive ingenuity was often displayed not only in the instruments themselves but also in their names, for example, holiday detector, psophometer, xerograph, etc. A 'holiday' is, in fact, a pin-hole in the protective coating of a steel pipe-line. If such pin-holes are not detected and filled before the pipe is buried in the ground, they form a possible source of corrosion. Pre-heating the gas and air supply to a bright-red heat makes it possible to use a gas–air hand-torch to melt a 1-mm. diameter platinum wire. The torch is very convenient for brazing and copper-soldering. A reciprocating drill operated at ultrasonic frequency, using a magnetostrictive transducer at 22 kc./sec., is used for the rapid drilling and cutting of brittle materials when a paste of carbide abrasive is fed to the vibrating tip. The absence of any rotary motion renders this type of instrument particularly useful for drilling holes of any required shape and for making cuts and depressions in materials which are difficult to machine by more conventional methods. A square hole was cut in a thin plate of glass in a minute or so. Two types of watch rate-recorder were exhibited, the first being a cathode-ray tube indicator and an oscillator of variable frequency adjusted in such a manner that the rate of the watch could be read off directly from a dial. The second type is a printing machine, which records the watch ticks on a tape carried by a small synchronous motor controlled from a crystal oscillator. This system not only gives the rate of the watch but also permits of detection of faults in the movement to a high degree of accuracy. The Science Museum, South Kensington, exhibited the original Milne–Shaw seismograph designed in 1914; instruments of this type are easily maintained and are used extensively for general recording purposes at seismological stations throughout the world. As usual, a wide range of vacuum pumps and vacuum equipment accessories was on view.

A demonstration was provided to illustrate the strain-free cutting of soft metals when it is desired that the cut edge shall be free from strain, as in the X-ray determination of preferred orientation. The method consists in the removal of positive ions from the workpiece by an electric condenser discharge across a small gap to the cutting electrode and quenching the discharge in oil. This produces a precision cut, free from strain. A general purpose digital computer for mathematical and scientific work employed a rotary magnetic disk as a 'store'. Dynamic storage in the registers of the arithmetic units was obtained by magnetostriction delay lines. With this arrangement combined with an electric typewriter, tables of sines and cosines for every degree up to 90° could be worked out in a few seconds and typed out to nine places of decimals in a few minutes. The high speed of the machine was also demonstrated in tabulating the second, third and fourth powers of numbers. The Imperial College Mathematics Department demonstrated a large automatic computing machine performing all the basic operations of arithmetic on 20-digit binary numbers. This was housed in the Huxley Building, Exhibition Road. The Hydraulics Research Station (Department of Scientific and Industrial Research) exhibited a wave-height analyser in operation. This device measures each wave from a trough to the following crest using a series of probes dipping into the water. The result is recorded as a count on one of thirty-two telephone message registers and stops after 300 waves. The effective wave-height and the height distribution can then be determined. A roundness-measuring machine for examining the roundness of such parts as balls and rollers, ball and roller races, pistons and cylinders, with electrical indication of departure from ideal was shown to give magnifications of inaccuracies in steps from 50 to 10,000. An ingenious device for measuring air flow (as a spirometer for use with small animals) was shown by the Chemical Defence Research Establishment (Ministry of Supply). The air-flow carries a soap film along a tube towards a pair of electrodes at the exit end. Connexion of the electrodes by the soap film operates a relay and counting system which records the event, breaks the film and creates a new film at the inlet end of the meter. Another demonstration by this Establishment showed how large drops of liquid can be freely supported in an upward stream of air. The technique employed for this purpose has been used successfully in an investigation of the mechanism of atomization when freely supported drops are shattered by high-speed air streams.

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[*] Handbook of Scientific Instruments and Apparatus, 1953, as shown at the 37th Physical Society Exhibition. Pp. xii+262+A72. (Physical Society, 1 Lowther Gardens, Prince Consort Road, London, S.W.7.) 6s.; by post, 7s. 3d.

In the ultrasonic field a number of exhibits showed the latest developments in barium titanate transducers for flaw detection, high-power treatment of liquids, etc. It is well known that the amplitude of a tuning fork must be constant to maintain an accurate frequency. A fork was shown which incorporated a novel device for maintaining a constant amplitude. It was also shown how a sinusoidal e.m.f. of constant frequency could be derived from the vibrating fork. An attractive exhibit staged by the Signals Research Establishment (Ministry of Supply) demonstrated the synthesis of speech from signals having a low 'information-rate'. Slowly varying parameters specifying the resonant frequencies of the vocal cavity system and the excitation applied to it serve to produce synthetic speech of good intelligibility. A somewhat unusual type of exhibit combined a chemical balance with an electric furnace for the study of change of weight during a prolonged heating process. A two-pen electronic recorder registers the variation of weight during the process. The Royal Aircraft Establishment (Ministry of Supply) showed the operation of a pyroheliometer for use in aircraft, designed to measure the solar radiation incident on the aircraft while in flight. In another exhibit, by the Services Electronics Research Laboratory, it was shown that amorphous selenium, which is opaque in the visible region, transmits radiation in the range from the near infra-red to centimetre wave-lengths. Optical components such as lenses and prisms can be made by simple casting techniques.

The Technical Optics Section of the Imperial College gave a fine series of demonstrations of optical devices. Perhaps the most popular of these was the one dealing with stereoscopic photography and projection. The photographs were taken with a 'Verascope' camera and projected with a pair of Aldis film-strip projectors through 'Polaroid' filters. The three-dimensional picture was viewed with 'Polaroid' spectacles. The projectors were provided with various adjustments for controlling the relative overlap of the two projected pictures as part of a general study of problems in stereoscopic vision. The xerograph, to which reference has already been made, was shown to be a process of photographic image reproduction which depends on a simple application of electrostatics and a photoconduction mechanism in selenium. By this method it is possible to produce either a positive or a negative picture in about a minute, without the usual wet chemical processing. Two stands exhibited what is described as the flying-spot microscope. The object on the microscope stage is scanned by a blue-violet light from a cathode-ray tube and the transmitted light received on a sensitive multiplier photoelectric cell, the output of which is used to modulate a raster on a monitor tube. The latter showed a bright, very much magnified image of the microscopic object.

Permanent magnets in which the pole-pieces are sintered as an integral part of the magnet assembly of 'Alcomax' or 'Alnico' were exhibited, in forms suitable for moving-coil instruments, high-frequency generators, dynamo rotors, etc. By this sintering process it is now possible to obtain a low reluctance path across the junction of the permanent magnet and its soft iron poles. An interesting development in accumulators was shown in which silver (positive) and zinc (negative) form the active plates. Standard production sizes range from 0·5 to 40 amp.-hour capacity having weights ranging from ¾ oz. to 28 oz. The voltage of each cell is 1·5. A new application of the now familiar resistance strain-gauge was exhibited in the form of a submarine pressure meter, the out-of-balance of the bridge being used to indicate pressure, depth under the sea, weight, etc. Direct-writing electrocardiographs were demonstrated using a hot-wire stylus recording on thermo-sensitive paper. This form of recording is almost frictionless at the stylus point, and the hot wire makes a very clear black line as it burns off the ethyl cellulose coating of the recorder paper. An Admiralty research establishment demonstrated a comparator for magnetic materials of low permeability, based on a principle devised by Prof. A. O. Rankine, with a range of permeability of 1·00001–1·0003. This device could give direct indications of the permeability of materials such as distilled water or 'iron-free' copper. A quick-acting sensitive hygrometer is formed from an anodized aluminium wire coated with a thin layer of porous conducting material (for example, 'Aquadag'). The cylindrical condenser thus formed strongly absorbs water vapour (and other vapours), thereby increasing its dielectric constant. The instrument was demonstrated as an atmospheric humidity recorder, and as a detector of moisture in soils and at a number of points in a water-soaked piece of timber. A valuable aid to medical research, of a type mentioned by Prof. Mayneord in his discourse, was a scintillation counter demonstrated under conditions representing typical hospital use. It comprises an eleven-stage photo-multiplier tube, an interchangeable phosphor and a wide-band amplifier. A lead collimator mounted in front of the crystal is used to define the sensitive zone of the instrument. A contamination meter has been designed expressly for civil defence which will measure accurately the gamma-activity of fission products on clothing, etc., in terms of milli-röntgens per hour at a specified distance. The instrument can be used on a table allowing 'suspected' persons to file past the probe, or it can be carried around in a haversack, the probe (containing a Geiger counter) being brought near the suspected areas of contamination. Beta-ray thickness gauges, serving to measure or control the thickness of manufactured materials in the form of strip, foil or sheet, now appear to be in general use in numerous industries manufacturing paper, metal foil, lino, rubber, plastics, etc. A number of exhibits gave demonstrations of this useful device. The use of radioactive tracers in the study of furnace gas flow is now a possibility. By introducing a pulse of radon at the air intake, and scintillation counters to measure its concentration in gas samples taken at various points, valuable information on the furnace behaviour is obtained.

The exhibition of work by apprentices and learners was most impressive. The fine examples of glass-blowing, optical glass work and metal work left one with the feeling that there is plenty of young talent coming along which is quite capable of upholding the high standard of craftsmanship in the British scientific instrument industry. This year, the Silvanus P.

Thompson prize for the most meritorious performance was awarded to R. G. Munro (of the Marconi Wireless Telegraph Co.). Most of the entries were of a very high standard, and the selection of the prize-winner must have presented a very difficult problem for the judges.

As usual, an exhibitors' meeting was held during the exhibition to discuss possible improvements in the organization of future exhibitions. The Council and Exhibition Committee of the Physical Society are to be congratulated on yet another successful exhibition.

A. B. WOOD

# FUNCTION AND LOCATION OF ENZYMES IN CELLS

AT a meeting of the Royal Society on March 12 the subject of "The Function and Location of Enzymes in Cells" was discussed by a number of workers from Great Britain and abroad.

Prof. J. Z. Young (Department of Anatomy, University College, London), in opening the discussion, emphasized that the essence of the problem is to develop methods of high resolution. Much can be done by centrifugation and other methods of separation, but in the end we shall have to depend upon microscopy. Full use of microscopic methods would involve improvement of means of measurement, and a step in this direction might be found in the development of the technique of the flying-spot microscope. He also directed attention to the need for adequate models with which to speak about the organization of processes within the cells, and suggested that perhaps the techniques of information theory might be helpful to biochemists in this respect.

Dr. H. Holter (Carlsberg Laboratory, Copenhagen) described his experiments with the large amœba *Chaos chaos* and discussed the possibility of separation of different phases within its cytoplasm by centrifugation of the living cell. As test enzymes for these investigations, he chose succinic dehydrogenase, dipeptidase and catheptic proteinase, the last an enzyme likely to be difficult to localize because it is especially sensitive to autolytic changes, of which it is itself a mediator.

After cutting centrifuged amœbæ into heavy and light portions, it was found that their dipeptidase content was equal, which means that it is not associated with any centrifugable cell constituent but occurs throughout the cell in the hyaloplasm. On the other hand, the proteinase and succinic dehydrogenase were clearly displaced towards the centrifugal pole and are presumably bound to the mitochondria.

Comparable results were obtained by the technique of centrifugal separation after homogenization, except that the proteinase is liberated by this process from the cell constituent to which it is usually attached. Dr. Holter emphasized that homogenization techniques must, however, always give rise to equivocal results because the hyaloplasm is insoluble in water unless autolysis occurs.

Prof. J. F. Danielli (Department of Zoology, King's College, London) discussed the difficulties involved in the identification of the sites of phosphatase action by cytochemical techniques. He showed that phosphatase is found at sites concerned with active transport, such as the brush border of the proximal convoluted tubules of the kidney, epithelial cells of the small intestine and silk-secreting glands. He went on to develop the thesis that the enzyme is concerned particularly with making energy available for contractile proteins. Thus considerable amounts of phosphatase are found along chromosomes and during new collagen formation. During discussion of this paper, some objections to this hypothesis were raised by Prof. C. D. Darlington and others, who were doubtful whether the association of phosphatases with, for example, nucleoli, could be regarded as evidence of their action upon contractile proteins.

The distribution of enzymic activities of the mitochondria of pea seedlings were then discussed by Dr. D. D. Davies (Department of Botany, University College, Hull), who presented strong evidence that the enzymes responsible for the Krebs cycle in plants are closely associated with the mitochondrial fraction. Each step of the Krebs cycle was demonstrated by chromatographic identification of products in partially inhibited systems.

Dr. S. J. Holt (Courtauld Institute of Biochemistry, Middlesex Hospital Medical School, London) described the development of new staining techniques for the intracellular localization of enzymes, beginning with the necessity of finding readily penetrating chromogenic substrates of low molecular weight, but yielding highly insoluble products. The oxidation of indoxyl to indigo has been found to meet most requirements for a chromogenic reaction. The reactions of various substrates derived from indoxyl have been investigated and several found which are very suitable for the revelation of esterases. The chief problems are to obtain a precipitate of negligible granularity and to prevent diffusion effects. Using substrates such as 5-homoindoxyl acetate and 5 : 7-dichloroindoxyl acetate in the presence of suitable oxidizing agents, it is possible to show fine details of the distribution of esterases in motor end-plates and, for example, in the cells of the kidney, liver and pancreas. Methods for phosphatases have also been developed, and extension to other enzymes is well advanced. During discussion of this paper, it was suggested that false localizations might be obtained, due to the activity of oxidizing enzymes producing an indigo at their site of action. Dr. Holt replied that this had been fully investigated and that the same localizations were found in the presence of high concentrations of oxidase inhibitors.

Dr. F. R. Johnson (Department of Anatomy, University of Sheffield) presented slides, prepared by the Gomori technique, of the distribution of alkaline phosphatase in the epithelial cells of the small intestine. He showed that the appearance of the deposit of cobalt sulphide depends on control of the last steps of the technique and is related to the strength and age of the ammonium sulphide solution used. Under suitable conditions, a bilaminar distribution of the enzyme is seen in this tissue and also in kidney proximal convoluted tubules. Prof. H. A. Krebs pointed out that this distribution corresponds to that expected from suggested biochemical mechanisms of transport; but Prof. Danielli was doubtful whether the bilaminar appearance could be regarded as truly reflecting the distribution of the enzyme in the living cell.

Experiments showing that dipeptidase activity is a property of polynucleotides were described by Prof. F. Binkley (Emory University School of Dentistry, Georgia), who has been able to isolate a non-protein fraction from pig kidney which hydrolyses dipeptides such as cysteinylglycine. This activity is not destroyed or decreased by proteolytic enzymes, or in other procedures directed to remove all proteins, or by heating to 80° C., or concentration by evaporation on a water-bath. Further evidence for the absence of protein was obtained by the negative result of standard protein tests and by the fact that the material did not induce antibody formation. Ultra-violet absorption spectra were typical of nucleic acids, and chromatographic analysis showed good correlation with the properties of polynucleotides. Prof. Binkley emphasized that there is no evidence to suggest that any dipeptidase is a protein, and no real surprise should be caused by the discovery that they may be something other than protein. Electrophoretically homogeneous preparations could be prepared by extraction with aqueous acetone and autolysis at 50° C. Subsequent fractional precipitation with ethanol leaves the active component in the supernatant, and a crystalline product can be isolated of extremely high activity compared with that of proteolytic enzymes composed of protein. Some of the difficulties of this interpretation were mentioned, particularly that ribonuclease or snake venom does not destroy the enzyme activity, except at a low *p*H at which activity is rapidly lost even without added enzymes. However, these enzymes do combine in 1 : 1 proportions with the active material and inhibit it. A second difficulty is that commercial nucleic acids are not active as dipeptidases; but they may be made active by a purification procedure. Further experiments have shown that plant viruses have similar peptidase activities and that these are actually enhanced by digestion with proteolytic enzymes.

In the discussion of Prof. Binkley's paper, no convincing difficulties in his interpretation were raised. Prof. J. D. Bernal emphasized the extent to which our views on protein synthesis would be clarified if we could start with the presumption that nucleic acids were themselves proteolytic enzymes.

The localization of enzymes in muscle were discussed by Dr. S. V. Perry (School of Biochemistry, Cambridge), showing in particular that adenosine triphosphate cannot be free in the cell. The myofibrils probably contain bound adenosine triphosphate and the mitochondria an enzyme responsible for splitting it.

Prof. A. Claude (Laboratory of Cytology and Experimental Cancerology, University of Brussels) described his methods for separating cells into fractions of distinct particle size and enzymic activity. He showed that, even with small differences of density, sharp separation is possible by successive centrifugation, though this may be interfered with by agglutination. He compared quantitative determinations of the quantity of glycogen obtained by centrifugation and by chemical separation, and also clearly illustrated the value of this technique as a preparative method by showing gram samples of cell constituents isolated in a short working-time. Prof. Claude then surveyed the morphological features of cells and discussed the fine structure of mitochondria, as revealed by electron microscopy. In conclusion, he pointed out the need for developing more refined centrifugation techniques for the further separation of similar particles, such as mitochondria, into types with different enzymic activities.

Prof. H. A. Krebs (Department of Biochemistry, University of Sheffield) outlined experiments on the distribution of ions and inorganic substances in cells. He emphasized that an understanding of these distributions depends upon our treating the cell as not being in osmotic equilibrium, for the osmotic pressure in a cell may be two or three times that of the blood plasma. The conception that the cell is enveloped by a semi-permeable membrane is not complete because there are many intracellular boundaries; many substances may thus penetrate the cell and yet not gain access to all parts of it. Distribution of sodium ions is maintained by the mechanism of a 'sodium pump' actively removing the ion, and this may occur not only at the cell surface, but also at surfaces within the cell.

Experiments with slices of guinea pig brain and kidney cortex in which the potassium loss and sodium gain were studied were next described by Dr. R. E. Davies (Department of Biochemistry, University of Sheffield). Under proper conditions reversible interchanges can be recorded. The water content of the tissue depends more on its metabolic activity than on the composition of the medium. Thus the turnover number of sodium ions to oxygen consumed was very high (5,000 : 1), and it is necessary to postulate an energy-linking system between entry to and escape from the cell. Treatment with dinitrophenol unlinks the process of transport from its energy sources and allows accumulation of sodium within the cell. The whole of the sodium and potassium content of a cell was found to be able to exchange in a very short time. Dr. Davies then presented evidence that these activities are controlled by enzymes located in the mitochondria. Fractions consisting mainly of mitochondria are thus able to concentrate ions and pump out water.

In closing the discussion, Prof. Young thanked the contributors for the various original observations reported during the day; he directed attention to the fact that the only mention of a new model was Prof. Krebs's comparison of the cell with a leaky ship kept afloat by pumps.

# SAMPLE TABLES FOR THE 1951 CENSUS OF GREAT BRITAIN

In the past, the General Register Office has often been severely criticized for its delay in the publication of the results of the decennial census of population. The critics often ignored the fact that the professional staff of the Office was very small, and that they had to cope with the routine work of the Office in addition to the census. It is therefore most creditable to the Office that a summary of the main results of the 1951 census came into the hands of the public within nineteen months of the date of enumeration*.

This was only made possible by the decision—for the first time in the history of censuses in Great Britain—to make a preliminary analysis of a sample of 1 per cent of the census schedules. Sampling had an additional advantage—tabulations which would have been prohibitively expensive and complicated in a full census were quite feasible for a sample. A sample of census schedules is also likely to be more accurate than an *ad hoc* inquiry: the completion of the schedule is compulsory, and sample selection can therefore be strictly controlled. The problem of non-response is minimized, and there is probably more goodwill among the general public towards the census. The sample itself will be so large that sampling error will be negligible, and it is therefore to be hoped that the sampling procedure will be continued in the future. Although the sampling error is negligible, it is unfortunate that it is not discussed at greater length in the introductory pages. Those responsible for the publication of the report surely owe a duty to the public to explain their working methods fully, rather than treat them as esoteric mysteries. This is a small point; but there has recently been a general tendency on the part of those at the Office to explain their working methods in such general terms that it is not possible to follow their work in detail, so that criticism is made unduly difficult. (For example, the number of 'schedules' drawn in the sample as distinct from the number of 'persons' is nowhere given.) A second innovation must be gratefully mentioned. For the first time for a hundred years, the results for Great Britain are given in a single volume. It is to be hoped that the co-operation between the two registrars-general of England and Wales and of Scotland will continue, and that the national tables of the full census will also be given for Great Britain as a whole, as well as for the two constituent countries. It has been one of the minor irritations of persons working on British population figures to have to work with two different fat volumes, and occasionally to discover irritating minor differences in the definition of terms.

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* General Register Office and General Registry Office Scotland. Census 1951, Great Britain: One Per Cent Sample Tables. Pp. 367. (London. H.M.S.O., 1952.) Part 1, 17*s.* 6*d.*; Part 2, £2.

The sample tables in the two parts are numbered consecutively, so that the report may be regarded as a single whole. It is divided into different sections, and it would be invidious as well as presuming to try to deal with the results and their significance in a short article. I shall therefore content myself with describing the tabulations, indicating the innovations and commenting on some of the methods.

One of the main functions of the census is to give detailed statistics for local areas. In a 1 per cent sample the details must necessarily be less extensive than in a full enumeration, and the local tabulations are confined to the counties and larger towns. There is one welcome innovation, however: the provision of separate tables for the seven large conurbations centred on London, Birmingham, Manchester, Liverpool, Leeds, Newcastle and Glasgow.

*Ages, Marital Condition, Occupations and Industries.* These subjects are, of course, the main concern of the census-taker. The treatment follows conventional lines, but there are some minor innovations. The occupations are divided into thirteen 'socio-economic groups' in addition to the conventional five so-called 'social classes'. Any attempt at social classification which is based on occupations only must of necessity be rough, and can at best only approximate to what the sociologist understands by 'social class'; but given these limitations, a division into thirteen groups will, of course, be much more useful than one which makes use of five groups only, particularly when housing and fertility differentials are studied.

From the tables it is possible to obtain information about the structure of the population by sex, age, marital status, occupation and industry, and about some of these factors in combination. One can study the age structure of the labour force, the number of women in different industries, the extent of the employment of married women, and similar topics.

*Housing and Structure of Private Households.* The census defines a private household as a "single person living alone or a group of individuals voluntarily living together under a single menage in the sense of sharing the same living room or eating at the same table; boarders and domestic servants are included in the household with which they are enumerated as also are visitors when such are present. But a lodger or group of lodgers having or sharing separate accommodation to themselves should have been enumerated on separate schedules and are thus treated as separate private households, distinct from the main occupying household of the dwelling, whether or not they rely on the latter for incidental service in the matter of room cleaning, food preparation, etc.".

It will be seen that the definition of a private household is necessarily a little vague, and that ambiguities are bound to arise. In the case of lodgers there is an almost infinite gradation between the boarder who lives *en famille*, on one hand, and the lodger who merely rents a room to sleep in and has no dealings with the rest of the household, on the other; and in marginal cases it is difficult to ensure uniform treatment. Moreover, there is the problem of visitors. It is not very easy administratively to allocate visitors who are away from their homes back to the area of their usual residence. It seems likely *a priori* that members of small households are more likely to be mobile than those from larger ones, so that errors do not necessarily cancel out. It is also evident that the term 'private household' is not synonymous with the term 'family'. This confusion has been partly caused by the use of the latter word in previous censuses.

The tables show the total number of households by size and by number of rooms occupied, distinguishing in general those households which have to share a dwelling. Crowding indices can be calculated from these data. It should, however, be borne in mind that the number of rooms in the dwelling is obtained by the enumerator in the course of a hurried visit. Though substantial inaccuracies are unlikely, these figures are probably of a lower reliability than the rest of the census data.

The foregoing remarks also apply to a new feature. In 1951 enumerators were instructed to inquire whether the household had the exclusive use of piped water, cooking stove, kitchen sink, water closet and fixed bath, or whether any or all of these amenities were shared with another household. The tabulated answers make it possible to compare housing conditions in different parts of the country.

The second volume begins with tables showing information on household structure. The households are classified by the number of earners and the number of children that they contain; but it is the section next following which is of particular interest. Here an attempt is made to study in greater detail the structure and composition of private households, and, for this purpose, visitors have been excluded. Households are divided into those containing 'primary family units' only—that is, consisting merely of the head of the household, his or her spouse, children, ancestors and unmarried sibs of the head, and resident domestic servants. Such households form 86 per cent of the total contained in the sample. In the remaining 'composite' households, the members not belonging to a primary family unit have been further analysed into 'family nuclei' consisting of married couples or lone parents with their children. Composite households containing such nuclei were regarded as less stable than other composite households, as it was believed that they would in most cases desire separate accommodation of their own. Their number and distribution would give one index of the amount of involuntary 'doubling-up' that exists. It was found that roughly a half of all composite households contained family nuclei, the large majority of these consisting of married children of the head or his spouse.

This tabulation will not be repeated for the full census. It is therefore regrettable that the data are only broken down by geographical region and that no attempt has been made to obtain information regarding household structure by occupation or social class. Such information has not previously been available, and its publication might throw some light on the nature of the housing problem which we are facing.

*Education.* One of the new questions included in the census related to the age at which full-time educational instruction had ceased. For some incomprehensible reason, the question was confined to males and occupied females, so that no information is available about the education of housewives (whom the census authorities still regard as 'unoccupied'). Moreover, the figures are particularly difficult to interpret at present, as the education of many persons was interrupted by the Second World War and continued after demobilization, so that the proportion whose education ends comparatively late may well be abnormally high. More valuable results may be obtained at the next census, when the question should, however, be re-phrased, as the age at which education ends is only one of the factors influencing what might loosely be described as 'education status'.

*Fertility of Marriage.* In the present census questions relating to the fertility of marriage have been asked for the first time since 1911. All married women under the age of fifty were required to state the date of their present marriage, the total number of children born alive to them, and whether they had given birth to a live child in the year preceding the census. The information is tabulated in a special section of sixty pages, and the tables are well set out. The limitation of the questions to women under the age of fifty is, however, utterly incomprehensible and most deplorable. It means that no comparisons can be made with the fertility experience of older women who bore the greater part of their children in the early nineteen-twenties. It is true that the sample census of the Royal Commission on Population taken in 1946 will remedy some of the deficiency, but it is by no means certain that the material will be comparable.

Information is made available about the distribution of married women by marriage duration, age, age at marriage and total number of children. The figures for social class and socio-economic group are analysed, and the women who bore a child in the year preceding the census are separately distinguished. It is thus possible to obtain data on differential fertility without having to marry vital registration and census statistics, in which occupational and other definitions may sometimes differ, thus causing minor incomparabilities.

*Minor Tabulations.* Among other information presented there is a table dealing with non-private households, information regarding birthplace and nationality, and statistics on the Welsh- and Gaelic-speaking population.

Enough has been said to indicate the wealth of material available in the new publication. No full census has been taken in Britain since 1931, and the information is therefore all the more welcome. The sample tables will probably contain sufficient detail for most purposes. The full evaluation of the data will take time, but they promise to throw light on some social problems about which hitherto relatively little was known.

E. GREBENIK

# OBITUARIES

## Sir Francis Knowles, Bart.

SIR FRANCIS HOWE SEYMOUR KNOWLES, fifth baronet, who died at Oxford on April 4, at the age of sixty-seven, made notable contributions to two branches of the complex discipline of anthropology. Like many other anthropologists, he began his studies in a different field of knowledge, for he read law at Oriel College, Oxford. He then took the diploma in anthropology at the first examination held in Oxford (1908), and afterwards the degree of B.Sc. During 1909–12 he taught physical anthropology under Prof. Arthur Thomson, helping to place the subject on a firm scientific foundation. During that period he catalogued and measured two large collections of skulls; he also collaborated with Sir Arthur Keith in a study of teeth of palæolithic man from Jersey, and with Prof. W. J. Sollas in an examination of the Aurignacian skeleton from Paviland Cave, Gower.

He left Oxford to undertake field-work among the Iroquois in Ontario. In 1914 he was appointed physical anthropologist to the Canadian Government, a post which he held for five years. His work on the skeletal material from the Roebuck prehistoric village site, "The Physical Anthropology of the Roebuck Iroquois", was published by the National Museum of Canada. A severe attack of typhoid, contracted in the field, left his health permanently impaired, and brought his career as a physical anthropologist to a premature end.

Returning to Oxford, Knowles took up the study of a subject in which he had long been interested, namely, the techniques used by ancient and modern Stone Age peoples in the manufacture of their tools and weapons. Using only the materials and tools known to have been available to prehistoric man, he practised patiently until he had acquired a skill comparable to that of the best craftsmen of the past. In this way began his long association with the Pitt Rivers Museum, Oxford, where he studied, and added considerably to, the prehistoric collections, arranged exhibition cases showing the variety of techniques employed by stone-workers from ancient to modern times, and held practical classes whereby his pupils obtained an insight into the difficulties overcome by prehistoric man. One of his most important discoveries was described in "The Manufacture of a Flint Arrow-head by Quartzite Hammer-stone", published as the first of the Museum's "Occasional Papers on Technology". Shortly before his death, he completed "Stone-Worker's Progress" for the same series.

Knowles took nothing for granted, but taught and published only what he had learned and verified by personal observation and experiment, thus giving lasting value to his work. His scholarship, his enthusiasm for his subject, and the selfless devotion with which he applied himself even to the routine tasks inseparable from it, were greatly admired by his colleagues, who will long remember him with respect and affection.

B. M. BLACKWOOD

## Mr. W. M. Jones

The death occurred on March 15 of W. M. Jones, director of the Oceanographic Observatory of the Department of Scientific and Industrial Research, New Zealand. Born in Papakura in 1893, he graduated in 1914 with honours in mathematics. He was the New Zealand Rhodes Scholar of that year and took honours in physics at Balliol, Oxford. He served in the First World War in the Royal Field Artillery and N.Z. Engineers, and, after a few more years at Oxford as demonstrator in the electricity laboratory, returned to New Zealand.

His early magnetic, seismological and other geophysical work in New Zealand foreshadowed many of the discoveries which are of greatest interest to-day, and did much to establish the usefulness of scientific exploration. In 1950 he was given the task of developing oceanographical research in New Zealand, and has done much to advance the systematic study of the waters which influence its life, climate and fisheries. Being mainly interested in the applications of mathematics and physics, he has done useful research on waves, the relation between waves and microseisms, and the electromagnetic effects of tidal streams.

Jones had a wide interest in science apart from his own subjects, and an extensive knowledge of New Zealand. He was a very amusing travelling companion and always found the most interesting people to talk to and the most interesting things to do. His great fund of anecdotes about his early geophysical exploration showed a wealth of good feeling and love for his country. In his younger days he was a representative player of hockey and tennis both in Auckland and in Great Britain.

Jones's work was well known in Britain and the United States, as well as in New Zealand, and he will be greatly missed. G. E. R. Deacon

# NEWS and VIEWS

## Royal Institution:
### Sir Lawrence Bragg, O.B.E., F.R.S.

After the annual meeting of the members of the Royal Institution held on May 1, Lord Brabazon of Tara (president) announced that the managers had appointed Sir Lawrence Bragg to the office of Fullerian professor of chemistry, resident professor and director of the Institution's laboratories. He will take up the duties of the Fullerian professorship immediately and the laboratory and resident duties on January 1, 1954. Sir Lawrence has been Cavendish professor of experimental physics in the University of Cambridge since 1938. Previous to this he had been director of the National Physical Laboratory, and he had also been Langworthy professor of physics, University of Manchester. He brings great academic distinction to the Royal Institution, and is worthy to stand in the place of Humphry Davy, Faraday, and the many famous scientists who succeeded them. Sir Lawrence had a brilliant career as a student and Research Fellow at Trinity College, Cambridge. In 1915, at the early age of twenty-five, he was awarded a Nobel Prize for Physics for his work on X-rays and crystal structure with his father, the late Sir William Bragg, who is remembered with affection by all connected with the Royal Institution as not only one of the most distinguished holders of the offices his son now receives, but also one of the best loved. For his many contributions to physical science Sir Lawrence has been awarded the Hughes and Royal Medals of the Royal Society, and honorary degrees and distinctions from many universities and scientific societies at home and abroad. He will bring to the Royal Institution not only an unrivalled record of scientific achievement and experience, but also those personal attributes of friendship and sympathy so characteristic of his father.

### Other Officers

The following have been elected officers of the Royal Institution: *President:* Lord Brabazon of Tara; *Treasurer:* Dr. L. H. Lampitt; *Secretary:* Mr. S. Hobson; *Managers:* Mr. L. V. Chilton, Dr. A. Clow, Mr. E. R. Davies, Mr. F. P. Dunn, Dr. A. G. Gaydon, Dr. R. E. Gibbs, Mr. A. C. Hartley, Mrs. H. K. Hawkes, Mr. L. B. W. Jolley, Dr. L. A. Jordan, Dr. H. Lowery, Dr. A. C. Menzies, Dr. J. H. Schulman, Mr. P. H. Schwarzschild, Dr. S. Whitehead; *Visitors:* Mr. H. E. Baker, Mr. F. G. Brown, Dr. H. K. Cameron, Mr. A. D. R. Caroe, Mr. J. F. Coales, Dr. H. Heywood, Wing Commander G. e. Hughes, Dr. A. R. Kagan, Mr. M. M. Melinsky, Mr. E. B. Moss, Mr. F. Y. Poynton, the Hon. Philip Samuel, Mr. W. E. Schall, Dr. L. Simons, Dr. P. C. Spensley.

## Fuel Technology at Sheffield:
### Prof. R. J. Sarjant, O.B.E.

The University of Sheffield—and indeed the community at large—owes much to Prof. R. J. Sarjant, who retires from the chair of fuel technology at the end of the academic year. Educated at the Royal Masonic School, Bushey, he graduated in chemistry at the Royal College of Science, London, afterwards receiving postgraduate training there. In 1918 his appointment as fuel officer to the research department of Hadfields, Ltd., was the beginning of more than a quarter of a century's experience of steelworks problems, including those concerned with refractory materials and metallurgical engineering. With Sir Robert Hadfield he published a number of papers on the use of solid, liquid and gaseous fuels, gas producer practice, alloy steels for furnaces and chemical engineering; and in 1924 he gave the first course of lectures on furnace heating at the University of Sheffield, the following year publishing in a book the results of his pioneer work. In 1937 he was appointed a local director of Hadfields and head of its research department, relinquishing this position at the end of the Second World War on his appointment to the Sheffield chair; this chair had been vacant since R. V. Wheeler's death in 1938, and in returning to academic life after a successful industrial career Prof. Sarjant recognized the opportunity for wider service and the need for great expansion of university training in fuel technology. He has always been keenly interested in university education in applied science, and set about extending his department with characteristic enthusiasm. Shortly after his appointment, he visited American universities and research organizations, and two years later was invited to lecture in Spain. He has been associated with many research committees on fuel and allied problems and was awarded the O.B.E. for his services to the wartime Fuel Efficiency Committee of the Ministry of Fuel and Power. Prof. Sarjant was a vice-president of the Institute of Fuel during 1949–51 and in 1950 was awarded its highest honour, the Melchett Medal, choosing "Ignipotence" as the subject of his address. In this address he described some of the researches in his department, where incidentally there is now a record number of postgraduate students; the researches include work on coal chemistry, the reactivity, properties and production of metallurgical coke, heat transfer, furnace design, smoke repression in metallurgical operations, and gasification of low-grade fuels.

### Mr. M. W. Thring

MR. M. W. THRING, who succeeds Prof. Sarjant, was educated at Malvern College and Trinity College, Cambridge, graduating with first-class honours in Part 1 of the Mathematical Tripos and in Part 2 of the Natural Sciences Tripos. In 1937 he joined the staff of the newly formed British Coal Utilization Research Association, becoming head of the Combustion Research Laboratory in 1944. Experimental and theoretical work on the velocities and temperature drop in producer gas mains led to the award of the Student Medal of the Institute of Fuel in 1938. Among his war-time studies were the design of portable gas producers and the development of the down-jet system of combustion in fuel beds; these investigations culminated in a major study of port designs in open-hearth furnaces, carried out in 1944 in collaboration with Dr. J. H. Chesters, of the United Steel Companies, Ltd., and in 1949 Mr. Thring was awarded the Sir Robert Hadfield Medal of the Iron and Steel Institute for studies on open-hearth furnaces. In 1946 he took up a new post as head of the Physics Department of the British Iron and Steel Research Association, later being appointed superintendent and, recently, assistant director of the Association. In 1949 he took part in the early discussions leading to the formation of the International Committee for Research on Luminous Flame Radiation, and two years later became general superintendent of its researches. Mr. Thring is the author of a book on "The Science of Flames and Furnaces" and of many papers on fuel subjects, and he has made valuable contributions to the theoretical understanding of radiation during combustion and of the mechanism of combustion in turbulent jet flames.

### Atomic Energy Research in Britain

REPLYING to a question in the House of Commons on April 28, Sir Winston Churchill stated that the Government has set up a committee, consisting of Lord Waverley (chairman), Sir Wallace Akers and Sir John Woods, with the following terms of reference: "To devise a plan for transferring responsibility for atomic energy from the Ministry of Supply to a non-departmental organization and to work out the most suitable form for the new organization, due regard being paid to any constitutional and financial implications". He remarked that considerable strides have been made in the development of methods of using atomic energy for industrial purposes, and these aspects are now coming very much to the fore. A non-departmental organization is considered by the Government to be necessary to secure rapid and economical development, for both military and industrial purposes, and the committee has the task of visiting the various establishments concerned with the view of devising a form of organization to meet the very special needs of the case. Overall policy must remain firmly in the hands of the Government, and methods of financial control will have to be devised since in the foreseeable future the considerable cost will fall on public funds. The rights and interests of existing staff in atomic energy establishments will be fully respected. It will be recalled that in July 1951, Lord Cherwell, speaking in the House of Lords, asked for the transfer of atomic energy development to some such non-departmental agency.

### Atomic Energy Establishments in Britain

ON May 4, Mr. Duncan Sandys, Minister of Supply, gave some information in the House of Commons about the work of atomic energy establishments in Great Britain. He said that Harwell is responsible for fundamental research into nuclear physics and atomic energy, and provides basic scientific information to the other establishments. The radio-chemical centre at Amersham is an offshoot of Harwell. It deals with the preparation of radioactive substances such as radium, radon, and radioactive isotopes produced in the atomic piles, and these are used for medical, scientific and industrial purposes. The production of fissile material is directed from headquarters at Risley, near Warrington, where the design and planning offices are situated. A factory at Springfields, near Preston, produces pure uranium from uranium concentrates; another, at Windscale, in Cumberland, produces plutonium from uranium by means of atomic piles; and a third, at Capenhurst, in Cheshire, has a gaseous diffusion plant for separating uranium-235 from the more abundant isotope uranium-238, producing a fissile material which can be used as an alternative to plutonium. Research work on atomic weapons is carried on at Aldermaston, in Berkshire, and its out-stations at Woolwich and Fort Halstead.

### Effects of Toxic Substances on Wild Life

A WRITTEN reply by the Minister of Agriculture, Sir Thomas Dugdale, given in the House of Commons on May 4, stated that the working party considering precautionary measures in the agricultural use of toxic substances has been reconstituted under the chairmanship of Prof. S. Zuckerman and will now consider the effects of such substances on wild life in general. It will include representatives of the agricultural departments, the Agricultural Research Council, the Agricultural Improvement Council, the Nature Conservancy, the fisheries departments, and the Medical Research Council. Its terms of reference will be: "To investigate the possible risks to the natural flora and fauna of the countryside from the use in agriculture of toxic substances, including the possible harmful effects for agriculture and fisheries, and to make recommendations".

### Exhibition in the Science Museum, London, of Historic Books on Machines

THE second of a series of special exhibitions of historic books relative to science and technology was opened at the Science Museum, London, on May 1 and will remain on view to the public, free of charge, until August 30 (weekdays, 10 a.m.–6 p.m.; Sundays, 2.30–6 p.m.). The exhibition deals with machinery and traces the development of machines from classical times up to the period of the Industrial Revolution in the eighteenth century. Although some of the very early machines were exceedingly crude in appearance, they often embodied fundamental principles which were taken up in later times when materials and methods of construction were more developed. The progress of machines increased during the Renaissance, and more interest in them was stimulated about 1440 when movable-type printing was invented; it was then possible for books to be produced more cheaply and in larger numbers. The knowledge spread from Alexandria, to Greece, Italy, France, Germany and Britain, and by the seventeenth century there was much scientific activity, both theoretical and practical, which hastened their progress; with the development in Great Britain of the steam-engine during the eighteenth century, far-reaching economic and social changes occurred throughout Europe. The parts which great philosophers and pioneers, such as Heron of Alexandria, Archimedes, Cardan, Agricola, Gilbert, Galilei, Boyle, the Marquis of Worcester, von Guericke, Morland, Papin, Savery, Pascal and Faraday, played in the development of machinery is illustrated by many of the books. In general, the exhibition should appeal not only to those with a developed appreciation of machinery but also to all who, though they may have a slight knowledge of the subject, are interested in the materialistic progress of civilization.

### Agricultural Census in Iraq

Many important facts concerning agriculture in Iraq are being revealed for the first time by an agricultural and livestock census which was taken during the second half of 1952 under the direction of the government statistician, Dr. K. G. Fenelon, who was formerly director of statistics and intelligence at the British Ministry of Food. Every effort is being made to publish the data as rapidly as possible, and already reports are available for three out of the fourteen provinces (*liwas*) into which the country is divided for administrative purposes. These reports cover the Provinces of Baghdad, Basra and Amarah and show in considerable detail the great diversity of conditions under which farming is carried out in the country and the great variety of crops which can be grown. In Amarah Province, for example, the average size of the 483 farms in the area is 3,530 acres, there being a hundred farms of more than three thousand acres each, among which seven are more than thirty thousand acres each. In Baghdad Province, the 3,821 holdings average 240 acres, while in Basra the 18,013 farms average only 15 acres each, with some 11,000 farms less than 2½ acres in extent. The small size of farms in Basra is partially explained by the prevalence of date palm cultivation, which accounts for nearly one-third of the total area of the holdings. In Baghdad Province, there are more than three million fruit trees such as orange, apple, pomegranate, lemon and apricot, compared with two hundred thousand in Basra and thirty-five thousand in Amarah Provinces. The main field crops in the three Provinces are barley, wheat, rice and maize.

Considerable differences were found in the amount of labour engaged on the holdings. In Amarah there is one person for 25½ acres, in Baghdad one for 8 acres and in Basra Province one for 3½ acres. Livestock are somewhat more densely settled on the land, there being one head of livestock for every 3 acres in Amarah Province, 2·7 acres in Basra Province and 2 acres in Baghdad Province. In addition to the livestock on the farms, numerous other animals are maintained by 'stall feeding' or by pasturing on waste lands. In Baghdad Centre many cows, buffaloes and sheep are stall-fed, while in Basra Province many flocks were found pastured on waste lands, which varied in size from a few animals kept by individual families to immense herds of sheep, horses and camels owned by nomadic tribes, some of which roamed between Iraq, Kuwait and Saudi Arabia. Mechanical power is used on about eight hundred farms in the three provinces, but nearly all of these were situated in Baghdad Province. There are, however, eighteen thousand farms, mainly in Basra Province, which rely on human labour alone without any assistance from either animals or machines.

### Archæological Excavations near Behshahr, Iran

Three interesting articles on the excavations in the Hotu Cave, Iran, are contained in a recent issue of the *Proceedings of the American Philosophical Society* (96, No. 3; June 1952). The first of these, by C. S. Coon, deals with the site itself near Behshahr in the Caspian Sea region. Excavations were undertaken, and a brief account of them is given. Louis B. Dupree next describes the Pleistocene artefacts found. These consist both of bone and stone tools. There is plenty of material for study; but the industries contain few typical tools which can be linked up with finds made elsewhere. Further work at the site will be needed before any definite conclusions can be drawn. J. L. Angel in a third article describes the human skeletal remains from the Cave. Judging from the illustrations, the skull and jaw have been excellently preserved. Once again, it would seem that the skeletal remains do not fall into any well-known category. Obviously the excavators have discovered an interesting early occupation cave-site in an interesting region, and it is to be hoped that further explorations at Hotu and neighbouring sites will enable the authors to determine more accurately the age and relationships of the industries present.

### *Bulletin of the Italian Society of Geophysics and Meteorology*

The formation of the Italian Society of Geophysics and Meteorology in 1952 (see *Nature*, 170, 144; 1952) has now been followed by the first number of the Society's *Bulletin* (*Bol. Soc. Ital. Geof. Met.*, 1, No. 1; 1953. From the Society at Via Balbi 5, Genova; 3000 lire or 5 dollars a year). The contents of this first number include a paper on the exploration of the ionosphere over the Antarctic by an Argentine expedition, reviews of the present state of knowledge of cloud physics and artificial precipitation and of the relations between the electric field in the atmosphere and the humidity and quantity of pollution, a note on the causes of earthquakes, and reports of scientific conferences and news of recent researches on a world-wide scale. The cover carries a superb photograph of a waterspout off the Italian coast. It is not planned to publish large original papers by Italian geophysicists in this periodical. Such papers will continue to be published in *Geofisica pura e applicata*.

### Press Guide to British Chemicals and their Manufacturers

The Association of British Chemical Manufacturers has recently published a small book entitled "Press Guide to British Chemicals and their Manufacturers" (pp. 76; March 1953) and two thousand copies have been issued in the first instance to the national, provincial and technical press (including scientific correspondents, editors of learned journals, etc.). The first twenty-two pages list the names and addresses of 126 chemical manufacturers, with the name and telephone number of an individual (often two names are given) who is authorized to supply information. A similar short section of two pages follows in which thirteen chemical trade associations are listed, dealing with special sections of the chemical and closely allied industries. The third section, consisting of seven pages, is an alphabetical list of chemical products, each one being indexed to at least one code number that represents the firm handling the product. Finally comes the fourth section, forty-five pages long, which contains a list of proprietary and trade names, and opposite each entry is the chemical name and the firm owning the copyright. Inquiries relating to this booklet should be addressed to the Association at 166 Piccadilly, London, W.1.

## Announcements

Prof. F. J. M. Stratton, formerly professor of astrophysics and director of the Solar Physics Observatory in the University of Cambridge, has been elected president of the Society for Psychical Research in succession to Dr. Gilbert Murray.

The following appointments have been made in the University of London: Dr. C. B. Allsopp, reader in physics at Guy's Hospital Medical School, to the University chair of physics applied to medicine, tenable at the School; Dr. E. M. Crook, senior lecturer in the Department of Biochemistry at University College, London, to the University readership in biochemistry, tenable at the College.

The second British Instrument Industries' Exhibition will be held in the National Hall, Olympia, London, during June 30–July 11. The Exhibition will cover all spheres of instrumentation in industry, medicine, research and education. The organizers of the Exhibition are F. W. Bridges and Sons, Ltd., Grand Buildings, Trafalgar Square, London, W.C.2.

The North-Western Branch of the Institution of Electronics will be holding its eighth annual exhibition of electronic devices at the College of Technology, Sackville Street, Manchester, during July 15 (12–10 p.m.), July 16–17 (10 a.m.–10 p.m.), July 18 (10 a.m.–7 p.m.), July 20 (10 a.m.–10 p.m.) and July 21 (10 a.m.–9 p.m.). In addition to the usual commercial section of the exhibition, there will be a scientific and industrial research section, incorporating exhibits from research associations and the universities. Copies of the exhibition catalogue (1s. 6d. post free) will be available early in July. Admission tickets (available after June 1) and further information can be obtained from the secretary, W. Birtwistle, 17 Blackwater Street, Rochdale, Lancs.

A conference on nuclear physics at intermediate energies will be held by the University of Pittsburgh during June 4–6, the provisional list of topics to be covered being beta-decay, nuclear reactions and scattering at intermediate energies, energy levels of light nuclei, and photo-induced reactions. Further information can be obtained from Dr. E. Gerjuoy, Department of Physics, University, Pittsburgh 13, Pa.

Last year, a meeting for Nobel prize-winners in chemistry was held at Lindau, Bavaria (see *Nature*, 169, 868; 1952), and was attended by nearly a thousand visitors. A similar meeting is being arranged this year, at which Nobel prize-winners in physics will be asked to give addresses; it will be held during June 29–July 2.

A postgraduate summer school in optical crystallographic methods, organized by the Department of Inorganic and Physical Chemistry of the University of Leeds in association with the Department of Adult Education and Extra-Mural Studies, will be held in the University during August 31–September 11. The course, which will be similar to those held in 1951 and 1952, will provide basic training in the theory and the practical use of the polarizing microscope for the study of crystals and other birefringent materials, and in the applications of the instrument in various branches of science and technology. The general aspects will be dealt with during the first week, and during the second students will specialize in their particular group; for example, chemical, mineralogical or biological. The fee for the course is 15 guineas. Residence is available at a cost of £10. Application forms (to be completed by May 11) and further information can be obtained from the Secretary, Department of Adult Education and Extra-Mural Studies, The University, Leeds 2.

The report on research at the Royal Technical College, Glasgow, during the session 1951–52 (pp. 36; 1952), gives a brief summary of research work in progress in the various departments, and to each account there is appended a list of the more important publications by members of the staff of the particular department during the year, with the titles of theses approved for higher degrees and particulars of reports prepared. The report replaces the former *Journal of the Royal Technical College*, publication of which has now ceased.

The Library of the United States Congress and Princeton University are sponsoring a conference on "Islamic Civilization and Culture", to be held in Princeton, N.J., during September 8–17, and in Washington, D.C., September 17–19. Thirty eminent Muslim scholars and intellectual leaders from countries of the Middle East and Asia have been invited to participate, and there will be a similar number of American delegates. The conference will be concerned with three aspects of the subject: classical elements in Islamic culture; Islamic law and society; and intellectual and spiritual movements in Islam to-day. Dr. Bayard Dodge, president emeritus of the American University, Beirut, Lebanon, is the executive director of the conference.

A list, under their current titles, of periodicals received in the Technical Library, Ratcliff Place, has been issued by the Birmingham Public Libraries (pp. 20; 1953). The list shows the Library's holding of each periodical, irrespective of any change of title, but does not include 1,250 periodicals and transactions of societies taken in the General Reference Library or the five hundred received at the Commercial and Patents Library. Periodicals with distinctive titles are entered alphabetically, neglecting the article, but other periodicals published by corporate bodies are entered under the names of the corporate bodies.

Erratum. In the list of awards of Commonwealth Fund Fellowships in *Nature* of May 2, p. 776, for "J. M. Williams" read "R. L. Williams".

# SOCIAL POLICY AND THE SOCIAL SCIENCES

UNDER the broad, general title of "Social Policy and the Social Sciences", the recently formed British Sociological Association arranged its first conference, held during March 27–29 at Queen Elizabeth College, London. The opening address was given by Dr. Gunnar Myrdal, the executive secretary of the Economic Commission for Europe, who dealt with the relation between social theory and social policy. The whole of March 28 was devoted to group discussions, in which the conference was divided into three sections, meeting simultaneously; and on the following morning Prof. T. H. Marshall, after receiving verbal reports from the chairmen of the three groups, summed up on the work of the conference.

The first group began its discussions by considering what contribution social scientists could make to their main subject, namely, health. Dr. J. N. Morris, in introducing his paper on "Changing Needs", asked the pertinent question what, in our way of living, is leading to so much inefficiency and disease. Very little research, he said, is being carried out on the running of the health services, either to provide us with basic knowledge or even to enable us to judge how good the services are. More study is required if we are to know how far we are preserving freedom and the essential ideals of democracy. He suggested that social scientists might well collaborate with the medical profession in acquiring fundamental knowledge that would help us to deal effectively with such matters as smoke pollution, the defects of the catering industry, and the building industry. Many of these problems are social rather than medical; but teamwork is needed.

Prof. Ferguson Rodger, in a useful paper, took up the theme of changing needs from the angle of the psychiatric services. He showed how the scope of psychiatry has expanded rapidly from the concept of mere custody to a concerted and intelligent plan designed to care for the far greater numbers who are incapacitated by neurosis. In spite of this, half the hospital beds in Great Britain are devoted to major mental illness, and it is natural that we should still be hospital-minded and only half aware of the great advances in non-institutional psychiatric treatment. Prof. Rodger cited, for example, the therapeutic and economic value of hostels and day hospitals; the development of the latter means that twice as many patients can be treated in the same space, through the saving in beds and other night furniture.

As the discussion went on, it became clear that the emphasis was shifting from the consideration of medical needs as such to the *terra incognita* between medical and social science. Dr. M. I. Roemer, for example, asked how social science could help in the transfer of new ideas from one culture to another. This means that it should address itself to study of the best time for their absorption, as well as the rate at which new findings in medical care could be digested. Dr. J. H. F. Brotherston carried the discussion further by considering, in a thoughtful paper, how medical education could be helped to give the student a deeper knowledge of the springs of human behaviour. Much could be done, he felt, by showing the student the real practice of both medicine and social work in the homes of the people: "The medical student emerges from training with a well-developed scientific approach to disease processes. At the same time he may be as ignorant as the next man when it comes to understanding his patient as a person whose social situation is of the greatest importance in determining his reaction to ill-health. His scientific training may increase rather than diminish his difficulties in this direction".

In this way the issue of the practical contribution of social work to medical practice is revealed, and its value is generally agreed. A more fundamental question, however, was uncovered, so to speak, by Dr. Brotherston's plea for integration. What is social science, and how far can its practical applications be regarded as the core of the subject? Social science is concerned with human behaviour, but honour is not satisfied merely by its handing over a technique to medicine, even if it bears the pleonastic title of 'social medicine'. If social science and medicine are to work happily together, then each needs confidence in its own techniques, and there must be an agreed common basis of understanding. It may well be that the medical man needs the help of social science in therapy, in preventive action—such as the limitation of neurosis—and, above all, in framing policy through the study of priorities in medical care. The fundamentals of social science were again considered, by Prof. M. Ginsberg, in his closing commentary on the conference. While recognizing the great value of the conference in bringing together workers in so many different fields, he felt that the meeting as a whole suffered from the vagueness of its title, especially as it concealed a lack of real knowledge of the terms social science and social policy. He argued that a good deal of so-called social research is not research in any accepted sense of the term; much of it is plain common sense mixed with a little elementary physiology and psychology. There is a profound difference between fundamental and applied theory, and therefore the function of social science proper is to find out the principles themselves. Social psychology, for example, is in danger of being overwhelmed with new techniques, as in the study of public opinion. The theoretical side is not being investigated at all, as, for example, the theory of public suggestibility as a basis for propaganda. The study of the techniques of propaganda and public attitudes do not advance the theory at all. Similarly, in relation to values, Prof. Ginsberg pointed out the confusion between fundamental studies and the operational research which consists in trying to find out what people want. This is a relatively simple matter, he said; but when one begins to criticize what people want, that is where values come in.

The group dealing with health further considered the problem of co-ordination and integration of the tripartite services under legislation for the National Health Service in Great Britain. In many respects our lack of knowledge of how the Service works is a serious matter; and, as Prof. R. M. Titmuss pointed out in his paper, there is a great deal of confusion not only about the role of the social services but also about the theoretical framework within which these services can be appraised as an integral part of the total performance of the social system.

The papers belonging to the second section, 'Design and Planning", ranged over a very wide field, from the broad implications of the Town and Country Planning Acts to the more intimate social problems of rehousing the family. Hitherto, the social scientists have been able to do little to influence such plans, but the fruits of their research have had considerable potential value and ought not to be neglected. To the observer of the discussions relating to these papers the day's work was stimulating ; but sometimes there crept in a doubt about whether some of the more basic questions were being missed. There were so many different views on how the needs and aspirations of a planned community could be measured ; it was therefore disturbing to feel that the experts had not reached any solid basis of agreement.

The third section of the conference—on "Needs and Standards in the Social Services"—began by considering social security in the epoch following the Beveridge Report. Recent years have brought about developments which were not foreseen when the scheme was planned. Ever-increasing demands are being made on the central exchequer to supplement the allowances paid under national insurance. These allowances fall substantially below the minimum subsistence requirements as assessed by the scale of need of the National Assistance Board. In 1952, 24 per cent of the households drawing retirement pensions were receiving supplementary assistance compared with 18 per cent four years previously, and the same trend is apparent in the other branches of national insurance. Clearly it would be impossible to raise the level of contributions to make the scheme actuarially sound. Would it therefore be better to drop the figment of a contributory insurance and finance the entire scheme out of general taxation ? Or should one follow some other British Commonwealth countries and raise the money through a progressive social-security tax ? In such a case should there be progressive rates of benefits, thus taking account of the fact that different people have different needs ? Would it be advisable to develop some branches of social security as self-supporting insurance schemes—for example, those providing for short-term crises such as sickness or unemployment —while financing the remainder out of general taxation ? These were some of the questions raised in the discussion. There was a general feeling that the abandonment of the principle of a contributory insurance for the purpose of economy and simplification in administration would, in the popular mind, entail the abandonment of the right to benefit. This right is held dear by working people, particularly in regard to unemployment. The imposition of a test of need would be considered as harking back to the days of the means test and the Poor Law. There is some recent evidence to show that there is still reluctance to claim assistance on the part of unemployed workers. Old people, too, it has been said, like to feel that they have something which they have earned, contributed or 'put by' for themselves and generally deplore the idea of charity.

It seems desirable that the purpose of the various social-security schemes be thought out and defined more clearly with the view of bringing about modifications designed to meet the needs for which they were intended.

The group turned to subsistence standards and to methods of measurement in social science. A method of measuring poverty that takes into account the actual purchasing behaviour of people was discussed and shows promise of an improvement over its precursors. Then followed a discussion on the advantages and limitations of social survey techniques. It was agreed that such investigations could provide accurate factual data on the problem of needs and standards in the field of social insurance, but there was a lively debate on their value to the administrator in policy-making and in assessing priorities in the field of social welfare. Here the question of values which had obtruded itself many times in the conference came to the fore. Social scientists cannot claim the right to pronounce on how value judgments are to be made, but—and perhaps this was a keynote of the meeting—they can provide factual data by which such judgments can be considered and made more rationally.

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# INSECTICIDES AND COLONIAL AGRICULTURAL DEVELOPMENT

SOME eighty representatives of Colonial agricultural administration, of applied entomology, and of insecticide research and development were invited to Bristol by the Colston Research Society during March 23–27 to take part in a symposium dealing with insecticides in relation to Colonial agricultural development. The conference, which had the support of the Colonial Office and the Agricultural Research Council, was directed by Prof. T. Wallace, head of the Bristol University Agricultural and Horticultural Research Station at Long Ashton.

In the opening session, Dr. W. G. Hall (Commonwealth Institute of Entomology) stated that entomologists have been appointed in only fourteen of the thirty-eight British Colonies. The Colonial Empire, totalling 2½ million square miles, with a population of 70 millions and an annual export of crops valued at £182 million, employs, in all, 29 entomologists. Dr. Hall referred to the coming expiry of the Colonial Welfare and Development Act in 1956 and expressed the hope that ample funds will be made available to continue the pest-control work initiated by that Act.

Mr. C. B. Symes, of the Colonial Office, outlined the insecticide research programmes in the British Colonies, emphasizing the uses of the chlorinated hydrocarbons on pests of food plants. He pressed for an increase in fundamental work on specific Colonial problems.

Mr. S. Callaway, of the Chemical Defence Experimental Establishment, Porton, gave a detailed account of an air-spraying operation against locusts in Tanganyika, in which a spray of 20 per cent dinitrocresol in oil destroyed 4¼ million locusts (96 per cent of the original population).

In the discussion on these papers, several speakers questioned the practicability of introducing insecticide treatments on peasant-grown crops. Sir Harold Tempany pointed out that the yields from peasant holdings are exceptionally low and will have to be increased because population is outpacing food production. Mr. W. T. Cowan noted that co-operative societies of native cotton growers are starting in Uganda.

In the afternoon session of March 24, Mr. E. O. Pearson (Empire Cotton-Growing Corporation) said that the control of jassid on irrigated cotton in the Sudan is the only instance in Africa of large-scale insecticide applications to this crop. He considers that the employment of insecticides on peasant cotton awaits a more orderly system of farming and an increase in basic yields by improved cultivation and manuring.

Mr. R. S. McKinlay (East African Agriculture and Forestry Research Association) described a method of assaying *Lygus* damage to cotton by using weekly spraying of individual rows with DDT and toxaphene to provide pest-free plants for comparison of yields with those of surrounding *Lygus*-infested rows. He suggested that the inevitable delay in extending insecticide treatments to peasant crops might give time for the perfection of effective techniques.

In the discussion, Mr. Pearson recorded that the United States yields, being ten times those of Africa, carry a much higher cost of spraying. Mr. Leyland Cole deprecated the use of over-crude methods for applying the potent modern insecticides. A question on developments in the Congo elicited the reply that a much greater degree of direct control of agriculture is established there than in British colonies. Mr. McKinlay believes that the peasant cultivator can be taught to use insecticides but that it will be a slow process.

On the second day, Mr. G. Swaine (Department of Agriculture, Tanganyika) recorded experiments showing that treatment of cotton with five applications of 10 per cent DDT plus 3 per cent BHC greatly increases yield by controlling American bollworm. On coffee, the Pentatomid bug ***Antestia lineaticollis*** is now widely controlled in East Africa by DDT emulsion. Contact insecticides have given striking results when applied as seed dressings or mixed with soil; for example, BHC against termites or sugar-cane white grubs, aldrin and BHC against the wheat pest, *Heteronychus consimilis*, and toxaphene against cutworms.

Mr. M. J. Way (Rothamsted Experimental Station) described certain ecological balances between pests and predators that might be adversely affected by insecticides. In Zanzibar the *Theraptus* bug attacking coconut palms is often kept in check by a predatory ant. This ant, however, encourages the mealy bug suspected of being the vector of a virus attacking clove trees. A similar relationship between ants and mealy bugs exists on cacao in West Africa.

Mr. J. Bowden (Agricultural Department, Gold Coast) described the damage done by insects to the African's principal food crops—maize, sorghum and millet.

During the discussion it was stated that seed dressing with BHC uses only one-tenth of the quantity of material employed in broadcast applications, but still gives a residual effect. The phytotoxicity of BHC to tobacco seedlings was noted.

In the afternoon, a paper by Mr. R. G. Fennah (Imperial College of Tropical Agriculture) was read by Mr. D. B. Murray. Mr. Fennah considers that, in the West Indies, losses due to the inefficiency of agricultural methods far outweigh those caused by insects. The successes so far gained by insecticides in that area are the suppression of the sugar-cane froghopper in Trinidad and the simplification of parasol ant control.

Prof. J. W. Munro (Imperial College, London) warned the conference that transfers of native labour from subsistence agriculture to industry will bring famine nearer, unless satisfactory storage and transport of foodstuffs can be provided. Much existing knowledge of stored-products pest control is not being used. Prof. Munro emphasized the importance of training selected Africans and West Indians as technicians in the practice of storage pest destruction.

In the discussion, Dr. Jepson said he hopes that the development of agriculture as a subject of study in African universities will be encouraged by the provision of sufficiently attractive posts for Africans trained in agricultural science. He described the methyl bromide fumigation of the groundnut 'pyramids' at Kano as an outstanding example of co-operative effort. Mr. Swaine explained the method of pit storage in Tanganyika, which depends on the production by hermetically sealed grain of sufficient carbon dioxide to act as a fumigant. Dr. R. C. Fisher directed attention to infestations of timber, and outlined the activities of the West African timber-borer research team appointed by the Colonial Office to study infestation in logs before export.

The first paper of the morning session of the last day of the Conference was a general review by Sir Thomas Dalling (Food and Agriculture Organization, Rome) of the insect-transmitted diseases of livestock in Colonial territories. This was followed by a film and paper by Dr. J. Carmichael (formerly of the Uganda Veterinary Department) describing tsetse control in Zululand by application of DDT aerosols from Anson aircraft. Seven such applications in the period September 1950 to January 1951 reduced tsetse populations by 97–99·9 per cent.

Mr. H. E. Harbour (Cooper Technical Bureau) referred first to the earlier treatment of ticks on livestock by sodium arsenite dips, and the development of arsenic-tolerant tick populations. At present, BHC, DDT and toxaphene are making great contributions to tick control. In two areas in Tanganyika tanks have been installed and compulsory dipping instituted. As substitutes for dipping tanks, spray 'tunnels' are proving effective.

The discussion was opened by Dr. J. C. Matthysse (Cornell University), who has been working on ticks in Rhodesia under the auspices of the Mutual Security Agency. He described systems of pen spraying of cattle, using itinerant spray teams. Dr. J. T. Martin suggested that the cost of derris treatment against warble flies might be lowered by the use of synergists. Mr. Symes described the contribution of the workers at Porton in the design of pumps and nozzles for tsetse-eradicating sprays.

In the final session, Dr. H. G. H. Kearns (Long Ashton Research Station) stressed the fact that the successful solution of a spraying problem must take into account the biology of the pest, the spray material, the culture of the crop, the machinery and the user. Present designs, particularly of small manual sprayers, are capable of much improvement, but low-priced standardized designs necessitate large orders. 'Air-flow' mist sprayers can be used for drift spraying only in exceptional cases, as in locust control. Appreciation by the engineer of the biologist's problems is fundamental to the development of satisfactory equipment.

Dr. E. Holmes (Plant Protection, Ltd.) summarized the magnitude and cost of the search for, and development of, new insecticides. He emphasized the necessity for the overseas user to give the manufacturer ample time to ship materials to ensure their delivery at a given date. He referred to the benefits that are accruing from the closer co-operation between official research workers and those from industry.

In the discussion, Mr. Higgins mentioned that the training of entomologists at the Imperial College, London, includes instruction in the use of spray machinery. Mr. Hoare stressed the importance of obtaining exact data on spray deposition and offered the use of an electronic deposit analyser. Mr. Joyce described low-volume spraying in the Sudan, using 25 per cent DDT concentrate at just over ½ gallon per acre. Mr. Symes considers that until formulations of insecticides and designs of machinery are based on much more fundamental research there will be much guesswork in pest-control procedures.

Throughout the conference the outstanding value of co-operation between home and overseas workers was apparent, and it was made clear that one of the immediate problems in Colonial agriculture is the reconciling of peasant cultivation with the need to increase food production by modern methods of pest control. R. W. MARSH

# NATIONAL RESEARCH DEVELOPMENT CORPORATION

## REPORT FOR THE YEAR 1951–52

SIR HENRY TIZARD'S cautious reference to the National Research Development Corporation in his Messel Memorial Lecture last July would of itself induce careful scrutiny of the third report of the Corporation, covering the year ended June 30, 1952, which has now been published*. Although in content and arrangement this report differs somewhat from the two previous reports, which were concerned largely with describing the administrative arrangements, internal and external, and the policy it was proposed to pursue, and describes in more detail the kind of work now being done, it still appears that the Corporation has been in operation for too short a period for a sound judgment as to whether the fear is justified that the existence of such a government body will of itself discourage the spirit of adventure on the part of industry. The brief factual account of its work contained in this report gives no indication of any such trend, if indeed such a trend is likely to be reflected in the work of the Corporation itself.

Some 1,736 patents and patent applications have been vested in the Corporation during its first three years, and, of the 1,027 of which the Corporation was first apprised during 1951–52, 491 were from government departments and research councils, sixteen from British Commonwealth official organizations, one from a nationalized industry, eight from industrial research associations, fifty-three from universities, three from charitable organizations and 455 from private firms and individuals. Many of these last-named, of which 432 were British, were not of public importance. Of patent rights in inventions assigned to the Corporation during the year, 414 were from government departments and research councils, three from industrial research associations and twenty-two from universities, out of a total of 445; and of 401 United Kingdom patent applications and 559 United Kingdom granted patents that were held by the Corporation at June 30, 1952, 235 of which were the subject of 776 overseas patents and patent applications, 844 came from government departments and research councils, seven from industrial research associations and eighty-seven from universities. Most of the 199 licence agreements entered into at June 30, 1952, were not yet revenue-carrying, and net receipts from the various assets were £25,676.

During the year details of 361 inventions were the subject of 8,871 circulations to industrial firms and led to 245 inquiries. Of these, and of a further hundred inquiries brought forward from the previous year, 166 eventually proved abortive and 101 were still under consideration at June 30: the balance resulted in licence negotiations, of which thirty-one had been completed and forty-seven were still proceeding at that date. A second group of inventions includes some two hundred government and research council inventions, represented by patents and patent applications assigned to the Corporation, about eighty from universities, and a few from research associations and private inventors. All these cases are somewhat complex, requiring more-or-less constant individual attention. Sometimes the subject-matter is still too immature or tentative or the field of possible application as yet too remote or obscure to call for any action at this stage, but, from this whole group of inventions, nine licence agreements were concluded and thirty-two were still the subject of licensing and development discussions.

From the third group of inventions, of a long-term character, for which no individual enterprise can be found that is prepared to spend money on development, and in which the Corporation has undertaken the financial responsibility for development, some fifteen development projects have been sponsored during the Corporation's first three years, and further details of some of these are given in the report. Electronic digital computers have been the subject of ninety-nine inventions assigned to the Corporation, fifty-nine being from universities, thirty from government departments and corporations and ten from industrial firms. Patents have been applied for in respect of seventy-four of these inventions in ten foreign countries, and the Corporation has given a contract for the supply of four machines similar to that installed according to the design of Prof. F. C. Williams at the University of Manchester, where grants for development have also been made by the Corporation. The Corporation is, too, entering into a further contract for the supply of a prototype of a machine of much-reduced size based upon the development of special techniques which are expected to decrease cost and increase reliability.

The Corporation is assisting with grants of money for staff and materials experimental work at the Imperial College of Science and Technology, London, on a project for hydrocarbon synthesis; and development work at the National Physical Laboratory, Teddington, arising out of Sir Thomas Merton's work on diffraction gratings, and particularly in relation to spectroscopes, is being assisted by the provision of staff. Two industrial firms in the instrument industry have already taken out licences under the patent rights assigned to the Corporation in respect of these inventions. The Corporation has also agreed to sponsor a project, emanating from Sir Harry Ricardo, for a light steam-engine, which is operated off boiler plant designed to be fired with low-grade fuel and which is based on the application to such engines of the considerable engineering processes made during recent decades in the field of light internal-combustion engines. The project is regarded as likely to contribute materially to Commonwealth interests by meeting the need for small prime movers in under-developed regions of the world. A pilot plant in East Africa, where sisal juice is available in quantity for the production of hecogenin, based on a laboratory unit set up under the joint auspices of the East African Industrial Research Board and the Medical Research Council, is being sponsored by the Corporation to provide a centre for more extended study of the methods of extraction and processing. In the field of scientific instruments, the Corporation has undertaken, jointly with an industrial firm, the development of a British photogrammetric plotting instrument from an invention of Prof. E. H. Thompson, professor of surveying in University College, London; and, in order to accelerate production, it has, with Board of Trade approval, undertaken a share of the financial risk involved in the development of an aural microscope and chick-sexer from the invention of Mr. C. S. Hallpike, of the Otological Research Unit of the Medical Research Council.

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* National Research Development Corporation. Report and Statement of Accounts for the Year 1st July, 1951, to 30th June, 1952. Pp. 18. (London: H.M.S.O., 1953.) 9d. net.

# TESTING OF BEARING PROPERTIES OF METALS

ENGINEERS and metallurgists have long been faced with the problem of assessing the bearing properties of any particular bearing alloy. One obvious method (and perhaps the best) has been to test the materials under practical working conditions; but, although this may be effective, it is extremely costly and slow. For these reasons a number of simplified empirical methods have been devised which aim at providing a useful 'figure of merit'. In a paper on "Some Experiments with Sleeve Bearing Metals" (*Trans. Danish Acad. Tech. Sci.*, No. 2; 1952), Dr. Borge Lunn has described another test of this type. As he points out in his introduction, it has generally been recognized as a defect of existing hydrodynamic theory that it does not take into account the nature of the journal or bearing material. In practice, however, the behaviour of a bearing is very markedly dependent on the type of lubricant and bearing material used, and this, in turn, is associated with the frequency and extent to which the hydrodynamic film is penetrated. Dr. Lunn's test has therefore been primarily designed to give a measure of the breakdown and penetration of the lubricant film.

The experimental arrangement is a development of that described by Kauppi and Pedersen[1]. It consists of a hard steel ball which reciprocates over the surface of the bearing alloy at a frequency of about seventy strokes a minute, the load being of the order of several kilograms. The rubbing surfaces are insulated and the electrical resistance between them measured during the reciprocating motion. The method is similar to that described by Courtney-Pratt and Tudor[2] and by Popinga[3] in their investigation of the lubrication between the piston ring and cylinder wall of a running engine, and shows results of the same type. When the surfaces are instantaneously at rest the resistance is low, indicating some metallic contact or, at best, a regime of boundary lubrication. During the central part of the stroke the resistance fluctuates between high and low values as a fluid film is built up and then punctured. Further, as a result of a running-in effect, there is an overall increase in the resistance during the first few minutes of the test, a steady state being reached after several hundred strokes have taken place. Dr. Lunn's procedure is to determine the average resistance during the first 250 sec. of running by a current-potential method using a pen-recording voltmeter of relatively low frequency. The difference (expressed as a percentage) between the full potential drop obtained when the surfaces are completely separated by a fluid film and the average potential drop observed in any particular experiment is then taken as a measure of the breakdown of the lubricant film. The '*L*-values' so obtained are found to vary with the bearing alloy examined and with the lubricant used. Thus a good combination, implying little breakdown of the lubricant film, gives an *L*-value of 10–20 per cent, a poor combination 80 per cent and a bearing using a silicone oil as much as 95 per cent.

Dr. Lunn finds that with tin-base bearing alloys the *L*-values obtained are lower when the alloy is quickly solidified. The *L*-values are decreased when lead is introduced in place of copper and antimony and, to a smaller extent, in place of tin. With bronze alloys the presence of a phosphide eutectic produces a low *L*-value.

Ageing of the lubricant usually produces a reduction in the *L*-value implying improved lubricating properties, while the presence of an antioxidant gives poorer lubricating properties. As a result of these investigations, Dr. Lunn suggests that the effectiveness of a bearing-lubricant combination depends on the formation of a suitable surface film as a result of chemical reaction between the rubbing metals, the lubricant and the surrounding atmosphere. In addition, Dr. Lunn claims that his *L*-value provides a single 'figure of merit' which agrees well with practical performance. It would be interesting to see this extended to other materials and to see if the order of performance is significantly changed by simple alterations in the experimental conditions.

D. TABOR

[1] Kauppi, T. A., and Pedersen, W. W., *Nat. Petr. News*, **37**, 944 (1945).

[2] Courtney-Pratt, J. S., and Tudor, G. K., *J. Inst. Mech. Eng.*, **155**, 293 (1946); see also Tudor, G. K., *J. Coun. Sci. Indust. Res. (Australia)*, **21** (3), 202 (1949).

[3] Popinga, R., *Automobiltech. Z.*, **44**, 247 and 272 (1941).

# NOISE FROM AIRCRAFT AT SUPERSONIC SPEED

REFERRING to recent correspondence on this topic in *Nature*, Dr. E. Esclangon has directed attention to two communications by him published in the *Comptes rendus* of the Paris Academy of Sciences. The first, published on November 17, is "Sur les détonations balistiques, engendrées par les projectiles et les avions supersoniques", and the second, published on November 24, 1952, is "Sur les sifflements de projectiles et bruits d'avions en vitesse supersonique". Dr. Esclangon's views on the acoustic effects of supersonic aircraft are based on his extensive work on the shock waves of projectiles during the First World War, published in 1925 in "L'Acoustique des Canons et des Projectiles" (Paris: Gauthier-Villars, 55 Quai des Grands Augustins, Paris 6^e^).

Dr. Esclangon points out that aircraft do not differ essentially from projectiles in the production of shock waves, except that they carry very noisy contrivances which add to the disturbance resulting from their movement alone. The distinction is emphasized between (1) the continuous and uniform disturbance due to the pushing aside of the air, and (2) the periodic disturbances due to the rear turbulence and precessional movements of the projectile and to the roar of the jets of the aircraft.

For the uniformly evolved disturbance, the arrival at a distant observer's position $P$ of disturbances set up over an element of the trajectory will be simultaneous and in correct phase to produce considerable amplification, and the resulting bang will be all the greater as the size of the moving body is increased. The 'ballistic wave' (to use Dr. Esclangon's term) is a closed surface for a body the velocity of which is increasing through the velocity of sound, consisting of two sheets, a forward one of conical form and a rear one more nearly spherical, the two merging tangentially. More than two 'ballistic detonations' may be perceived, depending on the shape of the trajectory.

In his second communication, Dr. Esclangon considers the periodic disturbances. He points out that these are generated in an element of the trajectory in the period of the disturbance which will arrive at $P$ simultaneously; but in all phases corresponding to the period and which, added algebraically, will destroy the periodicity. If the mean pressure is not zero, it will add to the ballistic wave. Dr. Esclangon gives details of a critical experiment. An observer was placed near the point of impact of a large inert projectile fired from a gun at a distance of 54 sound-seconds. The speed of the projectile was, at all points of the trajectory, greater than that of sound, and the duration of its flight was 37 sec. It was expected that after the ballistic wave had arrived the whistling of the projectile would be heard in reverse for 17 sec.; but in fact nothing at all was heard. Dr. Esclangon finds difficulty in explaining this, although the experiment would appear to emphasize the fact that the bang is predominantly due to the ballistic wave and that the whistling from the remote beginning of the trajectory is too feeble to be heard.

After pointing out the possibility of further study through the medium of supersonic aircraft, Dr. Esclangon concludes with a forecast that, as the ballistic wave appears when the speed of the aircraft resolved in the direction of the observer equals the speed of sound, a flight path in the form of an equi-angular spiral, centre $P$, would make $P$ a sort of focus for a particularly powerful 'acoustic detonation'.

# MARINE BIOLOGY RESEARCH IN GREAT BRITAIN

FIFTEEN papers on the species and habits of marine animals, the chemical constituents of sea water and the utilization of these substances by living animals and plants, etc., make up the contents of the last (No. 3) number of Vol. 31 of the *Journal* issued by the Marine Biological Association of the United Kingdom.

Dr. D. P. Wilson has continued his experiments on the settlement of *Ophelia bicornis*. Earlier work had shown that there is a range in the size of particles suitable to larval metamorphosis; but Dr. Wilson has now discovered that an organic film on the sand particles of suitable size renders them attractive to the larvæ, whereas sterilized sand of similar particle-size is repellent, with a neutral category between these two extremes. D. B. Carlisle records three species of *Trididemnum*. J. A. Allen has made an exhaustive study of more than two thousand five hundred specimens of *Nucula turgida* and *N. moorei*, and shows that they grade into one another, representing, in fact, a single species, *N. turgida*. Prof. N. Millott, while on a visit to Plymouth from Jamaica, investigated the skin pigment of *Holothuria forskali* and found that the cœlomic amœbocytes produce melanin for the skin pigment and that this production is coupled with the presence of an active phenolase system. G. Hoyle has studied spontaneous squirting in the ascidian *Phallusia mammillata*. Rhythmical patterns of activity in sedentary animals occur also in *Metridium* (Batham and Pantin, 1950) and *Arenicola* (Wells, 1949). This activity, which is inherent, is modified by external stimulation, but is not initiated from without. The inherent activity may be myogenic, "with considerable neurogenic control". Spontaneous squirting of certain ascidians is an integral part of their feeding mechanism, and clears out waste from both the pharyngeal and atrial cavities. Dr. D. T. Gauld and Prof. J. Raymont contribute a paper on respiration in the copepods *Temora*, *Acartia* and *Centropages*, in which they point out that estimation of the food requirements of copepod populations based on the respiratory-rate, as used by other workers, is unreliable unless the size distribution of the copepods making up the population is known. Moreover, at least in *Centropages*, different generations of the same species may, for unknown reasons, have different respiratory-rates, and temperature is therefore not the sole cause of variation. Dr. Gauld has also studied the grazing of copepods, chiefly *Calanus finmarchicus*, and has found that some fed continuously during a twenty-four hour period near the surface, not migrating downwards, while others underwent vertical migration and fed only at night near the surface. There is thus no general feeding rhythm, as postulated by certain workers.

Dr. W. R. G. Atkins and Miss P. G. Jenkins have examined monthly for a year the phytoplankton from a station ten miles south-west of the Eddystone Rock, between the surface and fifty metres depth. For the surface the maximum was in March, the minimum in June, with a moderate rise in September and a winter minimum in November. The botanical composition of the water was studied after culture in diffuse light in the laboratory, twenty species of diatoms, eight members of the Chlorophyceæ, and one each of the Chrysophyceæ, Dinophyceæ and Cryptophyceæ being recorded. Mr. R. F. Hutton describes a new furcocercous *Cercaria*, *C. reesi*, from the digestive gland of *Hiatella arctica* and *H. striata*. Dr. J. S. Alexandrowicz has continued his investigations on the nervous system of marine arthropods by observations on the nerves of the pericardial organs of the decapod Crustacea. He finds evidence that these organs, bathed directly by blood from the gills, produce substances influencing the heart rhythm.

Dr. H. W. Harvey has two papers on the utilization of chemical substances in sea water by *Nitzschia closterium*. This diatom can absorb organic phosphorus when inorganic phosphorus in solution has been exhausted, both in light and in darkness. Nitrogen-deficient cells can also synthesize organic nitrogen in darkness from ammonium, nitrate and nitrite, with intensity decreasing in that order, and also chlorophyll and yellow pigments. Dr. W. R. G. Atkins has resumed his work on the phosphate and silicate content of sea water, and compares the data with those for the 1923–25 period. He also reports on the seasonal variation in the copper content of sea water; this builds up in the winter and drops from May onwards, with a minimum in October.

Tests with materials for the preservation of fishing nets, by Dr. Atkins and Mr. F. J. Warren, showed that on cotton netting 'Cuprinol', or Dr. Olie's method with cutch and ammoniacal copper sulphate, worked well, the latter being the cheaper of the two, while on trawl twines 'Cuprinol' (British Columbia grade) was best. Work on the preservation of ropes is proceeding. This number of the *Journal* concludes with abstracts of memoirs recording work done at the Plymouth Laboratory and published elsewhere.

N. B. EALES

# ARTIFICIAL STIMULATION OF RAIN AT KONGWA

DURING January–April 1952, cloud-seeding experiments for the artificial stimulation of rain were carried out at Kongwa, Tanganyika, in connexion with the growing of groundnuts and other crops there by the Overseas Food Corporation. The director of the East African Meteorological Department, Mr. D. A. Davies, has already described the methods used (see *Nature*, 169, 1001; 1952), and now the results of the experiments have been published in the Department's "Memoirs"* and they prove to be very surprising.

The full details of the methods need not be given in this article, but, briefly, the seeding agents were released in a three-day cycle: silver iodide was released on the first day at a height of 14,000–15,000 ft., and hygroscopic particles (sea salt) at about 5,000 ft. on the second day. On the third day there was no seeding. Balloons carried canisters containing the seeding agent, which was released by exploding a small gunpowder charge by a time-fuse after a time of flight to bring the balloons to the desired height. The balloons were released downwind at a distance measured each day to ensure scattering of the particles over the same point at the centre of the farm area. Silver iodide is effective only at temperatures below − 5° C. and so had to be released at a much greater height than the hygroscopic particles which were released in the lower part of the cumulus clouds. Rainfall was measured by a network of gauges distributed over the roughly rectangular area, 22 miles by 7 miles in size, occupied by the farm area. The long side of the rectangle lay from east to west. The wind was easterly for nearly all the 114 days of the experiments. There is a ridge of high land running from north to south in the centre, and rainfall is normally appreciably greater there than in the eastern and western ends of the area.

The results are presented in isohyetal maps showing rainfall on all the days of each type of seeding and no seeding, with comparison with normal. There is no description of the rainfall of any individual day. The overall results are briefly as follows. (*a*) On days of seeding in both ways, the rainfall in the central area over which the particles were released was reduced from a total of 9 in. on days of no seeding to one of 3–4 in. for the days of each type of seeding; seeding thus appears to have produced a great decrease of rainfall over the central area. (*b*) On days of releasing hygroscopic particles, the rainfall in an area 6–12 miles downwind was above that on days of no seeding by up to 6 in.; rainfall over an area 5 miles upwind was also increased by 2–3 in. (*c*) On days of releasing silver iodide particles, rainfall upwind from the point of release was increased by at some places more than 6 in.; downwind there was a small decrease. (*d*) On some occasions, clouds in which hygroscopic particles had been released were seen to disperse rapidly.

The memoir explains the increase of rainfall 6–12 miles downwind on days of seeding with hygroscopic particles by the delay in formation of large drops. No reason for result (*c*) is suggested in the memoir, and there is no mention of a reversal of wind with height to carry the silver iodide particles to the east and so stimulate precipitation there.

On thirteen days when particles should have been released, it was already raining and balloons were not released because the fuses would have been extinguished. These days have been counted in the statistics as though seeding actually took place. As the memoir says, this makes the rainfall deficit in the central area even more surprising.

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* East African Meteorological Department. Memoirs, Vol 2, No. 10 Reports on Experiments at Kongwa on Artificial Control of Rainfall, January–April 1952. By D. A. Davies, D. Hepburn and H. Sansom. Pp. 14 + 8 pl. (Nairobi: East African High Commission, 1952.) 4*s*.

# FORMATION OF GALL STONES: PHYSICAL PROPERTIES OF BILE SALTS

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STONE formation in the various secretory or excretory ducts of the human body is one of the problems being studied in this Surgical Unit. The gall stone is the particular type of stone selected for study, especially that which, as a rule, primarily arises in the gall bladder—the pure cholesterol and the mixed gall stone, as opposed to the pigment or metabolic stone which arises in the hepatic ducts.

Pure cholesterol stones, single or multiple, are uncommon, for usually bile pigments, among other compounds, are included in varying amounts, either diffusely or by way of lamination, so that mixed stones are the rule. Because pure cholesterol stones exist with varying amounts of pigment, it is likely that the latter is an inclusion and that the prime disturbance involves the cholesterol. This is the 'crystallization out' of cholesterol; but the chemical reaction which starts this off, or the character of the nucleus around which the cholesterol stone forms, is unknown, even though Wilkie[1] noted that granular calculi of calcium and cholesterin were formed in the infected bile of an experimental animal. Gall stones have not been produced, at least convincingly, by any other means.

Two important contributory factors (or pieces of circumstantial evidence) in the formation of these gall stones are hypercholesterolæmia and infection; but to these a third factor should be added, namely, the power of the gall bladder to concentrate bile.

Associated with cholesterol are the salts of the bile acids, in the solutions of which the sterol is dissolved, and it was therefore considered that any chemical study of the factors responsible for the formation of gall stone must commence with the exploration of the cholesterol – bile acid relationship, first with the physico-chemical properties of the salts of the bile acids.

The inference that the molecules of bile salts should exhibit physico-chemical characteristics similar to those of the paraffin-chain salts may be drawn from the fact that in structure they contain water-attracting and water-indifferent parts—they are 'amphipathic'. Like the paraffin-chain salts, they have foaming, detergent and emulsifying properties, consequent upon their power to reduce surface tension.

McBain[2] put forward the micelle theory in order to explain the abnormal curves produced by plotting equivalent conductivity or the depression of freezing point against varying concentration of certain colloids (paraffin-chain salts) in solution. With the increase in concentration, a critical point is reached when an abrupt change in the slope of the curve or a discontinuity may be considered to be due to a change of phase ; in fact, ionic aggregation or micelle formation, as McBain called it, begins and extends over a certain range.

In Hartley's[3] contribution to the fuller understanding of the phenomenon, attention was directed to the fact that the salts of nucleic acid and possibly bile acids might undergo micelle formation at appropriate concentrations, though no experimental work on the latter had been done at that time.

Some particular observations of bile acid salts have been made since Hartley's paper ; Bashour and Baumann[4], Roepke and Mason[5], and Johnston and McBain[6] conducted experiments in order to study the equivalent conductivity and depression of the freezing point at varying concentrations of different salts. The results showed that although there was no sharp change in the slope of the equivalent conductivity – concentration curves, the osmotic coefficient – concentration curves, as measured by the depression of freezing point or the vapour pressure, did in fact indicate ionic aggregation. McBain considers that the measurement of equivalent conductivity alone may not give direct evidence of the formation of ionic micelles. The bile salts studied were sodium cholate, deoxycholate, glycocholate and glycodeoxycholate at temperatures of 20° C.[4], 25° C.[5] and 0° C.[6]. The temperature of a solution known to show evidence of ionic aggregation is important, for it will affect the critical concentration at which the micelles begin to form and the range over which they continue to do so. As the bile salts occur naturally in the animal world, their propensity for micellar forms were studied by us at 37–38° C., that is, at the normal environmental temperature of man.

The bile salts examined are among those commonly present in human bile : sodium cholate, deoxycholate, glycocholate and taurocholate, and the properties studied were equivalent conductivity, osmotic pressure, surface tension, turbidity and viscosity in order to detect any evidence of change of phase.

*Methods*. The bile salts were obtained from Ward, Blenkinsop and Co., Ltd., together with a statement of their purity. All the determinations with the exception of freezing point were performed without removal from the water-bath, which was thermostatically controlled at 37° ± 0·5° C. by a Kodak 250-W. heater and a Sunvic *T.S.I.* bimetal thermostat with relay.

Conductivity measurements were made with a Mullard conductivity bridge, Type *E*7566 (range 0·1–100,000 micro-mhos). The conductivity cell was the dip-cell Type *E*7591 supplied with the instrument and had a cell constant of 0·79. The water used for making up the solutions had a conductivity of $3 \times 10^{-6}$ mhos, thus limiting reliable measurements to concentrations greater than $M/320$.

The osmotic coefficient $g$ was calculated from the relation

$$g = \frac{\Delta t}{(2 \times 1{\cdot}858 \times m)},$$

where $\Delta t$ is the depression of freezing point in degrees and $m$ is the molarity, $g$ thus being the ratio of the value of the observed lowering of freezing point to that which would be expected for an 'ideal' fully dissociated electrolyte. $\Delta t$ was measured with the conventional type of Beckmann freezing apparatus.

Relative surface tension values were determined by a stalagmometric method employing a Steiner pattern stalagmometer. In spite of ensuring that a drop number of 15 per min. was not exceeded, it was realized that this method could not give reliable values of relative surface tension, though interesting and significant results were obtained by a simple comparison of drop numbers. For maintenance of temperature during surface tension experiments, the stalagmometer was fitted into an air jacket and the whole unit submerged in the water-bath to below the level of the top graduation of the stalagmometer.

Relative viscosity readings were made with a Steiner pattern No. 1 viscometer inserted into a water-bath well above the highest graduation.

Photographs were taken of the bile salt solutions at times when changes in turbidity became apparent. In most cases this occurred within a day or two of making up the solutions, and microscopic examinations were carried out to eliminate the possibility of interfering fungoid contamination.

*Results*. Graphs of conductivity and the effect on surface tension were constructed for each particular bile salt. For the sake of brevity, a composite graph of a simple and a conjugated salt is shown (Fig. 1). The curves for the other bile salts studied showed similar characteristics. The range of concentration commences at $M/5$ and decreases to $M/1,280$. Sufficient quantities of the bile salts were not obtained to enable concentrations higher than $M/5$ to be studied and, due to possible limitations in sensitivity of the apparatus and the methods employed, figures for concentration less than $M/320$ were not plotted, although results were obtained. The surface tension values are expressed simply as drop numbers and are plotted as such.

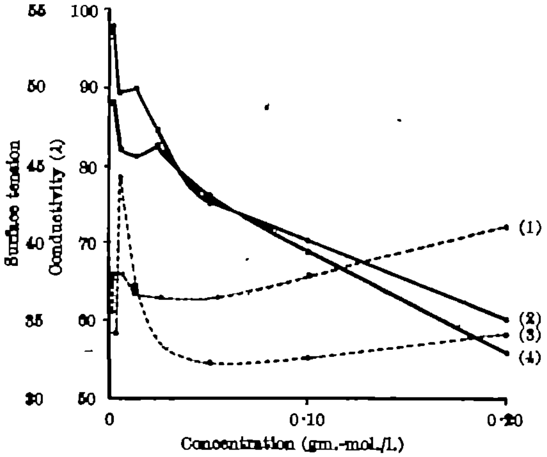

Fig. 1. Conductivity (full line) and surface tension (broken line) at 37° C. of: (1) and (4) sodium deoxycholate ; and (2) and (3) sodium glycocholate

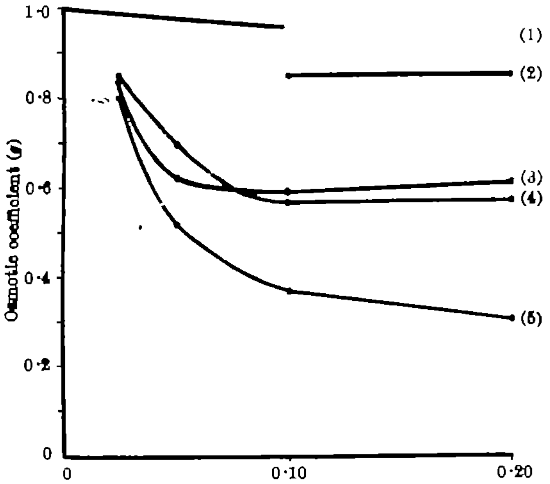

Fig. 2. Osmotic coefficients of: (1) potassium chloride; (2) sodium taurocholate; (3) sodium glycocholate; (4) sodium cholate; (5) sodium deoxycholate

It was not found possible to determine freezing point depressions at a concentration lower than *M*/40; in particular this was the case with sodium taurocholate—even at *M*/20. These curves are shown together (Fig. 2). In addition, the conductivity and osmotic coefficient values were compared as percentage decreases over the range *M*/40–*M*/10. It was found that although the osmotic coefficient for deoxycholate and glycocholate decreased by 54 and 30 per cent, the conductivity decreased by only 17 and 4 per cent, respectively. This may be of importance in assessing relative tendency to micelle formation by the bile salts, for Hartley, with paraffin-chain salts, and Roepke and Mason, with sodium cholate and glycodeoxycholate, believed such large differences of these properties to indicate appreciable association of bile acid ions.

Observations were made on the turbidity of the solutions 48 hr. after making them up, and photographs were taken under normal studio lighting conditions. Sodium deoxycholate and glycocholate produced markedly turbid solutions between concentrations of *M*/1,280 and *M*/160; from *M*/80 to *M*/5 they were crystal clear. Taurocholate showed the change at *M*/40, though not so abruptly. Sodium cholate solution showed no turbidity at any concentration.

Values for viscosity were obtained, but the limitations of a simple viscometer in such a study, with the difficulty of resolving the values into absolute viscosity, showed that the results could be of no assistance, and they are therefore omitted.

*Discussion.* The equivalent conductivity curves show a change of phase at about *M*/160; at about this point a 'kick' is shown on the graph; this may be due to the commencement of aggregation[3]. The curves are more convincing than those obtained by Roepke and Mason, or Johnston and McBain. The point of change of phase fits in with the point of maximal effect on surface tension, the point at which the abnormal depression of freezing point occurs, and also with the change-over from the turbid to clear state in three of the solutions.

In salts where visual changes were most apparent, namely, sodium deoxycholate and sodium glycocholate, greater differences in the percentage decrease of equivalent conductivity and osmotic coefficient over the range *M*/40–*M*/10 are shown than with sodium cholate, a salt in which no significant visual change occurred, and therefore these two salts perhaps have a greater tendency to micelle formation.

*Conclusion.* The bile salts, sodium cholate, deoxycholate, glycocholate and taurocholate, in solutions of increasing concentration undergo a change of phase which is demonstrated most readily by the equivalent conductivity, osmotic coefficient and surface tension curves, and which is taken to indicate ionic aggregation or micelle formation. Our turbidity findings may well be confirmatory evidence of this. The phenomenon is shown to advantage at 37° C. The range of the concentration of solutions in which these experiments were carried out is likely to occur in the human bile. Further work on the affinity of the bile salt micelle for cholesterol is to be published.

Grateful acknowledgment is made to the Medical Research Endowment Fund of the Birmingham United Hospitals, from which a grant in aid of this work was given. Thanks are also due to Profs. H. J. Melville, F. A. R. Stammers and Melville Arnott for their advice and assistance.

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# A HIGH-RESOLUTION AERIAL FOR RADIO ASTRONOMY

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IN observations at radio wave-lengths, it is impossible to obtain an angular resolution which is comparable with that of even a small telescope. Even a relatively large object like the sun, which has been studied intensively by radio astronomers, is difficult to resolve at radio wave-lengths. It is known that solar radiation, at radio-frequencies, consists of several components, one steady over a period of months or years, and the others variable. The steady component has been identified[1] with thermal radiation from the 'quiet' or undisturbed sun. A determination of the distribution of brightness over the solar disk of this component would provide information about densities and temperatures in the atmosphere of the sun.

A 'slowly-varying component'[2] of the solar radiation which is prominent at decimetre wave-lengths can be correlated with the area of visible sunspots on the solar disk. Although it is known that this radiation originates in small 'bright' regions near sunspots[3], the shape and position in the solar atmosphere of these regions and their rates of growth and decay are not known.

Until now, most information about the distribution of radio brightness over the solar disk has come from eclipse observations. Such observations, however, have the serious drawback that they can be made only infrequently, and it is not possible to separate with certainty the various components of the solar radiation. The problem requires frequent observations with very highly directional radio equipment.

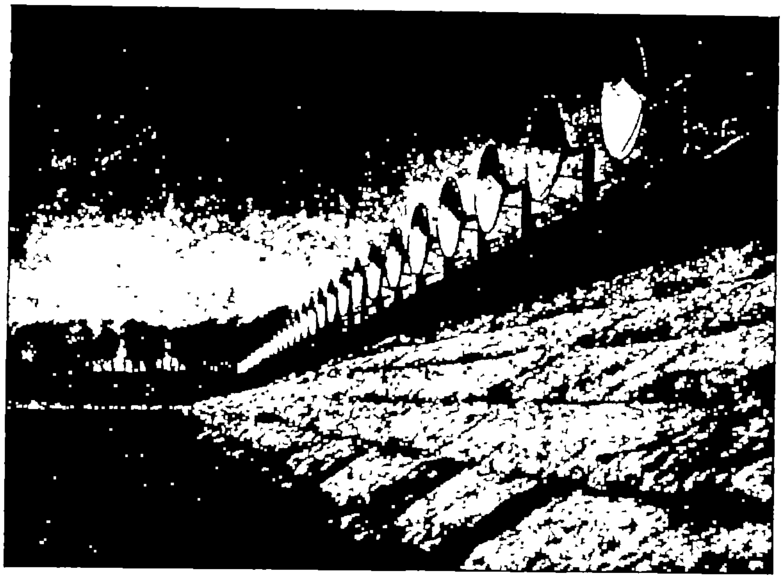

Fig. 1. 32-aerial interferometer at Potts Hill, Sydney

The size of an aerial required to achieve an angular resolution which is small with respect to the sun, say one-tenth of the visual diameter of the disk, is about 1,000 wave-lengths. At a wave-length of 2 decimetres, this corresponds to a diameter of about 700 ft. A rotatable antenna of such dimensions, and with the required constancy of shape, is not practicable.

If the resolution is to be provided in only one angular co-ordinate, the problem is greatly simplified, as the aerial has to be large in only one dimension. The aerial need not then be steered, because the beam is fan-shaped and the system may be arranged so that the rotation of the earth sweeps the beam across the sun. A two-aerial interferometer is a system of this type, but in its normal form is not useful for scanning a complex source like the sun.

A spaced-aerial interferometer with variable spacing between the aerials was used by Stanier[4] in an attempt to measure the distribution of the background component of the radiation at a wave-length of 60 cm. His method requires the solar disk to be free from any localized areas of enhanced brightness, and the background component to be symmetrical with respect to the centre of the disk. It is not clear from the published description how well the first of these conditions was fulfilled during the course of the work.

An aerial system which provides the required angular resolution in one dimension for scanning the sun has been constructed near Sydney. It produces multiple beams, but, unlike the case of a spaced-aerial interferometer with two elements, these beams have an angular spacing large enough to ensure that only one beam can scan the sun at one time. The system consists of thirty-two paraboloidal aerials, each 6 ft. in diameter, mounted individually on polar axes and arranged at equal intervals in a straight line of length about 700 ft. lying in an approximately east–west direction; it operates at a wave-length of 21 cm. (Fig. 1). The individual aerials are connected to a radio receiver by a branching system of open, two-wire transmission lines, arranged as shown in Fig. 2, so that the length of line between each aerial and the receiver is the same.

The system operates in a manner analogous to that of a diffraction grating. A family of knife-edge beams is produced, each beam being 3′ in width and separated from adjacent beams by 1·7°, or about three times the angle subtended by the diameter (visual) of the sun. The rotation of the earth causes each aerial beam in succession to sweep across the disk of the sun. A recording milliammeter at the output of the receiver indicates continuously the magnitude of the radiation being received from the strip of the solar disk to which the aerial beam is directed. The resultant trace is of the type shown in Fig. 3, in which the effect of several successive scans of the sun are seen. The records for each day's observations are averaged to reduce errors produced by random fluctuations in the receiver output.

A feature of the records is the appearance of peaks on the curves, indicating the presence of localized areas of enhanced brightness on the solar disk. As shown in Fig. 4, the positions of these bright areas change from day to day, which suggests that they rotate with the sun. The position of an aerial beam with respect to the solar disk at any time may be calculated from astronomical data and the geometry of the aerial system. From the time at which a peak appears in the output record of the receiver, one can deduce that the corresponding bright area on the sun is located along a certain line on the solar disk. The position of this line can then be compared with the positions of any optical features on the disk. Such a comparison is shown in Fig. 5, where lines indicating the positions of five distinct bright areas

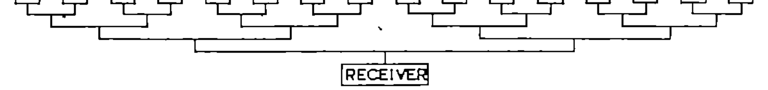

Fig. 2. Arrangement of aerials and feeder lines. The aerial response shows a maximum when the optical path difference for adjacent aerials is an integral number of wave-lengths

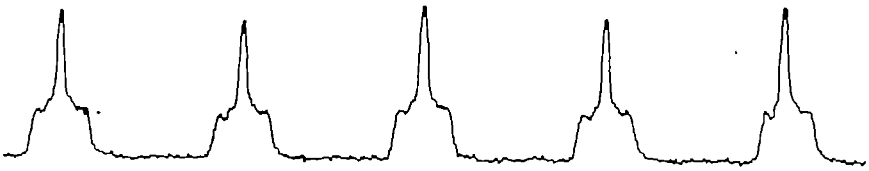

Fig. 3. Record of the sun passing in succession through several beams of the aerial

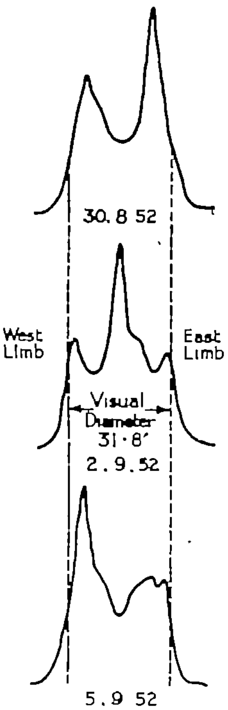

Fig. 4. Records obtained at intervals of several days. The change in position of bright areas is seen

are shown to fall close to sunspot groups.

If it is assumed that the bright areas have no independent movement with respect to the solar photosphere, then a series of daily records of position of any such area can be used for a determination of the heliographic latitude and longitude of the region and also the height of the region above the photosphere. Results to date indicate that the bright regions lie above sunspot groups or close to places previously occupied by sunspots.

The day-to-day variations in the brightness of such a region may be expected to show the combined effects of non-uniformity in angular distribution of emission from the region and of changes in actual emission with time. A statistical study of this should allow the two factors to be separated.

The one-dimensional brightness distribution of the background radiation, or radiation from the undisturbed sun, may be found directly if a record can be obtained during a period when the solar disk is free from areas of enhanced brightness. Alternatively, the distribution may be derived from a succession of daily records if a lower boundary curve is found below which the level never falls. In practice, it has been found that either method involves recording over a long period, even during the present period of low sunspot activity. A series of daily observations has been plotted in Fig. 6. The appearance of a relatively sharp lower boundary to the curves confirms the presence of a background radiation which is constant over a period of at least weeks. The shape of this boundary agrees with records obtained on two occasions when one half the solar disk was apparently free from areas of enhanced brightness. Preliminary results suggest that marked limb-brightening is present.

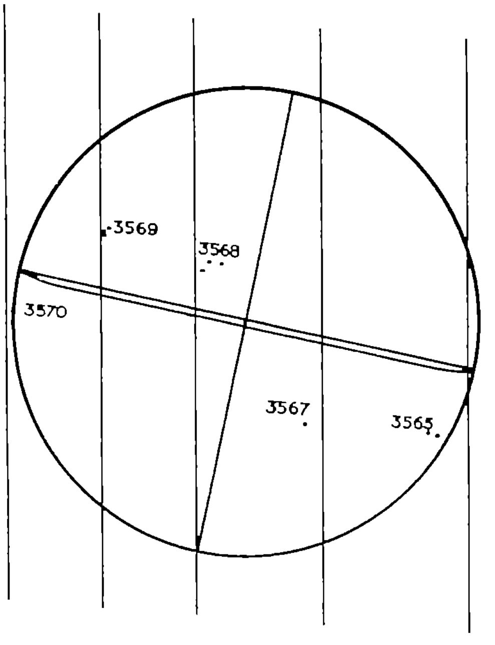

Fig. 5. The position on June 23, 1952, of five areas of enhanced brightness, indicated by lines on a sketch of the solar disk. The positions of sunspots are also shown

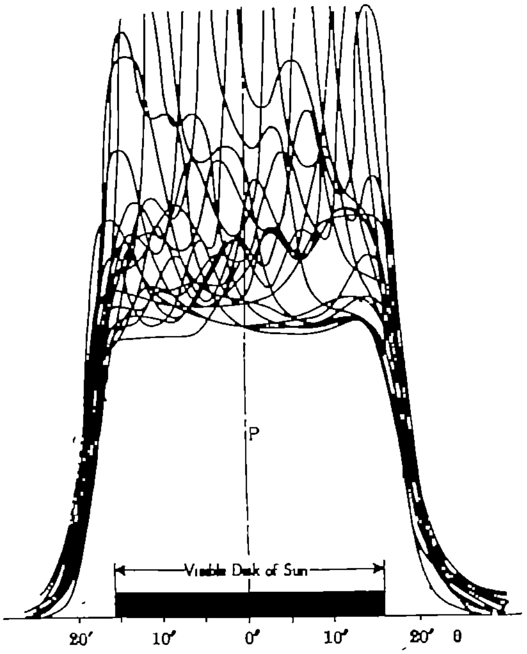

Fig. 6. Combined plot of a series of daily observations showing distinct lower boundary. *P* is the power received, in arbitrary units; θ is the angular separation between the centre of the aerial beam and the centre of the optical disk of the sun

Two series of observations, one made during March and April and one during June and July 1952, have shown a small change in the brightness distribution near the limb. Non-circular symmetry of the source would be a possible cause of this, since in the interval the direction, relative to the sun's axis, in which the sun was scanned had changed considerably. This possibility is supported by eclipse observations[5] at a wave-length of 1·78 metres, which gave a brightness distribution that is not circularly symmetrical. A second aerial system arranged at right-angles to the existing system is being constructed to investigate this.

The observations are continuing and will be further reported in the *Australian Journal of Physics*. I wish to acknowledge the assistance of Mr. J. A. Warburton and Mr. A. J. Harragon in the work, and helpful discussion with Dr. J. L. Pawsey. [Nov. 28.

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## LETTERS TO THE EDITORS

*The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications*

### Measurements on Superconductivity in Thin Tin Films

Continuing our previous measurements[1] on superconductivity of thin tin films, we have now measured the change in superconductivity, under the influence of a magnetic field and also under the combined action of the current and a magnetic field.

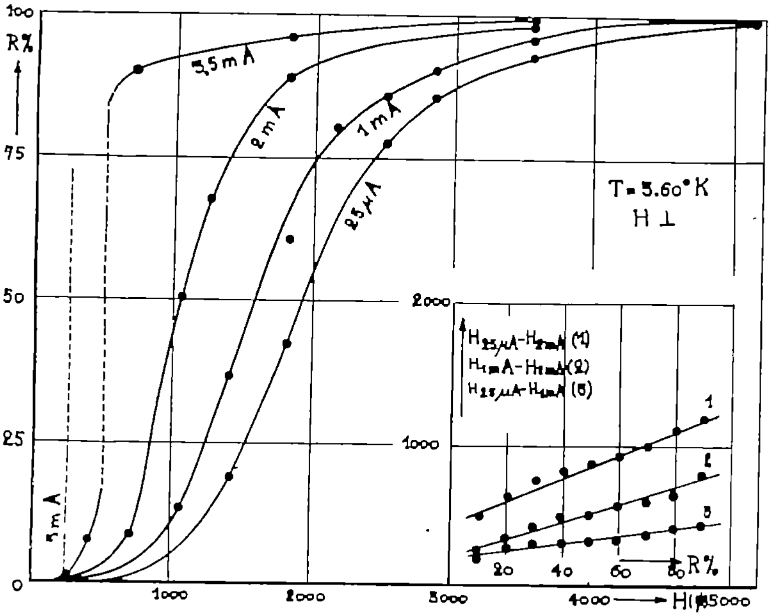

Fig 1

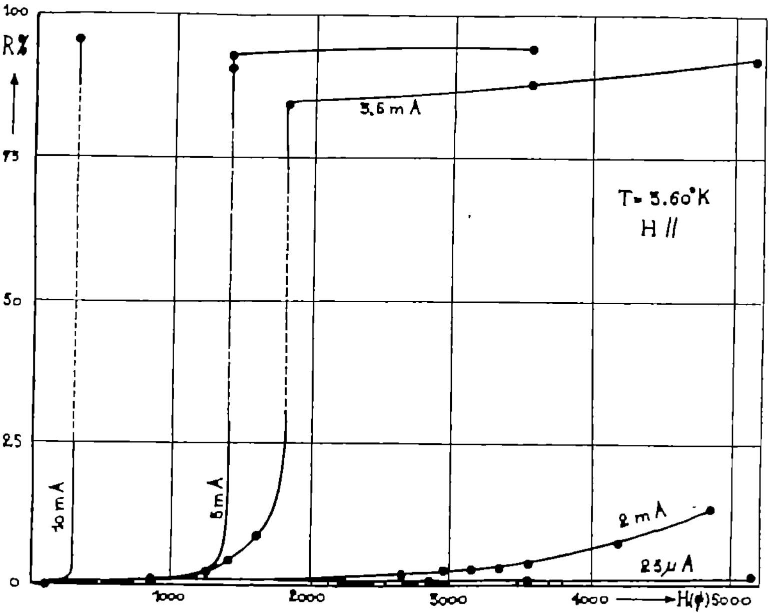

Fig. 2

Our deposits are obtained on small glass strips (length of the film, 5 mm.; width, 3 mm.) by sputtering in argon at room temperature using a cathode of spectrographically pure tin prepared by Johnson Matthey and Co., Ltd. In order to eliminate oxidation, the films are transported to the cryostat in an evacuated tube belonging to our special transport system. In the cryostat the film is dipped into the liquid helium. Hence it is possible to study the change in superconductivity even when using large current densities without the film being warm.

Just as in our previous measurements, we found that, for our films, the transition temperature is a few tenths of a degree higher than for normal tin. The behaviour of one of our films is described in this communication. The resistance of this film at room temperature is 116 ohms, at the boiling point of liquid oxygen it is 104 ohms, and at the boiling point of liquid helium 87·8 ohms. The transition temperature is 3·82° K., and after the transition there remains no residual resistance. This film, and also the others, showed a peculiar effect when we measured the disturbance under the influence of the combined action of an external magnetic field and the current. Figs. 1 and 2 illustrate the influence of a field, normal to the surface of the film and parallel to the film (in both cases perpendicular to the current) respectively, for different currents. The following points may be noted:

(1) By increasing the current, the transition curves become more and more sharp. Experiments of the same kind have been carried out by de Haas, Voogd and Jonker[2] on a monocrystalline tin wire, but they obtained flatter curves when the current was increased.

(2) The critical field for the direction parallel to the film is much larger than for the perpendicular direction. This fact has also been observed recently by Zavaritskii[3]. Moreover, we observed that even for large values of the current, the magnetic threshold value for the film is considerably greater than for the bulk metal.

(3) In Fig. 1 (inset) *R* per cent is plotted as a function of $H_{i_1}-H_{i_2}$, which is the compensating field for the current difference. It is noteworthy that straight lines are obtained.

The same general behaviour was found for this film at other temperatures below the transition temperature, and also for our other films.

We wish to thank the Belgian Department of Education for financial aid for these experiments.

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L. De Greve
L. Van Gerven
J. Schepers

Instituut voor Lage Temperaturen
én Technische Physica,
Louvain. Feb. 11.

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## Temperature of the Interior of the Earth

In a previous communication[1], I gave an outline of a new method for estimating temperatures in the earth's interior. The method was based on what I have called the temperature–pressure hypothesis, namely, that the reciprocal of the volume coefficient of thermal expansion $\alpha$ is a linear function of the pressure $p$ :

$$\frac{1}{\alpha} = \frac{1}{\alpha_0} + bp. \qquad (1)$$

This relation was suggested by the analogous compressibility–pressure hypothesis of Bullen[2] and Ramsey[3], namely, that the reciprocal of the adiabatic compressibility is a linear function of the pressure.

Support for the temperature–pressure hypothesis was obtained using Uffen's[4] values of $\alpha$, which were based on the theory of solids. An independent investigation based on Murnaghan's theory of finite strain has now been carried out, the results of which add further support to the temperature–pressure hypothesis. More important is the fact that the values of the coefficients $1/\alpha_0$ and $b$ in equation (1), as obtained by these two methods, agree to within 10 per cent. Thus two independent lines of attack not only support the general hypothesis, but also agree among themselves as to the numerical value of the coefficients.

Birch[5], however, in his most recent paper on the constitution of the earth, disagrees with the compressibility–pressure hypothesis of Bullen and Ramsey, and regards the linear relationship between the reciprocal of the compressibility and the pressure as at best approximately valid over limited ranges of pressure for the particular materials of the earth's interior. It is not claimed that the temperature–pressure hypothesis is necessarily a fundamental physical relationship ; but it is suggested that, in view of the agreement between two independent investigations, it should give a very fair approximation to the truth. Because of the lack of experimental data, which are both scanty and subject to relatively large uncertainties, the empirical relation (1) should be of considerable help in estimating temperatures within the earth.

The full implications of the temperature–pressure hypothesis are being investigated—in particular, the problem of the transfer of heat from the core. Assuming that the core has the composition of an iron meteorite, an estimate can be made of the conductive flow of heat in the core near the boundary of the core and mantle. Using the adiabatic temperature gradient based on the temperature–pressure hypothesis, a value of $5 \times 10^{-7}$ cal./cm.$^2$sec. is obtained. On the other hand, using the melting point gradient and conductivity of olivine as obtained by Uffen[4], a value of $5 \cdot 5 \times 10^{-7}$ cal./cm.$^2$ sec. is obtained for the conductive heat flow in the mantle near the boundary of the core and mantle. The difference between these two figures is not significant, being within the limit of their probable accuracy. It thus appears that sufficient heat can be removed from the core by conduction alone—a result hitherto not thought possible. This has far-reaching effects on Bullard's[6] dynamo theory of the origin of the earth's magnetic field, which requires a motion of the material of the core. It has been shown that thermal convection provides the only satisfactory mechanism for the generation of such motions. The results of the present investigation show that, in order to have convection in the core, it is not necessary to have convection in the mantle as well. This lends considerable weight to the contraction theory of orogenesis put forward by Wilson and Scheidegger[7] as against the convection current theory.

Finally, Bullard[8] found that the heat flow required to maintain convection currents in the core was about four times greater than that available from a core with a radioactive content comparable to that of iron meteorites. This discrepancy is almost entirely removed if figures based on the temperature-pressure hypothesis are used.

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## Tensile Strength of Liquid Nitrogen

Several authors[1] have suggested that included gases have an appreciable effect in lowering the observed tensile strength of a liquid. For this reason it was decided to attempt to measure the tensile strength of a low-temperature liquid which, when cooled below its normal boiling point, would contain none of the normally included gases found in most liquids.

A review of the available experimental methods[2] of measuring the tensile strength of a liquid suggests that the static and dynamic tensile strengths of liquids are different. Since the tensile strength of a solid is a static concept, it seems reasonable to consider the static tensile strength of a liquid as a true measure of its tensile strength. For this reason an adaptation of Vincent's bellows method[3] was used. The apparatus was designed with a spring-loaded bellows, and the whole assembly was immersed in the liquid under test. The tension on the liquid-filled bellows could be varied by adjusting the extension of the spring until the tensile strength of the liquid was reached and the rupture of the liquid column ensued. The maximum observed tensile strength of liquid nitrogen was found to be 3·5 atmospheres at 71·0° K., while the maximum theoretical tensile strength based on the theory of Volmer[4] was calculated to be 60 atmospheres at the same temperature.

An attempt was made to study the tensile strength of liquid nitrogen as a function of temperature. It appears that no apparent relation exists between temperature and observed tensile strength, although one would be expected from previous theoretical work[4,5]. It is possible to explain this fact and the discrepancy in observed and predicted values of tensile strength by assuming a bubble-trapping process in the small surface cavities of the bellows. This suggestion has been made previously[1] to explain the lowering of tensile strength of a liquid by the trapping of bubbles of included gases in the Griffith's cracks in the wall of the container. In our case however, the process will not depend on the trapping of bubbles of normally included gases, but on the trapping of bubbles of nitrogen gas in the walls of the container, the size of the nitrogen gas bubble in the liquid being defined by the existing temperature and pressure of the system.

It is hoped to continue the experiments with liquid helium both above and below the λ-point.

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## Paramagnetic Resonance and Covalent Bonding

IN the course of a programme of investigating paramagnetic resonance in compounds containing 4*d* and 5*d* transition elements, we have recently found an unusual hyperfine structure in ammonium chloroiridate, which gives information about the bonding in this compound. The essential experimental result is that in a crystal of $(NH_4)_2[IrCl_6]$, diluted with the isomorphous diamagnetic platinum salt, the resonance spectrum at a temperature of 20° K. and wave-length of 1 cm. shows a complex hyperfine structure consisting of many lines, of which sixteen equally spaced lines can be resolved in the most favourable directions, with overall separation of about 150 gauss. At first sight one would expect only four lines corresponding to the known nuclear spins ($I = 3/2$) of iridium-191 and 193. (The nuclear magnetic moments are approximately equal.) It is possible to explain the presence of the additional lines as arising from the chlorine-35, 37 ($I = 3/2$) nuclei, and the detail of the spectrum by assuming that the hyperfine structure of chlorine is one-third of that of the iridium.

Each iridium ion lies at the centre of a regular octahedron of chlorine ions, and on a purely ionic model these ions would be $Ir^{4+}$ ($5d^5$) and $Cl^-$ (an inert gas structure). The susceptibility of the complex corresponds approximately to that of a single electron spin, and using Van Vleck's theory[1], this would be interpreted as arising from a hole in the $d_{xy}$, $d_{yz}$, $d_{zx}$ shell. Van Vleck shows how this result can be reached either by the directed valence bond, or the strong crystal field, or the molecular orbital approach; although in the molecular orbital method he only considers combinations between orbitals such as $d_{x^2-y^2}$, $d_{3z^2-r^2}$ (central ion) and $p_\sigma$ (attached ions). The experimental evidence in ammonium chloroiridate suggests that the magnetic hole is described by admixtures of $3p_\pi$ (Cl) orbitals with $5d_{xy}$, $d_{yz}$, $d_{zx}$ (Ir) orbitals. This can also be pictured as a mechanism whereby for part of the time an electron is transferred from $Cl^-$ to $Ir^{4+}$, cancelling the unpaired spin on the iridium, and leaving an unpaired spin on a chlorine atom.

In the paramagnetic resonance spectrum, this leads to two effects, both of which have been observed: (i) there will be a hyperfine structure from the chlorine nuclei, and (ii) the spectroscopic splitting factor will be smaller than $g = 2$, the value given by Van Vleck's theory. From the measured size of the hyperfine structure, and from the observed value, $g = 1 \cdot 8$, we have tentatively estimated that the electron hole is on a particular chlorine atom for about 3 per cent of the time, and on some chlorine atom for about 18 per cent. The paramagnetic resonance method thus gives a direct and quantitative measure of π-bonding, or, crudely, of the whereabouts of the electron hole.

Theoretical and experimental work is proceeding, and we hope soon to look for similar phenomena in other compounds, particularly potassium bromoiridate. All this work will be reported more fully in due course.

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## Dielectric Relaxation Time of Polar Molecules in Solution

MEASUREMENTS of the dielectric relaxation time ($\tau$) of a polar substance ($B$) in a non-polar solvent ($A$) are usually interpreted in terms of the generalized Debye formula[1]:

$$\tau = (8\pi\eta_A a_B^3)/2kT, \qquad (1)$$

where $\eta_A$ is the viscosity of the solvent, and $a_B$ is the radius of the solute molecule.

A closer examination of the processes involved shows that this extension of Debye's formula to a solution is not justified, because $\eta_A$ is determined by the interaction between the solvent molecules, whereas $\tau$ is determined by the interaction between non-polar and polar molecules.

In a discussion to be published elsewhere, it is shown that, for a very dilute solution,

$$\tau = (A\eta_{AB})/2kT, \qquad (2)$$

where $A$ is a function of the moments of inertia and masses of the two types of molecule, and the intermolecular distances, and is of the same order of magnitude as $a_B^3$, and $\eta_{AB}$ is the 'mutual viscosity'

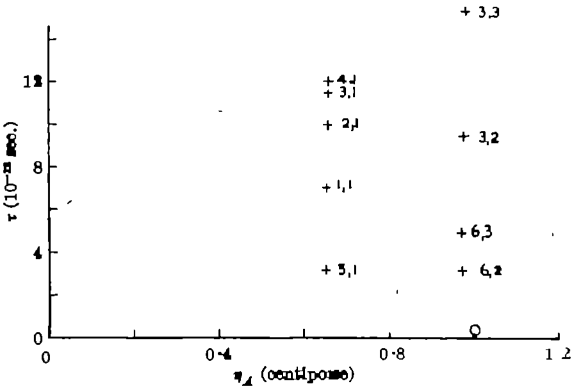

Fig. 1. Relaxation time and solvent viscosity. Numbers at points refer to solute and solvent respectively. Solutes: 1, phenyl chloride, 2, phenyl bromide; 3, phenyl nitrite; 4, phenyl propionate; 5, methyl acetate; 6, chloroform. Solvents: 1, benzene; 2, *cyclo*hexane; 3, carbon tetrachloride.
For the point marked by a circle, both scales should be multiplied by 200

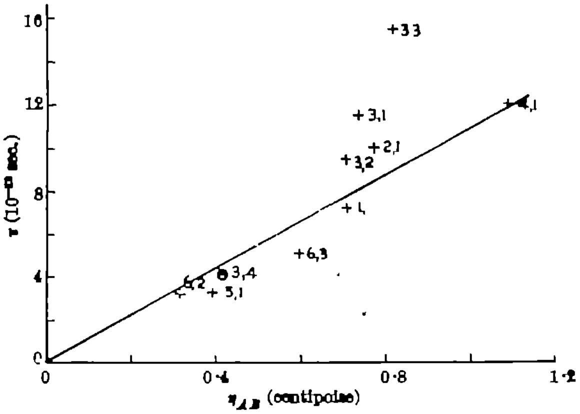

Fig. 2. Relaxation time and mutual viscosity. Numbers at points have the same significance as in Fig. 1. For the point marked by a circle both scales should be multiplied by 10

of the two substances, which can be found from the viscosity of the mixture, since

$$\eta\sigma = f_A^2\eta_A\sigma_A + f_B^2\eta_B\sigma_B + 2f_Af_B\eta_{AB}\sigma_{AB}, \qquad (3)$$

where the $f$'s are mole fractions, the $\sigma$'s are intermolecular distances, and terms without suffix refer to the mixture.

Relations (2) and (3) are derived using Andrade's[2] model of a liquid.

Figs. 1 and 2 show $\tau$ plotted as a function of $\eta_A$ and of $\eta_{AB}$ respectively for various polar solutes in benzene ($\eta$ = 0·65 c.poise), *cyclo*hexane ($\eta$ = 0·97 c.poise), carbon tetrachloride ($\eta$ = 0·97 c.poise) and medicinal paraffin ($\eta \sim 200$ c.poise). The relaxation times are taken from the results of Whiffen and Thompson[3], and of Curtis, McGreer, Rathmann and Smyth[4]. The values of $\eta_{AB}$ are deduced from data given in the "International Critical Tables" for solutes in benzene, and from measurements I have made in other cases.

From the graphs it can be seen that there is no simple relation between $\tau$ and $\eta_A$, as required by the Debye formula; but that the graph of $\tau$ against $\eta_{AB}$ does approximate to a straight line through the origin as required by equation (2). Deviations from the linear relation may be interpreted as reflecting variations of the function $A$ of the molecular sizes.

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## A.C. Operation of Ion Chambers

MEASUREMENT of low-intensity ionization in an ion chamber involves the amplification of very small currents. D.C. operation is conventional; but it is difficult to provide stable valve amplification of a weak D.C. signal. Conversion to A.C. by a vibrating-reed gives good sensitivity and stability, but the mechanical device is elaborate. A.C. operation and amplification appears to be stable and simple, and is capable of high sensitivity.

The current produced by irradiation in the A.C. case is caused not primarily by the collection of ions but by the oscillation of a space charge within the chamber. This builds up slowly to its equilibrium density after a source of radiation is brought near the chamber, giving slow response time but high sensitivity. With the bridge circuit described for 10 c./s. operation, an irradiation sensitivity equivalent to $10^{-14}$ amp. D.C. may easily be obtained; the current rises to its maximum value with a time-constant of about ½ min.

Kiehn[1] has described a single ion-chamber in a Wien bridge operated at 150 c./s. The high frequency gives rapid response times but reduced sensitivity. The apparatus developed in the present investigation was designed for high-sensitivity measurements of strontium-90 – yttrium-90 bremsstrahlung radiation.

Two T.P.A. (gamma-sensitive) ion chambers, filled with argon at 20 atmospheres pressure, are connected in opposition as two arms of an A.C. bridge; each balance arm consists of adjustable capacity and parallel resistance. The bridge is fed with 10 c./s. at 24 volts. Out-of-balance current is detected by an amplifier with electrometer triode input; the amplified signal is led to a 'gate' pentode where it is filtered for both frequency and phase, and the smoothed anode current measured on the output meter. The bridge is easily balanced to eliminate all capacitive current through the ion chambers, and much of the cosmic background current as well. Irradiation of either chamber separately causes additional resistive current to flow in the chamber; the output meter shows a change in reading proportional to the radiation intensity over a small range. The sensitivity is limited by variations in the balanced background currents to a value of about 2 microcuries radium at 100 cm. from one chamber.

This work will be reported in detail elsewhere.

I wish to thank Dr. D. Taylor and members of the Counters Group at the Atomic Energy Research Establishment, Harwell, for their advice and help.

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## Atmospherics with Very Low-frequency Components

THE low-frequency (c. 100–500 c./s.) or 'slow tail' component in the wave-form of an atmospheric was first studied in detail by Watson-Watt, Herd and Lutkin[1]. They defined two parameters: the delay $t$ as the time elapsing between the start of the main oscillatory section of the atmospheric and the commencement of the slow tail, and the quarter-period $\tau/4$ as the time occupied by the first quarter-cycle of the tail. Both $t$ and $\tau/4$ were found to increase in a somewhat irregular, non-linear, manner, as the distance of origin, $D$, of the atmospheric increased.

An extensive programme of observations of slow tails has recently been completed at the Cavendish Laboratory. Throughout the programme, the kind co-operation of the Meteorological Office "Sferics" Organization[2] has greatly enhanced the value of the work by locating the sources of individual wave-forms. Although it was noted that, for any estimated distance and any hour of the day, the individual values obtained for $t$ and $\tau/4$ showed considerable scatter, the results, when averaged, were found to be represented for distances up to 5,000 km. by two simple linear equations. With $t$ and $\tau/4$ in μsec., and $D$ in km.: $t = k(D - D_0)$, where $D_0 \sim 1{,}000$ km., and $\tau/4 = \tau_0 + cD$, where $\tau_0 \sim 500$ μsec.

The constants $k$ and $c$ have significantly different values by day and by night; in day-time, $k(d) = 0{\cdot}33$ and $c(d) = 0{\cdot}23$; at night, $k(n) = 0{\cdot}13$ and $c(n) = 0{\cdot}08$.

The transition from day-time to night-time was observed to occur gradually; the steady night-time conditions only became established some three hours after the latest time of ground sunset along the path of the atmospheric.

Many of the features in an atmospheric wave-form may be interpreted by examining the propagation of a primary pulse in the wave-guide formed by the earth and the lower boundary of the ionosphere[1]. This approach is especially applicable to low-frequency effects, since only one or two wave-guide modes, at most, are concerned, and Hales[4] has indicated how the slow-tail phenomena may be explained by considering propagation between a perfectly conducting earth and an ionosphere of finite conductivity. From the present results it is possible, on Hales's theory, to derive a range of solutions for $h$, the height of the ionospheric stratum involved, and $\sigma$ its conductivity; but neither can be determined separately. Estimates are, however, available from other sources for the electron and ion density and collisional frequency at various levels in the ionosphere, and hence for the variation of $\sigma$ with $h$, ignoring any effects due to the earth's magnetic field. Using these estimates, it is found that the slow-tail results by day indicate propagation between the earth and an equivalent, homogeneous, ionospheric layer of height 65 km. and conductivity $5 \times 10^3$ e.s.u.; at night the height of the layer is 90 km. and the conductivity $11 \times 10^3$ e.s.u.

It is hoped to publish a fuller account of this work elsewhere. This programme received financial assistance from the Department of Scientific and Industrial Research.

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## Paper Chromatography of Phosphate Esters

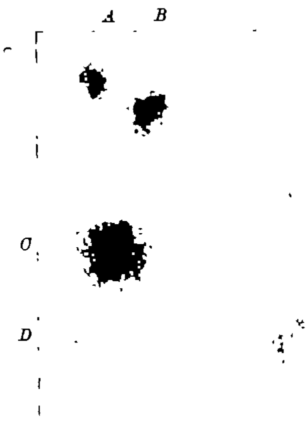
THE demonstration of phosphate esters on paper chromatograms has hitherto depended upon purely chemical methods for the liberation of the bound phosphate groups[1]. The specificity of these techniques might be a matter of some doubt and cause difficulties of interpretation when they are applied to chromatograms of unknown material obtained from a biological source. They also suffer from the disadvantage that the ease with which different organic phosphate esters are hydrolysed varies considerably, and the application of the method to esters which are not readily acid-labile, such as glucose-6-phosphate or phosphoglyceric acid, is sometimes uncertain[2].

In an attempt to overcome these deficiencies, we have developed an enzymic method, in which a solution of alkaline phosphomonoesterase, prepared by the method of Schmidt and Thannhauser[3], is used to liberate orthophosphate from the esters resolved on the chromatogram. The tendency for the resolved spots to spread and become diffuse when sprayed with the aqueous enzyme solution has been successfully countered by first spraying with a solution of calcium chloride in ethanol; any phosphate afterwards liberated on this impregnated paper at an alkaline $p$H is precipitated as insoluble calcium phosphate at the site of its liberation, and the compactness of the resolution is thus maintained. By this use of alkaline phosphatase, the paper chromatography of phosphate esters should gain both in specificity and in reliability of detection within the wide substrate range of the enzyme[3].

We have used Whatman No. 1 papers, 28 cm. square, washed for 10 hr. in 0·1 $N$ hydrochloric acid, then successively in running tap water and in distilled water, and finally dried at 70° C. The solvents used by Bandurski and Axelrod[4] and the two-dimensional development described by them were adopted with only slight modifications: formic acid was replaced by an equal volume of acetic acid in the acid solvent, and we usually ran our chromatograms in the basic solvent first.

After development by the two solvents, our procedure is as follows: the papers are thoroughly air-dried at room temperature, mounted on glass sheets slightly larger than the papers themselves, and sprayed with 10 ml. of a 5 per cent solution of $CaCl_2.6H_2O$ in 80 per cent ethanol. The ethanol is allowed to evaporate at room-temperature, and the papers are then sprayed with 10 ml. of the enzyme solution prepared in 0·1 $M$ glycine buffer at $p$H 9. (In our experiments the various enzyme solutions used liberated 50–200 μgm. phosphorus per ml. in 5 min. at 37° C. from an added excess of glucose-1-phosphate.) At this stage the papers are damp, but by no means saturated with solution; they are covered with a second sheet of glass, and the 'units', glass–paper–glass, incubated for 4 hr. at 37° C.

At the end of this time the papers, which are still damp, are firmly attached to their glass mounts and finely sprayed with 3 ml. of a solution of 5 per cent ammonium molybdate in 20 per cent hydrochloric acid (v/v). (Yellow phosphomolybdate spots quickly



Section of chromatogram showing resolution of: *A*, sodium glycerophosphate; *B*, 3-phosphoglycerate, *C*, glucose-1-phosphate; *D*, adenosine-5-phosphate appear where orthophosphate has been liberated in amounts equivalent to 1 μgm. phosphorus or more.) After standing for 2 min., the papers are further sprayed with 5 ml. benzidine solution (50 mgm. benzidine hydrochloride dissolved in 10 ml. glacial acetic acid and diluted with water to 100 ml.), using a fume cupboard with a good draught. They are then inverted over a trough of ammonia (sp. gr. 0·880, diluted 1 : 4) at a distance of 2 in. from the surface of the liquid, when the positions of liberated phosphate groups are shown by the appearance, within a minute, of bright blue spots which show distinctively on a white ground. 0·5 μgm. phosphorus is readily detected by this method. Over-exposure to ammonia at the final stage leads to rapid fading of the blue colour.

The accompanying photograph shows a resolution involving four typical phosphate esters: sodium glycerophosphate, 3-phosphoglycerate, glucose-1-phosphate and adenosine-5-phosphate.

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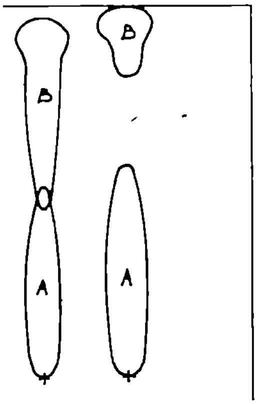
## Ion Exchange in Paper Chromatography

It has been shown by Schute that several mixtures of alkaloids can be separated by chromatography on paper using aqueous ammonia[1]. Because the chromatograms have the characteristics of a partition chromatogram, it is probable that the above separation is due to partition between an aqueous imbibition phase and an aqueous mobile phase.

It was also possible to show that, when the cellulose is not swollen (that is, it contains chemically bound water only) and the solvent is hexane, irreversible surface adsorption of alkaloids occurs[2]. An alkaloid can be displaced from the adsorbed state by a more polar one, and therefore it is probable that this adsorption is of a polar nature. Hence we may expect that the adsorption will decrease when the solvent becomes more polar. Moreover, when the cellulose is swollen by the solvent, an important part of the cellulose ceases to be a surface phase and becomes a volume phase. Surface adsorption on cellulose from a strongly polar and swelling solvent such as water is therefore very improbable.

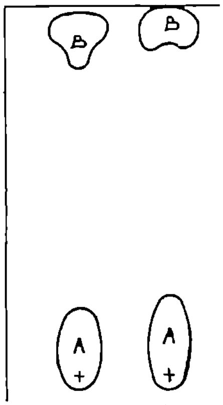
However, when acids and alkaloids are chromatographed on paper with water as a solvent, irreversible 'absorption' takes place. It can be shown that this is caused by ion exchange. When an aqueous solution of an acid (*HZ*) is in contact with paper, the hydrogen ions of the acid exchange with the cations ($M_p^+$) of the paper: $HZ \rightleftarrows H^+ + Z^-$ and $H^+ + M_p^+ \rightleftarrows H_p^+ + M^+$. Here $M_p^+$ represents ions of sodium, potassium, calcium, magnesium, etc., bound on carboxyl groups, silicate and other 'insoluble material'.

As the combination $M^+ + Z^-$ is chromatographed further and $H^+$ cannot be eluted from $H_p^+$ by pure water, the $H^+$ and $Z^-$ of the acid can be completely separated (Figs. 1 and 2). When the acid-spot *A* is separated from the salt-spot *B*, the area of *A* gives a measure of the total amount of exchangeable cation $M_p^+$. This amount is greater for the Schleicher and Schull paper than for the Whatman paper.



(a) (b)

Fig. 1



(a) (b)

Fig. 2

Chromatograms (Fig. 1, Whatman No. 1 paper; Fig. 2, Schleicher and Schull No. 1101 *L* paper) of 20 μgm. salicylic acid (*a*) and sulphosalicylic acid (*b*) developed with water. *A*, acid-spot visible after spraying with neutralized methyl red; *B*, salt-spot sprayed with ferric chloride, +, place of initial spot

When blank paper is chromatographed with water, electrolyte is eluted and the solvent contains cations, the concentration of which increases with the distance covered by the front. Because the $H^+$ is exchanged from the $H_p^+$ area by this electrolyte, the rear boundary of this area is removed farther from the initial spot, when this spot has been placed farther from the base. This phenomenon disappears almost completely when the paper is first washed 'chromatographically' with water. However, when washed paper is chromatographed with water for a second time, electrolyte is eluted again from the paper. This may be explained by the reaction:

$$M_p^+ + H_2O \rightleftarrows M^+ + OH^- + H_p^+,$$

a hydrolysis corresponding to the 'membrane hydrolysis' of Donnan, as suggested by Hirsch[3]. Thus, in washed paper, part of the exchangeable cation has already been displaced by hydrogen ion, and this agrees with the fact that the area of the acid spot increases on washing the paper with water. This must be taken into consideration when we wish to determine the amount of $M_p^+$ by measuring the acid area.

In Fig. 1 the front part of the acid spot from salicylic acid contains salicylate. In this part there is still unchanged salicylic acid, and it appears that this acid travels much more slowly than the solvent front ($R_F$ about 0·5).

When the paper is washed 'chromatographically' with hydrochloric acid and next with water to remove the excess of acid, all exchangeable $M_p^+$ is displaced by $H^+$ ($H^+$ paper). When salicylic and sulphosalicylic acid are chromatographed with water on this $H^+$ paper, normal chromatograms occur and both acids are separated, the $R_F$'s being about 0·55 and 0·70 respectively when Whatman No. 1 paper is used.

As ion exchange on this paper is impossible and surface adsorption highly improbable, we may conclude that the separation in this case is caused by partition between imbibition water and mobile water, the imbibition water having properties other than pure water.

When an alkaloid (*XN*) is chromatographed, ion exchange is possible:

$$XN + H_2O \rightleftarrows XNH^+ + OH^- \quad \text{and}$$
$$XNH^+ + M_p^+ \rightleftarrows M^+ + XNH_p^+.$$

When $H^+$ paper is used, direct salt formation will occur:

$$XN + H_p^+ \rightarrow XNH_p^+.$$

It appears that $XNH_p^+$ is only slightly eluted by pure water, and this gives another possibility of estimating the amount of $M_p^+$, displacing first the $M_p^+$ by $H_p^+$ and measuring the area of an alkaloid bound by the $H_p^+$.

The alkaloid ion in $XNH_p^+$ will be exchanged for cations. When the cation is another alkaloid ion which is bound preferentially, the two alkaloids can be separated; hence mixtures of alkaloids can be analysed by ion exchange on paper with water as a solvent.

It is clear that ion exchange will also occur when the mobile phase is an organic solvent and the stationary phase is an ionizing medium such as water. It is probable that many of the abnormalities occurring in paper chromatography of ionizable substances may be explained, at least partly, by this ion exchange. This is supported by the fact that abnormalities in the chromatography of alkaloids are decreased by impregnating the paper with potassium chloride, as is found by Munier *et al.*[4]. The excess of electrolyte in the stationary phase will make the $XNH_p^+$ bonding impossible.

This investigation is part of a study of the mechanism of paper chromatography, full reports of which will be published in due course. I thank Prof. E. H. Vogelenzang for his interest and encouragement, and the Dutch Organization Z.W.O. for financial support.

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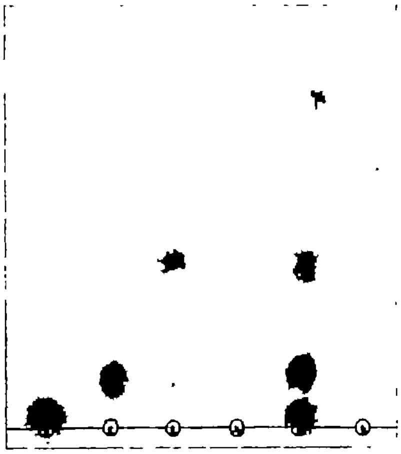
## Paper Chromatography of Thioureas

IN the course of a current investigation, it became necessary to separate and identify minute amounts of N-substituted thioureas. Paper chromatography suggested itself as the method of choice for this purpose, and a technique has now been worked out which gives satisfactory and reproducible results on some thirty thioureas investigated, separately or in complex mixtures.

As a result of numerous experiments, water-saturated chloroform was selected as the most satisfactory mobile phase. One-dimensional, ascending chromatograms were run on No. 1 Whatman paper at 23·5° ± 0·1°. The attainment of equilibrium in the chromatographic system presented some preliminary difficulties owing to the high density of the chloroform vapour. This problem was solved, however, by lining the glass walls of the chamber with filter paper soaked in chloroform and water. After equilibration of the sheets (17·5 cm. × 28·5 cm.) for 16–18 hr., the chloroform was allowed to rise 23·0 cm. from the starting line in the course of 110–120 min. Periods much outside this range were indicative of imperfect equilibrium and resulted in less satisfactory results. After development, the air-dried paper was sprayed with Grote's reagent[1] and, upon moderate heating, the thioureas appeared as distinct, deep-blue spots, gradually fading within a day or two. Comparable results were obtained by Feigl[2] on consecutive spraying with a starch solution and the iodine–azide reagent. In this case the thioureas appeared as colourless spots on a uniformly blue background. Owing to a slightly higher sensitivity of Grote's reagent, it was generally preferred throughout the present work.



Chromatogram of N-substituted thioureas developed with Grote's reagent. The substances were applied along the lower line as spots, each containing 0·002 ml. of a 1·0 per cent solution in ethanol. (1) Methyl, (2) ethyl, (3) *n*-propyl; (4) phenyl, (5) a mixture of methyl-, ethyl-, *n*-propyl, *n*-butyl and phenyl-thiourea, applied as 0·002 ml. of an ethanolic solution containing 1·0 per cent of each component, (6) *n*-butyl

Even under carefully controlled conditions, some variations in the $R_F$-values were noticed from one run to another. These fluctuations could be eliminated by including N-phenylthiourea as a reference substance in every run and considering the movement in relation to this arbitrary standard. For convenience, we have introduced the term $R_{Ph}$-value, defined as the ratio between the distances travelled by the individual component and phenylthiourea. The $R_{Ph}$-values were found to be reproducible within ± 0·01. In the accompanying table, results are presented for a few typical mono-substituted thioureas. Di-, tri- and tetra-substituted thioureas were also successfully separated; but S-substituted *iso*-thioureas did not respond to Grote's reagent. A series of thiobarbituric acids were separated and detected as yellow spots on spraying with the same reagent. However, Grote's reagent proved to be unsuitable for the detection of thiosemicarbazides owing to the varying and often transient nature of the colours produced.

| N-Substituent(s) | $R_{Ph}$-values |
|---|---|
| Methyl | 0·04 |
| Ethyl | 0·15 |
| *n*-Propyl | 0·48 |
| *n*-Butyl | 0·84 |
| Allyl | 0·26 |
| Benzyl | 0·90 |
| *sym*.-Dimethyl | 0·41 |
| Trimethyl | 1·22 |

Separations of mixtures containing individual components with $R_{Ph}$-values higher than c. 1·20 were often facilitated by using the slow No. 50 Whatman paper.

A fuller account of the work will be published in *Acta Chemica Scandinavica*.

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## Use of Ion-Exchange Resins in Paper Chromatography of Sugars

THE recent communication by Phillips and Pollard[1] suggests that results obtained here may be of interest. In the paper chromatography of dilute and very impure sugar solutions, such as non-diabetic urines or certain protein hydrolysates, it is common practice to use beforehand a 'mixed bed' ion-exchange resin to remove interfering anions and cations[2]. For example, 'Bio-Deminrolit E', a mixture of a weakly basic resin containing amine groups and a sulphonic acid type resin, is shaken with the solution for 20 min. and, after centrifuging, the clear supernatant contains all the sugars (except amino-sugars and uronic acids) uncontaminated by ionizable substances[3]. When 'Bio-Deminrolit E' was replaced by 'Bio-Deminrolit' or 'Bio-Deminrolit F', which are mixtures of sulphonic acid type resins with strongly basic resins of the quaternary ammonium hydroxide type, it was found that all fructose, glucose, galactose, mannose and fucose were removed from the dilute solutions employed.

The effect was investigated using columns 1 cm. diameter and 2–5 cm. long of 'Amberlite IRA400' (OH form), and it was found that 2 mgm. of glucose, for example, was completely removed from solution by such a column and, with the quantity used, none or at most 10 per cent of the sugar was recoverable by immediate elution with dilute hydrochloric acid. Of the sugars investigated glucosamine[4], galactosamine and N-acetylglucosamine were anomalous in that, while they were completely removed by the resin, they were recovered quantitatively by hydrochloric acid elution. Non-reducing sugars were not investigated.

If 'Bio-Deminrolit' is saturated with carbon dioxide, the quaternary ammonium bicarbonate is formed. The resulting mixed resin is used in this laboratory in place of 'Bio-Deminrolit E' (now unobtainable) and is very satisfactory. There was no appreciable loss of fructose or glucose from a dilute solution of the sugars left over 'Bio-Deminrolit' ($HCO_3$' form) for nine days at 0 °C.

I wish to thank Mr. J. D. Cheshire and Miss S. D. Birchenough for technical assistance.

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## Separation and Structural Determination of the Olefinic Components of Poison Ivy Urushiol, Cardanol and Cardol

THE noxious saps of numerous members of the Anacardiaceæ, such as Japanese lac, poison ivy, cashew nut shell liquid, etc., contain phenolic bodies carrying long unsaturated side-chains attached to the benzene ring. Earlier investigators[1] have in certain cases established the length and the position of these alkenyl side-chains; but prior to the present investigation only very limited information was available concerning the structural details of the unsaturation. There is no doubt, however, that the unsaturation in the side-chain plays an important part both in the physiological properties[2] and industrial uses[3] of these compounds.

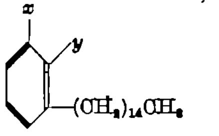
To explain the formation of a variety of oxidative degradation and ozonolysis products, Majima[1] concluded that Japanese lac urushiol is hetero-olefinic in character. He proposed structures for mono-, di- and tri-olefinic components; but he was not able to separate these components for their decisive structural identification. In fact, work now in progress in these laboratories[4] indicates that two of the structures proposed by Majima will have to be modified.

Earlier investigations[5] in this laboratory have established that the alkenyl phenols, anacardic acid and cardanol (also called anacardol[1]) obtained from the shell liquid of the cashew nut are also hetero-olefinic in character. However, no evidence has been available concerning the olefinic heterogeneity of cardol, the resorcinol component largely responsible for the dermatitis caused by cashew nut shell liquid[6].

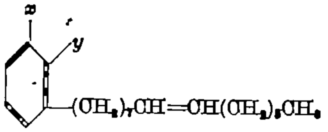
Most of the interest in the United States in regard to the physiological properties of these alkenyl phenols has been focused on poison ivy. The difficulty of obtaining the toxic phenol in pure form from the poison ivy sap has seriously hampered efforts to gain more information about its unsaturated character. Poison ivy urushiol absorbs hydrogen equivalent to about two double bonds and is converted into 3-pentadecylcatechol[1b]. Although Mason and Schwartz[7] concluded on the basis of preliminary chromatographic experiments that at least three toxic components are present in poison ivy urushiol, they did not separate these components in a form suitable for structural elucidation.

By means of chromatographic adsorption of the methyl ethers of three of these alkenyl phenols (poison ivy urushiol, cardanol and cardol) on alumina, we now have been able to separate the different olefinic components in pure form. In the case of poison ivy dimethyl urushiol, four components have been isolated—one of which had a completely reduced side-chain and the other three possessed one, two and three double bonds. Each of the three olefinic components absorbed the theoretical amount of hydrogen on catalytic reduction and yielded in pure form the saturated component (3-pentadecylveratrole). The structures of the four components of poison ivy urushiol now established on the basis of the products isolated from ozonolysis and oxidative degradation involving the dimethyl ether are shown in the accompanying formulæ (p. 842).

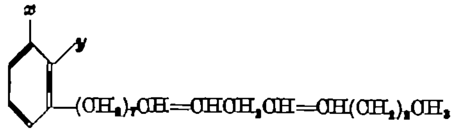
Cardanol, the monophenol obtained from the cashew nut shell liquid, was found to absorb hydrogen equivalent to about two double-bonds. Its methyl ether was also separated into four chromatographically pure components, the side-chains of which proved to be identical with those of the corresponding



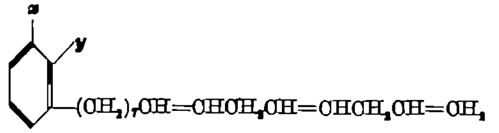
(I)



(II)



(III)



(IV)

Components of poison ivy urushiol ($x = y =$ OH)

components of poison ivy urushiol. The structures of the pure components of cardanol, therefore, can be represented as I, II, III and IV, respectively, where $x$ = OH and $y$ = H.

Anacardic acid, the alkenyl salicylic acid component of cashew nut shell liquid, also absorbs two moles of hydrogen and is hetero-olefinic. On reduction it is converted into 2-carboxy-3-pentadecylphenol. Since anacardic acid gives cardanol on smooth decarboxylation, it seems probable that the hetero-olefinic character of anacardic acid can be explained in terms of olefinic components corresponding in structures to those found in cardanol (I, II, III and IV; $x$ = OH, $y$ = COOH).

Cardol, the toxic resorcinol component of cashew nut shell liquid, usually absorbs somewhat more than two molar equivalents of hydrogen and is converted into 1,3-dihydroxy-5-pentadecylbenzene. It was found to be composed mainly of a diolefin and a triolefin having alkenyl side-chains identical with those shown above.

No component having more than three double bonds could be detected in any of the three alkenyl phenols investigated.

A detailed account of this work will be reported elsewhere. We are indebted to the Lederle Laboratories Division of the American Cyanamid Company for a grant supporting this investigation. An extract of poison ivy was also supplied by the Lederle Laboratories. The cashew nut shell liquid was kindly supplied by the Irvington Varnish and Insulator Company.

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## Specific Volume of Cellulose in Aqueous Solutions of Inorganic Salts

THE specific volume of cellulose (sheet viscose) in aqueous solutions of ammonium, sodium and potassium chlorides, at 25° C., has been measured, using a 'hydrostatic balance', for the whole of the solubility range of the salt.

The curve obtained in the plot of specific volume against concentration passes through a maximum in each case. The concentration of the external solution at the maximum specific volume for each salt is:

| Salt | Concentration (wt. per cent) |
|---|---|
| Ammonium chloride | 14·3 |
| Sodium chloride | 18·0 |
| Potassium chloride | 16·0 |

Calculation of the ratio of gram molecules of water per gram cation at this concentration, assuming equal hydration of anion and cation in all cases, gives the following values:

| Ion | Ratio |
|---|---|
| $NH_4^+$ | 8·9 |
| $Na^+$ | 7·5 |
| $K^+$ | 11·6 |

From the effective radius of the ion[1] and of the water molecule, the number of water molecules which can be arranged around each ion, from purely geometrical considerations, may be calculated:

| Ion | Radius (A.) | 'Geometrical' number of water molecules |
|---|---|---|
| $NH_4^+$ | 1·42 | 12·0 |
| $Na^+$ | 0·95 | 7·5 |
| $K^+$ | 1·33 | 12·0 |
| $H_2O$ mol. | 1·38 | 12·0 |

The following suggestion is offered in explanation of the specific volume curve.

There is evidence[2] for believing that, in the initial stages of water adsorption by cellulose, the water is under a compressive force, causing it to have a density greater than ordinary liquid water.

Addition of a salt provides polar centres which disorganize the water atmosphere, and has a decompressing effect on the adsorbed water layer. The specific volume of the cellulose therefore increases with increasing salt concentration, until the activity of the water in the system is so reduced that it is unable to satisfy the hydration requirements of the ions. Further addition of salt then results in direct linkage of the salt ions with the cellulose, and the specific volume decreases once more.

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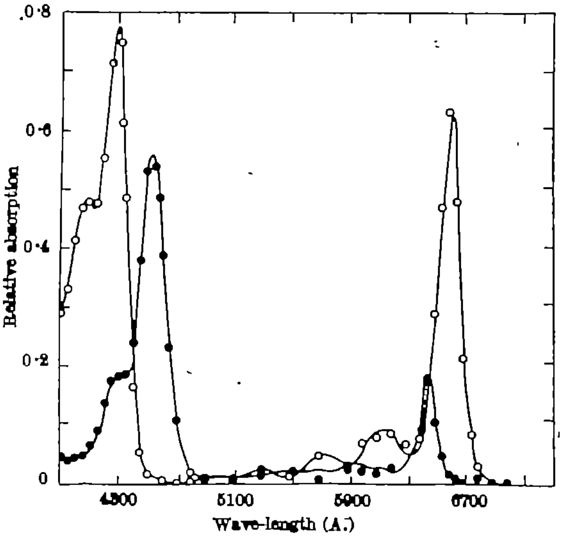
## Absorption Spectra of the Ethyl Chlorophyllides

THE spectra of the ethyl chlorophyllides, the crystalline derivatives of chlorophyll by replacement of the phytyl by the ethyl radical, are of interest as these compounds are valuable as actinometry standards in the study of the efficiency of photosynthesis. No report seems to have been made of



Absorption spectra of the ethyl chlorophyllides in ether. Solid lines, absorption spectra of chlorophylls *a* and *b*, from Harris and Zscheile (ref. 2), open circles and filled circles, relative absorption coefficients for ethyl chlorophyllides *a* and *b* respectively

their absorption spectra, except for some indirect evidence that they are different from those of the chlorophylls[1].

This has now been tested directly. A sample of the mixed chlorophyllides, which had originally been prepared by A. Stoll, was kindly supplied by Dr. J. Weiss. This sample was dissolved in petroleum ether and chromatographed by the method employed for the chlorophylls[2]. A dark residue remained within ½ mm. of the top of the column. This probably accounts for part of the spectral results previously obtained. The two bands of the chromatogram were twice re-chromatographed.

The spectra of the two chlorophyllides in ether and methanol were measured using a Beckman spectrophotometer. These spectra could then be superimposed exactly on the corresponding chlorophyll spectra[2] on adjustment of the absorption coefficients at one point, as is illustrated in the diagram. An attempt was made to obtain the absolute extinction coefficients by direct weighing after extracting the dissolved sugar with water. This was unsuccessful, as the chlorophyllides were altered in spectra by this treatment. Despite the lack of the absolute extinction coefficients, the identity of spectral shape leaves little doubt that the spectra of the ethyl chlorophyllides are the same as those of the corresponding chlorophylls.

This work is part of a study of chlorophyll *in vitro* being carried out under the direction of Prof. R. Livingston, of the University of Minnesota, and supported by the U.S. Office of Naval Research (Contract N6 ori—212).

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## Electrolytic Polishing of Lead in a Sodium Acetate – Acetic Acid Bath

In the course of experimental work on the anodic behaviour of lead, it was found desirable to produce a high degree of polish on specimens which might have overall areas of as little as 1 sq.cm. An examination of the literature indicated that the recommended bath for polishing this metal was one consisting of 250 c.c. of 60 per cent perchloric acid, with 750 c.c. glacial acetic acid. We considered that, because of the intermittent use that would be made of the solution, it would be unpleasant to store; a search was therefore made for alternatives. The experiment was tried of increasing the conductance and buffer capacity of glacial acetic acid by the addition of sodium acetate, and the present note gives details of useful operating conditions for electrolytic polishing in the resultant solution.

For most of our experimental work, we employed cylindrical lead specimens, about 1 cm. in diameter and mounted with the exposed face vertical. The electrical connexion to the back surface, and also this surface, were coated with a thermal-setting insulating varnish. A graphite or platinum cathode was placed about 5 cm. away from the anode. Contrary to normal practice the current, rather than the applied voltage, was controlled, and by this means the specimen could be etched or polished. Polishing occurred at current densities between 50 and 100 mA./cm.$^2$ in a bath of the following composition:

| | |
|---|---|
| Anhydrous sodium acetate | 60 gm. |
| Glacial acetic acid | 315 c.c. |
| Water | 80 c.c. |

The over-potential at the anode has been measured by means of a Luggin capillary and saturated calomel electrode, and a value of 4–5 V. was recorded during polishing. Polishing occurred in the following stages on the 1-cm. diameter specimens: (*a*) etching; (*b*) polishing began at the edges, working inwards across the surface, followed by the inward growth of a film; (*c*) after about two minutes, this film completely covered the surface, the over-potential reaching a maximum value; oxygen was not evolved; (*d*) patches of polish began to show, and after four minutes a highly reflecting surface appeared which was maintained on continuing to pass the current.

If the current is interrupted for a few seconds, on re-starting the above cycle is repeated, etching being first produced on the smooth surface.

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## Natural Origin of Optically Active Substances and Optical Resolution by Symmetric Agents

The communication by R. C. Ferreira[1] stresses the implications of his findings (and those of H. M. Powell[2]) on the origin of 'molecular dissymmetry' in living matter through nucleation of a saturated solution of an externally compensated compound by a crystal containing an excess of one enantiomer. Possibly certain earlier work bearing upon the same fundamental principle runs some danger of being overlooked. It was observed more than a hundred years ago[3] that a solution of externally compensated ammonium hydrogen malate upon evaporation deposited crystals containing about three parts of the (−)-salt to one part of the (+)-salt, showing that a partial spontaneous resolution had taken place.

A remarkable susceptibility to nucleation was recorded by Anderson and Hill[4], who showed that when optically inactive atropine sulphate was crystallized in a laboratory in which the (−)-form had been racemized, the first crop was almost invariably (−)-rotatory, owing to inoculation from the atmosphere. It has even been established that effective nucleation of this kind may be brought about by crystals composed of *symmetric* molecules. In 1908, Ostromisslensky[5] described the optical resolution of externally compensated asparagine through nucleation with crystals of glycine, $CH_2(NH_2).COOH$, as follows: "Beim Impfen der übersättigten wässrigen *d,l*-Asparaginlösungen mit vereinzelten Glykokollkrystallen scheidet sich bald die rechte, bald die linke Antipode aus. Es ist in diesem Falle nicht möglich vorauszusehen, welche der beiden Antipoden ausgeschieden wird, weil die Hemiedrie des Glykokolls nur in vollständig versteckter Form auftritt".

The bearing of such phenomena upon the origin of optically active organic substances in Nature was expressed, for example, in 1926, as follows[6]: "A solution of a substance susceptible to spontaneous separation dries up by natural evaporation and deposits a conglomerate of the two kinds of crystals. One of these crystals is introduced fortuitously into an adjacent supersaturated solution of the substance. It is known that under such conditions a crystalline separation may occur of the optical isomer similar to the inoculating crystal. Imagine at this point that the mother-liquor is drained from the crystalline deposit by a further natural process. Two optically active nuclei are now available, namely, the crystalline separation and the substance remaining in the mother-liquor".

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## Repetitive Post-Synaptic Discharge in a Sensory Nucleus

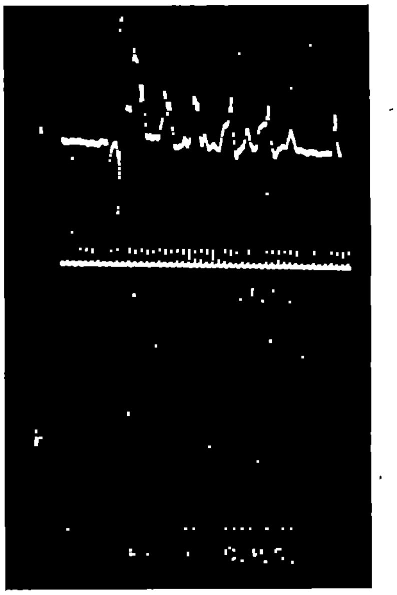
In the course of an investigation into the mechanism of synaptic transmission in the dorsal nucleus of the lateral geniculate body of the cat, the phenomenon of repetitive firing by the ganglion cells has been repeatedly observed following a brief electrical stimulus to the optic nerve.

Extensive electrophysiological studies in this laboratory have shown that the optic nerve and tract contain two groups of fibre sizes. This is clearly shown when only the crossed or uncrossed components of the optic tract are stimulated separately. The fibre groups in the crossed pathway, however, conduct somewhat more slowly than the corresponding groups in the path that remains uncrossed at the chiasm. This fact tends to obscure a clear-cut demonstration of the two groups in the fibre-size spectrum of the optic nerve. The form of the compound action potential of the optic nerve and its relation to the fibre-size spectrum will be reported in detail elsewhere.

By electrical stimulation of the optic nerve, it is possible to activate the group of large-diameter fibres in the opposite tract without significantly affecting the smaller-diameter fibres. In these circumstances a micro-electrode within the corresponding lateral geniculate records the typical waveform shown in record (*b*). It has been shown to consist of an initial positive negative diphasic wave (1) representing the arrival of impulses along optic tract fibres, followed after a short delay by post-synaptic activity leading to the discharge of impulses along optic radiation fibres. The post-synaptic discharge (2) has been shown to consist of a negative positive diphasic radiation spike superimposed upon and initiated by a negative synaptic potential. This wave (2) may be termed the primary post-synaptic response; but in most preparations it may be seen to be followed after a delay of 2–4 m.sec. by another negative wave which represents the beginning of the secondary response. The latter is attributed to repetitive firing or after discharge on the part of the optic radiation neurones.

Record (*a*) shows the same response on a slower time-base sweep. As many as ten distinct secondary spikes have been seen, and they occur at fairly regular intervals of 1·5–3·0 m.sec. The repetitive discharge is prevented, without significantly affecting the primary response, by increased rate of stimulation (greater than 2 per sec.), increased depth of anaesthesia (dial or nembutal) or by mild asphyxia.

The spikes of the secondary response are frequently clearly diphasic, negative positive, and appear to arise out of a synaptic potential. This similarity in form to the primary response suggests that the spikes



(*a*) Repetitive firing by the cells of the contralateral lateral geniculate body following a single optic nerve stimulus. These records were obtained from an intrageniculate recording site with only the group of larger-diameter optic nerve fibres stimulated
(*b*) The same phenomenon recorded from a different position in the lateral geniculate using a faster time-base sweep

represent impulses discharged along optic radiation fibres.

Repetitive firing has been previously reported in sympathetic ganglia[1] and in motoneurone pools[2]. The repetitive firing in the lateral geniculate is not related to the former, for in sympathetic ganglia the phenomenon is not observed unless the ganglia are conditioned by a tetanus of at least 50 stimuli per sec., whereas in the case of the lateral geniculate it is prevented by a stimulation-rate greater than 2 per sec. The phenomenon is probably due to internuncial activity, which also forms the basis of the after-discharge from motoneurone pools. It is suggested that in the lateral geniculate the discharge is the result of the activity of a large number of relatively simple reverberating circuits arranged in parallel array, each possessing an optic radiation neurone and one or more interneurones.

Histological studies provide good evidence for the existence of short axon cells in the lateral geniculate, and recurrent collaterals from optic radiation neurones have been described. It appears that repetitive firing by the lateral geniculate is a normal response under these experimental conditions. The observations of Lloyd and McIntyre on the gracile and cuneate nuclei[3] make it likely that repetitive firing is a property of these nuclei also. These findings suggest a more important role for the sensory nuclei in the organization of sensory impulses than is generally supposed.

This investigation was aided by grants from the National Health and Medical Research Council of Australia and the A. E. Kahn Donation.

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## Vitamin $B_{12}$ Content of Calf Thymus Extract

THYMUS and thymus extracts have been reported by Asher[1], Rowntree, Clark and Hanson[2], and others using rats as test animals, to have a growth-stimulating effect. Later experiments did not confirm this observation[3,4]. The conflicting results may have been due to deficient diet given to the control animals of the earlier investigators[4], or to the varying value of the calf thymus extracts used. No generally accepted explanation, however, has been found for the growth results. Hammar[5] was of the opinion that some vitamin of the B group may be a contributing factor.

The necessity of an animal protein factor for the growth of several animals has been proved in recent times. This animal protein factor has been regarded as either identical with vitamin $B_{12}$ or as containing vitamin $B_{12}$. In rats, the growth-stimulating effect of vitamin $B_{12}$ appears so distinctly that their growth is employed as an assay method for this vitamin[6].

We have endeavoured to determine the vitamin $B_{12}$ content of a calf thymus extract used in growth experiments[2-4]. The thymuses were taken from freshly slaughtered calves and preserved deep-frozen. The calves were classified into three age groups: 2–4 weeks, 3–4 months and more than 6 months old. The first two groups had been on a milk diet, whereas the third had received ordinary vegetable food. 600 gm. of thymus per litre was used in each group for the preparation of the extracts. The extracts were made according to the method introduced by Hanson[7]. The vitamin $B_{12}$ content of the sterile extracts filtered in a Berkefeld filter was determined with mutant *E. coli* strain 113–3 by the serial dilution method. The composition of the nutrient medium was as follows[8]: $K_2HPO_4$, 7·0 gm.; $KH_2PO_4$, 3·0 gm.; $Na_3$.citrate.$3H_2O$, 0·5 gm.; $MgSO_4.7H_2O$, 0·1 gm.; $(NH_4)_2SO_4$, 0·1 gm.; glucose (autoclaved separately), 10·0 gm.; and water, 1,000 gm.

The thymus extract of calves 2–4 weeks old contained 0·01 μgm. per ml. of vitamin $B_{12}$, that of calves 3–4 months of age contained 0·04 μgm. per ml. and the thymus extract of calves more than six months old contained 0·01 μgm. per ml. of vitamin $B_{12}$.

According to our results, the vitamin $B_{12}$ content in thymus extracts is such that it can have a growth-promoting effect if the basal diet has been deficient as regards vitamin $B_{12}$. Hence, the vitamin $B_{12}$ content of thymus may play a part in growth results obtained with thymus extracts.

W. J. KAIPAINEN

Department of Serology
and Bacteriology,

ANTTI TELKKÄ
KIMMO K. MUSTAKALLIO

Department of Anatomy,
University of Helsinki.
Nov. 18.

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[1] Asher, L., *Wien. med. Wochenschr*, 84, 565 (1934).

[2] Rowntree, L. G., Clark, J. H., and Hanson, A. M., *J. Amer. Med. Assoc.*, 103, 1425 (1934).

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[5] Hammar, J. A., "Die Normal-Morphologische Thymusforschung" (J. A. Barth, Leipzig, 1936).

[6] Lewis, U. J., Register, U. D., and Elvehjem, C. A., *Proc. Soc. Exp. Biol. and Med.*, 71, 509 (1949).

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[8] Diding, N., *Scandinav. J. Clin. and Lab. Invest.*, 3, 215 (1951).

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## Effect of Dietary Penicillin on Blood Composition and Œstrogen-induced Oviduct Growth in the Folic-Acid Deficient Chick

STUDIES designed to elucidate the processes responsible for the growth-promoting effects of dietary antibiotics have shown that the growth-rate of chicks and rats deficient in individual vitamins is increased by addition of an antibiotic. Growth responses to antibiotics on adequate diets have also been shown to be accompanied by increases in blood and liver concentrations of certain vitamins[1]. It has been pointed out by Coates *et al.*[2] that such increases may be non-specific to antibiotic treatment and may merely accompany a growth acceleration. Common *et al.*[3] demonstrated an increase in the blood levels of calcium and riboflavin in œstrogen-treated pullets as a result of adding aureomycin to an adequate diet. On the basis of experiments by Hertz *et al.*[4] such an increase could be attributed to an increase in dietary availability of these nutrients. In view of these remarks concerning the difficulty in interpreting such increases in blood- and tissue-levels of a particular metabolite resulting from the inclusion of an antibiotic which also causes a growth stimulation, the two criteria of folic acid availability chosen in the experiment reported here were end-organ response to œstrogen and hæmoglobin-level in the blood. A short period of œstrogen treatment affects both blood composition and oviduct growth-rate, and the latter has been shown to be specifically reduced by folic-acid deficiency[4].

For the experiment eighty Light Sussex female chicks were reared for two weeks on a commercial chick mash and then placed on a purified folic-acid deficient diet similar to that of Lillie and Briggs[6], with the addition of vitamin $B_{12}$ ('Distivit') at a level of 5 μgm./100 gm. The chicks were maintained on this diet for two weeks and then allocated at random to two groups of equal number and balanced for live-weight. One of these groups was fed procaine penicillin at a level of 20 mgm./kgm. diet for a further period of seven days, while the other group was maintained on the control diet. Both groups were offered the same amount of food, which they consumed completely. The chicks in each group were then weighed individually and allocated at random to three groups, each of twelve chicks, for hormone and folic-acid treatment over a further period of four days. The treatments given to the three groups on the control and the penicillin diet are shown in the accompanying table. Each group consumed the same amount of food daily, and during this time folic acid and œstradiol dipropionate were given by intramuscular injections on the first and third days at the levels shown.

| Group | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| No. of chicks | 12 | 12 | 12 | 12 | 12 | 12 |
| Final body weight (gm.) | 611 | 617 | 620 | 624 | 615 | 617 |
| Procaine penicillin (mgm./kgm. diet) | Nil | 20 | Nil | 20 | Nil | 20 |
| Œstradiol dipropionate (mgm.) | Nil | Nil | 2×2·0 | 2×2·0 | 2×2·0 | 2×2·0 |
| Folic acid (mgm.) | Nil | Nil | Nil | Nil | 2×0·5 | 2×0·5 |
| Hæmoglobin (gm./100 ml.) | 8·72 | 9·70 | 9·41 | 10·35 | 10·43 | 10·54 |
| Oviduct weight (gm.) | 0·088 | 0·095 | 1·876 | 2·161 | 2·818 | 2·898 |
| Serum riboflavin (μgm./ml.) | — | — | 0·29 | 0·65 | 0·19 | 0·44 |
| Significance of difference between penicillin and control groups: Hæmoglobin | $P < 0.01$ | | $P < 0.001$ | | Not significant | |
| Oviduct weight | Not significant | | $P < 0.05$ | | ,, | |
| Serum riboflavin | — | | $P < 0.01$ | | $P < 0.05$ | |

The results show that the inclusion of penicillin in the deficient diet was accompanied by significant increases in hæmoglobin-levels in the blood of both control and œstrogen-treated chicks. The significant increase in the weight of oviduct of the chicks in group 4 as compared with group 3 is in agreement with this observation. Such increases in the weight of oviduct resulting from folic acid supplementation, as in groups 5 and 6, have been shown by me to be paralleled by an increase in dry weight and nitrogen content.

The higher serum riboflavin content of the penicillin-treated chicks receiving œstrogen confirms the observation of Common *et al.*[3], and shows that such changes in blood composition as a result of œstrogen treatment are unrelated to the specific failure of end-organ response attributable to a deficiency of folic acid. It would seem from this experiment that the addition of penicillin to the diet can result in a functional increase in folic-acid activity, as judged by the criteria cited above.

I am indebted to the Distillers Company (Biochemicals), Ltd., for the gift of procaine penicillin and vitamin $B_{12}$.

W. O. BROWN
Queen's University of Belfast,
and
Ministry of Agriculture (Northern Ireland).
Nov. 25.

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## Adsorption and Hæmolytic Action of Diacetyldeoxycholate

In an investigation of the relation of the hæmolytic activity of sodium cetyl sulphate and sodium lauryl sulphate to their adsorption to red blood cells, we found that hæmolysis only starts when a minimum quantity of the detergent is really fixed to the cell walls[1,2]. On the assumption that such hæmolysis does not necessarily involve a unique mechanism, we undertook the study of the relationship between hæmolysis and adsorption for a bile acid derivative.

Ponder[3] concluded from his experiments that sodium taurocholate reacts with some definite component of the cells which is solubilized, but that the lysin is not bound to the walls. After equilibrium it was found that the sodium taurocholate concentration, which was estimated colorimetrically, had remained constant, but the hæmolytic activity of the supernatant fluid had decreased enormously. We determined by the same technique the adsorption of radioactive deoxycholate, which was obtained by acetylation of deoxycholic acid with anhydric acetic acid labelled with carbon-14. A dilution series of the labelled lysin with borate buffer (*p*H 7·4) and a constant number of red cells ($7 \times 10^{9}$ in a total volume of 8 ml., bovine blood) were separated by centrifugation after four hours. The distribution of the deoxycholate was estimated both in the red cells and in the solution by measuring its specific activity, and the rate of the hæmolysis was recorded (Table 1).

Adsorption in this case is also found to be positive, and hæmolysis starts only after a critical quantity of lysin has been bound to the cells. This corresponds to an adsorption of $0.45 \times 10^{8}$ molecules of diacetyl deoxycholic acid per cell for 50 per cent hæmolysis. A figure of $1.0 \times 10^{8}$ molecules per cell was found for both alkyl sulphates[2].

Table 1

| Quantities of diacetyldeoxycholate In initial solution (γ/ml.) | Bound to the cells (γ) | Hæmolytic rate (per cent) |
|---|---|---|
| 4·800 | 250 | 88 |
| 4·000 | 242 | 38 |
| 3·200 | 234 | 6 |
| 2·400 | 210 | 4 |
| 1·600 | 212 | 3 |

Table 2

| Time (min) | Hæmolytic rate (per cent) | Diacetyldeoxycholate bound to the cells |
|---|---|---|
| 0 | 3 | 352 |
| 5 | 10 | 364 |
| 30 | 15 | 408 |
| 60 | 20 | 479 |
| 225 | 25 | 528 |
| 390 | 50 | 520 |

In the case of the alkyl sulphates, it was not possible to follow the adsorption-rate with time as the adsorption speed was too high; but in the case of deoxycholate it was possible to relate the time function of adsorption and hæmolytic rate using the same technique (Table 2).

We find evidence here of further development of hæmolysis after an initial rapid adsorption of the main quantity of the diacetyldeoxycholate.

The failure of Ponder to find adsorption of sodium taurocholate in a hæmolytic system can be explained by the recent results of Pethica and Schulman[4]. They found practically no hæmolytic activity for the highly purified compound and the activity was attributed to the accompanying impurities. A constant concentration of the taurocholate before and after the hæmolysis can thus be expected.

R. Croes
R. Ruyssen

Laboratory of Physical Biochemistry,
University of Ghent. Sept. 19.

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## Swarming of *Nereis succinea* (Leuckart) off the East Coast of Canada

In June 1952 the crew of a fisheries patrol boat cruising in Miramichi Bay, New Brunswick, observed what they took for a sand-bar in an unexpected situation. On closer inspection they found that there was no such bar, but that the surface of the sea over a wide area was in a state of violent turmoil ("a sort of boiling") due to the presence of enormous numbers of polychætes. The area covered was some 150 yards in radius and was broken up into several minor patches. The largest one, from which they took a sample of the polychætes, was estimated to be 75 ft. long and 15 ft. wide, and the polychætes seemed to extend to about 2 ft. deep. The tide was low at the time and the depth of the water about 7 ft. The bottom consisted of hard mud. The observation was made on a fine, warm day.

The polychætes involved were the heteronereid forms (both sexes) of *Nereis succinea* (Leuckart). This is the first record of that species from eastern Canadian waters, though it is known from the eastern coast of the United States, usually under the name *Nereis limbata* Ehlers. Ehlers[1] described in detail the male heteronereid of *Nereis acutifolia* Ehlers, which appears to be another synonym of *Nereis succinea* (Leuckart) (cf. Monro[2]). The specimens from Miramichi Bay agree closely with Ehlers's description.

We know of no other case of the swarming of a nereid with such activity and in such concentrated masses as occurred in this instance, and should be glad to hear of any that has been recorded.

The specimens were submitted by the collectors to Mr. R. A. McKenzie, a representative of the Fisheries Research Board of Canada at Chatham, New Brunswick, and were forwarded by him to Dr. A. H. Leim, of the Atlantic Biological Station, St. Andrews, New Brunswick, who, in turn, sent them to us for identification. We are indebted to the former for particulars of the conditions of swarming.

C. Berkeley
E. Berkeley

Pacific Biological Station,
Nanaimo,
British Columbia.
Nov. 15.

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## Factors affecting Choice and Judgment

Dr. R. G. Hopkinson[1], in his account of a meeting of Section J of the British Association at Belfast, discusses certain aspects of subjective assessments. While admitting that subjective judgments can be of very real value, it does seem that Hopkinson has under-estimated some of their disadvantages in comparing them with 'objective' methods of measurement.

When subjective and objective methods of measurement can equally well be used, it may well be that, in certain cases, smaller differences can be detected by the subjective method. The 'success' of subjective assessments, however, is generally described in terms of accepted threshold-levels (generally 80 per cent correct), and there may have to be a relatively very large difference between stimuli before they can be distinguished 100 per cent correctly. In fact, a 100 per cent discrimination may be unattainable by subjective methods.

It is above all when absolute judgments have to be made, however, that subjective methods become inefficient. This is because a subjective judgment tends to be affected by others made just previously and, in particular, to be influenced by the average quality-level of the group within which the samples to be assessed are presented. Thus, for example, food products have often to be assessed by experts in terms of mental standards, when it is not possible to keep a standard sample for comparison purposes. In such a situation, Dove[2] has shown that a sample of sweet corn is described quite differently when presented with groups of samples differing in quality, and Sheppard[3,4] has shown that absolute judgments for firmness of a given sample are affected by the average firmness of the group within which it is judged.

It is interesting that Hopkinson found little variation in glare settings, since such judgments are likely to be more important biologically to the individual than the type of assessments described above, and it may be for this reason that they are made more accurately. Since fatigue mechanisms usually operate to safeguard the individual from physiological damage, it would be interesting if they could be shown to do so with a greater degree of accuracy than is usual in psychological assessments.

There are, however, other possible reasons for these differences. Thus it may be easier to maintain a mental standard for visual judgments than it is for flavour or tactual assessments; while it seems likely that the criteria for glare ratings can be more successfully defined. A more probable explanation is that the stimulus range is (subjectively) wider for glare situations than for the others referred to and, since Hopkinson used a small number of rating values, it is for this reason that the subjective assessments appear to be reliable. The other possibility is that the difference can be attributed to the use of the 'method of adjustment' by Hopkinson, since this is not a commonly used psychophysical method.

There are two further disadvantages of absolute judgments made subjectively: the first is that the skill and knowledge required to make them have to be passed on by training, whereas an objective method of measurement can be precisely described in a written form, and can be used again after any period of time by anyone who is sufficiently skilled to construct and use the apparatus required. Secondly, fatigue may be important; thus, for example, a judge should not make more than five to seven assessments for flavour at one time. Instruments do not have this disadvantage.

With reference to Hopkinson's comments on the training of subjects to make judgments, Harper[5] has been able to show that relative discrimination, at least, can be improved by suitable training; but whether the factors influencing absolute judgments, as described above, can be overcome by suitable training, is less clear.

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National Institute for Research in Dairying,
Shinfield, Nr. Reading.

[1] Hopkinson, R. G., *Nature*, 170, 555 (1952).

[2] Dove, W. F., *J. Comp. Psychol.*, 35, 29 (1943).

[3] Sheppard, D., *J. Dairy Res.*, 19, 348 (1952).

[4] Sheppard, D., *Quart. J. Exp. Psychol.*, 5, 1 (1953).

[5] Harper, R., *Brit. J. Psychol.*, Monog. Supp. No. 28 (1952).

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MR. SHEPPARD'S letter directs attention to one of the many matters associated with subjective judgments that failed to receive consideration at the Belfast meeting, and I hope he will accept that my summary was concerned only with problems which arose out of the meeting itself. However, I am grateful for the opportunity which his letter affords to acknowledge that there are indeed situations where subjective judgments should be replaced by objective measures. I would go so far as to assert that, wherever the relation between the subjective reaction and the physical variables is fully understood, and the physical variables can be measured with the necessary degree of absolute and repetitional accuracy, the objective method should be used. For this reason we use, for example, photoelectric methods of photometry to replace visual methods, having satisfied ourselves that we understand the exact nature of the visual response to radiation of complex spectral characteristics inasmuch as it affects the ability of the eye to judge amount of light.

The need for subjective judgments arises when the relation between the physical variables and the subjective reaction is not fully understood. Then my contention is that it is often a wiser course to rely on a carefully planned series of subjective judgments than on a physical measure the inadequacy of which is hidden by its ability to repeat its judgments with apparent consistency. An instrument can be made which gives an objective reading which it correlates well with the subjective judgment of the 'graininess' of a cathode-ray tube screen, provided the same particle-size distribution of screen material is always used. Change the distribution, or the shape of particle, and the correlation breaks down. The instrument continues to churn out its apparently consistent readings, but these are no longer correlated with the subjective judgment they purport to replace.

The decision as to whether one should replace a subjective judgment by an objective measure should be based on the nature of the physical variables which govern the subjective reaction. Where one variable only is involved (for example, the amount of light on the recognition of the presence of a signal) or where only one variable can be assumed for the purpose to be involved (for example, the air temperature or the feeling of warmth when other factors are constant), this easily measured physical variable can be taken as an objective measure of the subjective quality.

In other situations the subjective quality can be linked with certainty to the physical variables, but the relation is so complex that only in special cases does the design and maintenance of an instrument based on it justify itself. Such a special case is the measurement of light of complex spectral quality, where a 'physical eye' of considerable complexity is needed in order that the manufacturer of fluorescent lamps may control his product.

Further up the scale are situations, like the judgment of paper quality, the characteristics of semi-diffusing materials for lighting, or the quality of wine, where only partial success has been achieved in establishing the complete range of physical variables which govern the subjective judgment. Such qualities can, however, be judged with accuracy, after training and experience, provided the judging is assisted and not deceived by the experimental conditions. It is in such cases that I query whether the time and effort expended in a search for an objective measure is justified.

Further still up the scale are judgments of æsthetic quality. Some of the physical factors which influence such qualities are understood—the proportions of a building, the order of progression of musical intervals, and so on—but the quality is essentially dependent on the weighting and integration, at a high level of thought, of a greater number of physical variables than could be handled at one time by any objective assessing-equipment at present within human conception.

It is probable that the clue to any remaining differences between Mr. Sheppard and myself is tied up in what we understand by a 'reliable' subjective judgment. He asks for every single judgment to be exact. I only ask that the mean of a convenient number of judgments should not drift, and that the variance of the judgments should be small in relation to the differences in which my experiment is interested. If this difficulty could be resolved, it might be possible to agree that some of the effort now devoted to the development of objective measures of complex situations might well be expended on the systematizing of a discipline for the conduct of subjective experiments and the training of human judges. There is still a great deal of prejudice which leads to distrust of experiments involving human judgments. This can be swept away only if the tools used in subjective experiments are sound, and are used in a way which commands respect.

R. G. HOPKINSON

Building Research Station,
Watford, Herts.

# FORTHCOMING EVENTS

(*Meetings marked with an asterisk * are open to the public*)

## Monday, May 11

UNIVERSITY OF LONDON (in the Anatomy Theatre, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Prof. A. Koyré: "An Experiment in Measurement in the XVIIth Century" (Special University Lectures in the History and Philosophy of Science, 1).*

ROYAL GEOGRAPHICAL SOCIETY (at 1 Kensington Gore, London, S.W.7), at 8.15 p.m.—Prof. J. A. Steers: "The East Anglian Floods".

## Tuesday, May 12

UNIVERSITY OF LONDON (in the Anatomy Theatre, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Prof. A. Koyré "An Experiment in Measurement in the XVIIth Century" (Special University Lectures in the History and Philosophy of Science, 2).*

ILLUMINATING ENGINEERING SOCIETY (at the Royal Society of Arts, John Adam Street, Adelphi, London, W.C.2), at 6 p.m.—Annual General Meeting.

INSTITUT FRANCAIS DU ROYAUME-UNI (at 15 Queensberry Place, London, S.W.7), at 6 p.m.—Dr. P. Lépine (Paris): "Le Problème du Cancer dans ses relations avec les Virus".*

## Wednesday, May 13

ROYAL SOCIETY OF ARTS (at John Adam Street, Adelphi, London, W.C.2), at 2.30 p.m.—Sir Richard Southwell, F.R.S.: "Training for Science and Technology" (Trueman Wood Lecture).

GEOLOGICAL SOCIETY OF LONDON (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Dr. G. Y. Craig: "The Palaeoecology of the Top Hosie Shale, Kilsyth, Stirlingshire"; Dr. D Flinn: "On the Time Relations between Regional Metamorphism and Permeation in Delting, Shetland".

BEDSON CLUB (in Lecture Theatre 1, King's College, Newcastle-upon-Tyne), at 5 30 p m.—Prof. J. H. Hildebrand: 91st Bedson Lecture.

INSTITUTION OF ELECTRICAL ENGINEERS, RADIO SECTION (at Savoy Place, Victoria Embankment, London, W.C.2), at 6 p.m.—Dr. R. Warnecke and Monsieur P. Guenard: "Recent Work in France on New Types of Valve for the Highest Radio Frequencies".

SOCIETY OF CHEMICAL INDUSTRY, CORROSION GROUP (at the Chemical Society, Burlington House, Piccadilly, London, W.1), at 6.30 p.m.—Dr. W. H. J. Vernon: "Corrosion—a Field for Action" (Chairman's Address).

## Thursday, May 14

COUNCIL FOR THE PRESERVATION OF RURAL ENGLAND (at the Royal Institution of Chartered Surveyors, 12 Great George Street, London, S.W.1), at 2.30 p.m.—Annual General Meeting.

LABORATORY ANIMALS BUREAU (at the Royal Society of Medicine, 1 Wimpole Street, London, W.1), at 2.30 p m.—Symposium on "Laboratory Animals".

ROYAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Mr. H. Cary Gilson: "The Freshwater Biological Association".

BRITISH INSTITUTE OF RADIOLOGY (in the Reid-Knox Hall, 32 Welbeck Street, London, W.1), at 8 p.m.—Annual General Meeting, at 8.30 p m —Dr. L. H. Gray: "The Initiation and Development of Cellular Damage by Ionizing Radiation" (Thirty-second Silvanus Thompson Memorial Lecture).

## Friday, May 15

INSTITUTE OF NAVIGATION (joint meeting with the CHALLENGER SOCIETY, at the Royal Geographical Society, 1 Kensington Gore, London, S.W.7), at 5 p.m.—Dr. G. E. R. Deacon, F.R.S., and Commander G. S. Ritchie: "Navigation and Oceanography".

UNIVERSITY OF LONDON (in the Anatomy Theatre, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Prof. A. Koyré. "Philosophical Factors in the Evolution of Science" (Special University Lectures in the History and Philosophy of Science, 3).*

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 9 p.m.—Dr. Edwin Hubble: "The Observational Evidence for an Expanding Universe".

## Friday, May 15—Saturday, May 16

PHYSICAL SOCIETY (at the Imperial College of Science and Technology, Imperial Institute Road, London, S W.7).—Discussion on "Recent Research in Electron Optics".

## Saturday, May 16

ROYAL PHOTOGRAPHIC SOCIETY, SCIENTIFIC AND TECHNICAL GROUP (in the Arthur Worthington Hall, The University, Manchester), at 10 a.m.—Conference on "Photographic Science and Technique".

BIOCHEMICAL SOCIETY (in the Department of Physiology, The Medical School, Hospitals Centre, Birmingham), at 1.45 p.m.—Scientific Papers.

BRITISH PSYCHOLOGICAL SOCIETY (in the Psychology Department, University College, Gower Street, London, W.C.1), at 2.30 p.m.—Mr Harry Kay. "Remembering—some Recent Experiments".

# APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

ESSO STUDENTSHIP IN CHEMICAL ENGINEERING—The Registrar, University College, Gower Street, London, W.C.1 (May 15).

SENIOR LECTURER (with general experience of veterinary practice, and a particular knowledge of veterinary medicine in relation to farm animals and metabolic diseases) IN VETERINARY MEDICINE—The Secretary of University Court, The University, Glasgow (May 15).

ASSISTANT, Grade B (with honours degree) IN CHEMISTRY, to teach general chemistry up to Intermediate level and assist with teaching of physical chemistry to B.Sc. special standard, at Brighton Technical College—The Director of Education, 54 Old Steine, Brighton (May 16)

SENIOR LECTURER IN ORGANIC CHEMISTRY (with good honours degree in chemistry and, if possible, appropriate teaching, industrial and research experience, in pure or applied organic chemistry)—The Principal, Acton Technical College, High Street, Acton, London, W.3 (May 16).

SENIOR SCIENTIFIC OFFICER (university degree essential; experience in field experimentation and statistical analysis of results highly desirable), and an EXPERIMENTAL OFFICER or ASSISTANT EXPERIMENTAL OFFICER (must have at least N.D.A. or similar qualification, and practical experience with farm machinery essential)—The Secretary, Scottish Machinery Testing Station, Howden, Mid Calder, Midlothian (May 18).

READER IN PATHOLOGY at Westminster Medical School—The Academic Registrar, University of London, Senate House, London, W.C.1 (May 19).

SUPERINTENDENT (Deputy Chief Scientific Officer) OF THE AERODYNAMICS DIVISION, National Physical Laboratory—The Civil Service Commission, Scientific Branch, Trinidad House, Old Burlington Street, London, W.1, quoting S.4201/53 (May 21).

ASSISTANT PHYSICISTS (Senior and Basic grades)—The Secretary, Sheffield Regional Hospital Board, Broom Cross, Tree Root Walk, Sheffield 10 (May 23).

BIOLOGICAL RESEARCH ASSISTANTS (2) at the Biological Research Institute, Grange-over-Sands (one to take entire responsibility for care and maintenance of the research laboratories, the other for survey and experimental work on soil fauna in the field and laboratory)—The Establishment Officer (A), Nature Conservancy, 91 Victoria Street, London, S.W.1 (May 26).

SCIENTISTS (physicists, physical chemists or electrical engineers with at least second-class honours degrees or equivalent, and interested in the physics and chemistry of surfaces) to undertake investigations on both laboratory and pilot plant scales into novel methods of separating coal from associated minerals (Ref. TT/624); a SCIENTIST, Grade II (Ref. TT/625); a SCIENTIST, Grade III (Ref. TT/626); and a SCIENTIFIC TECHNICAL OFFICER, Grade I (Ref. TT/627) to lead a small team engaged in the systematic measurement of the physical properties of coal and associated minerals, in the Physics Department—The National Coal Board, Central Research Establishment, Stoke Orchard, Cheltenham, Glos, quoting the appropriate Ref. No. (May 26).

AGRICULTURAL ECONOMISTS (2) and ASSISTANT AGRICULTURAL ECONOMISTS (2) in the Provincial Agricultural Economics Service—The Registrar, The University, Reading (May 30).

ASSISTANT LECTURER or LECTURER IN THE DEPARTMENT OF GEOLOGY—The Registrar, The University, Liverpool (May 30).

LECTURER or ASSISTANT LECTURER IN PHYSICS (with good honours degree in physics)—The Dean, Medical School Office, Guy's Hospital, London, S.E.1 (May 30)

LECTURER IN EXPERIMENTAL PHYSICS—The Registrar, The University, Liverpool (May 30).

RESEARCH ASSISTANT (with at least two to three years experience in postgraduate research work) IN THE DEPARTMENT OF ORGANIC CHEMISTRY—The Registrar, The University, Liverpool (May 31)

RESEARCH BOTANIST (with good honours degree) for research on biennial bearing in fruit trees and other pomological problems—The Secretary, East Malling Research Station, East Malling, Maidstone, Kent (June 1).

SENIOR and JUNIOR FELLOWSHIPS—The Chief Superintendent, Telecommunications Research Establishment, Malvern, Worcs (June 1).

LECTURER and ASSISTANT LECTURERS (3) IN THE DEPARTMENT OF BIOCHEMISTRY (one appointment will entail research in certain physical aspects of biochemistry)—The Secretary, University College, Gower Street, London, W.C.1 (June 8).

LECTURER or ASSISTANT LECTURER IN THE DEPARTMENT OF OCEANOGRAPHY—The Registrar, The University, Liverpool (June 13).

CHEMIST (Experimental Officer grade) (with pass degree or equivalent qualifications and substantial experience in routine chemical analysis) for mineral analysis of plants—The Secretary, East Malling Research Station, East Malling, Maidstone, Kent (June 15).

SENIOR LECTURER IN VETERINARY MEDICINE AND ANIMAL HEALTH, a LECTURER IN GRASSLAND ECOLOGY, a LECTURER IN AGRICULTURAL CHEMISTRY, and a LECTURER IN SOIL SCIENCE, at the University College of the Gold Coast—The Secretary, Inter-University Council for Higher Education in the Colonies, 1 Gordon Square, London, W.C.1 (June 27).

RESEARCH BOTANIST (with good honours degree and substantial postgraduate experience, preferably in perennial crops) IN THE POMOLOGY SECTION—The Secretary, East Malling Research Station, East Malling, Maidstone, Kent (August 31).

ASSISTANT PHYSICIST (with honours degree in physics) IN THE RADIOTHERAPY CENTRE—The Physician Superintendent, St. Luke's Hospital, Guildford.

ASSISTANT PROFESSOR OF PHYSICS (with a well-developed knowledge of geophysics, and established interest in fundamental geophysical research)—Prof. W. H. Watson, Department of Physics, University of Toronto, Toronto 5, Canada.

CHEMIST in the Public Works Department, Gold Coast, for the supervision of the purification of Government water supplies and investigation of new supplies—The Commissioners for the Gold Coast, Melbourne House, Aldwych, London, W C.2.

Junior Assistant Chemist (with university degree including chemistry)—The Director, Fruit and Vegetable Canning and Quick Freezing Research Association, Chipping Campden, Glos.

Metallurgists and Metallurgical Engineers for (*a*) research on mild steel weld metal involving a relatively new problem of considerable interest and importance; (*b*) research on mild steel weld metal involving a constitutional approach to cracking problems; (*c*) research on the welding of high strength aluminium alloys—The Secretary, British Welding Research Association, 29 Park Crescent, London, W.1.

Research Fellow in Histochemistry—The House Governor and Secretary, Hospital for Sick Children, Great Ormond Street, London, W.C.1.

Senior Research Assistant (with good honours degree in engineering, practical experience and/or research training) in the Department of Civil and Mechanical Engineering—The Registrar, The University, Nottingham.

Senior Scientific Officers at Sellafield, Salwick and Culcheth, to lead research teams in theoretical and experimental work on the following: general physics and applied nuclear physics concerned with operation of nuclear reactors and associated processes, including health physics; physical and inorganic chemistry of metals and compounds used in atomic energy processes, including radioactive materials; extraction, purification and recovery of metals; refractory materials; physical metallurgy of radioactive metals; melting and casting of metals; X-ray crystallography of unusual metals and compounds—The Ministry of Supply, Division of Atomic Energy (Production), Risley, Warrington, quoting 444.

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# THE NUFFIELD FOUNDATION

THE Nuffield Foundation was established by Lord Nuffield in April 1943 with wide objectives, including the advancement of health and the prevention and relief of sickness, particularly by medical research and teaching and the organization and development of medical and health services; the advancement of social well-being, particularly by scientific research, and the organization, development and improvement of technical and commercial education; the care and comfort of the aged poor; and the advancement of education. These four objectives are sufficiently wide in themselves, but any other charitable purposes may be included in the Foundation's objectives on the written declaration of either Lord Nuffield in his lifetime or, after his death, of the trustees. That provision should sufficiently eliminate the danger of the dead hand, which Lord Nathan's Committee has been investigating since 1950; nor have successive annual reports of the Foundation indicated that there is any danger of the Foundation spreading its resources too thinly over too many objectives.

The principles upon which the Foundation has based the policies which have guided the administration of grants exceeding, in the past ten years, four million pounds, have been clearly indicated from time to time in its annual reports, notably in the fourth and sixth reports, in 1949 and 1951, respectively. Already when Lord Beveridge in 1948 published his report on "Voluntary Action", the work of the Foundation could be cited as an outstanding example of the way in which such independent private ventures could contribute to scientific and social advance, even with greatly increased State support for learning and research. The contribution which voluntary action could make to learning and culture by fostering enterprise and initiative, and ensuring that room for experiment and for testing opinion was maintained, had been fully demonstrated in the work of its first five years.

The tenth birthday of the Foundation was marked by a reception on April 30 at its new headquarters, Nuffield Lodge, Regent's Park, London, N.W., at which Queen Elizabeth the Queen Mother named a room "The Founder's Room" and unveiled a plaque in honour of Lord Nuffield. The first part has also been published of a review of the Foundation's first ten years, in which the main policies pursued are briefly recorded and the kinds of work supported are generally indicated. The grants themselves and, where appropriate, the progress made, are to be described in more detail in a second part, with appendixes, listing published research which the recipients of grants wish to attribute to the Foundation's help, and the names of Foundation fellows, scholars and bursars appointed during the decade. No attempt is made in this first part to distinguish the programmes of the first two five-year periods, though they have differed somewhat in emphasis; nor are the policies of the Foundation here discussed in relation to the current trends of government policy in quite the same way as they have been, for example, in the third, fourth or sixth annual reports.

Nevertheless, the record is of both public and scientific interest at a time when the place and activities of independent organizations in the promotion of research are being widely discussed both in Great Britain and in the United States of America. As a private fund serving the community, the Foundation has sought to be of service, in part directly, by forwarding projects of possible public benefit; and, in part indirectly, by providing a stimulus to research workers, some of whom might abandon promising but speculative work if there were not known to be resources available to support just this kind of pioneering. Reviewing, for example, the Foundation's support of the physical sciences and its early concern to assist in re-establishing university research in fundamental physics after the War, the review points out that university departments were endangered by the very successes of science and scientists in war-time work.

While most of the fundamental ideas and advances, so rapidly exploited to contribute to victory, had been born in academic departments before the War, there was a tendency to forget or neglect these origins and to attribute the ideas to the environment in which they had only been brought to swift and fruitful maturity. The urgent factor was the danger that the official establishments of government-sponsored applied research might prove too tempting to the brilliant men they had recruited from academic research, and some would be deterred by the prospect of inadequate apparatus and technical assistance from returning to the essential work of advancing knowledge and training research workers.

While not all the fears about the long-term after-effects of war on the standard of academic research proved to be justified, the part which the Foundation was able to play here was significant, and was the more valuable in that it was given quickly at a critical time. The lesson of research conducted under the press of war, that it is possible and worth while to multiply the effective work of a few good men by giving them technical tools and technicians on a scale well beyond that of peace-time, was applied by a private institution with a swiftness and efficacy that no government-controlled establishment could hope to emulate. As the review rightly but modestly remarks, when foundations and trusts accept such proper challenges to pioneer in the public interest, they should be judged not only by the success of this or that particular venture, but also by their general record of adventurousness.

The work here reviewed is in reality the product of less than ten years: the Foundation's first five-year programme dates from 1944. In the medical field, emphasis was laid on normal health rather than specific diseases, especially on child health, industrial health, and dental health, apart from rheumatism, the early study of which brought Capt. Oliver Bird's benefaction of £450,000; and, in physics, on nuclear research. For the second period, to end in 1954, the Foundation expressed a preference for assisting biological and sociological studies, and a willingness to begin to consider grants for research overseas; but a further desire to bring scientists and others together in research on practical problems has met with few opportunities. Grants for the welfare of old people and for research into their needs have continued through both periods, totalling £925,000, since 1947 chiefly through the National Corporation for the Care of Old People. The policy of awarding fellowships and similar personal help for training and travel has also continued over the whole period, accounting for a further £831,000, though the schemes have been varied from time to time to serve different purposes or opportunities. Grants for medical work totalled £786,000, including £229,000 for rheumatism; £347,000 for biological research; £560,000 for research in physics; £463,000 for projects in the social sciences; while research specifically related to agriculture received £32,000.

Such figures attest the scale and range of the Foundation's activities, rather than its pioneering character. That, however, is amply revealed in the sections which review in fuller detail the Foundation's policy in particular fields. In the medical sciences, for example, in accordance with a general policy of establishing and encouraging the study of child health, industrial health and dental health as academic subjects pursued at the highest level of academic work, and linked, where appropriate, to the conditions of the surrounding community, it has granted £100,000 towards the establishment in the University of London of a worthy institute of child health, and has assisted in making the study of health as it is affected by work and working conditions a subject of research in the Universities of Durham, Glasgow and Manchester. In rheumatism, besides encouraging fundamental work into causes and scientifically controlled trials of existing therapy, the Foundation has since 1949 supported much chemical work on the total synthesis of cortisone and the production of analogous substances with similar but less harmful effects.

In the biological sciences, where grants have on the whole been numerous and small, rather than, as in physics, few and large, the pioneer character of the programme is specially pronounced, the aim being to encourage work on the normal mechanisms of growth, differentiation and self-maintenance of living things. The early emphasis on nuclear research in physics has already been noted: besides this, the Foundation has sought to foster work on promising new techniques and tools of physics of value not only there but also in the investigation of biological problems by physical methods. In agriculture the Foundation has supported physical projects like that at the University of Cambridge concerned with soil mechanics as it affects drainage and tillage; but under its auspices also a study-group of economists, agricultural scientists and practical farmers is attempting to deduce in essentially a scientific way the long-term principles which should underlie any shorter-term policy for British agriculture. In the social sciences, where the choice of men, projects and institutions for support has, of necessity, been opportunistic, the absence of any clear pattern reflects not only the paucity of promising opportunities, especially for fundamental or adventurous research, but also the lack of coherence and systematic study in these subjects. Moreover, the review points out that the research which can be encouraged by the grants of private bodies is necessarily limited, and steady progress is unlikely until more public money is devoted to research as well as to teaching, so that the subject can be developed systematically and scientifically by an assured body of workers permanently established in universities.

This part of the review demonstrates clearly the primary function of the independent institution as providing the growing points of new knowledge, or new projects. The work on the care of old people, the basis of which in scientific research, especially fundamental research, is made clear, does, it is true, illustrate the same point; but it does not emphasize the related point that the independent institution should not be expected to commit its resources permanently to the support of activities the value of which, whether to society or scholarship, has been well attested. The value of the voluntary body or private institution lies precisely in its freedom to transfer its resources freely, to test the value of activities, projects and lines of investigation for which it would be premature or difficult to secure official or government support. Once the value of that line of investigation has been established, the voluntary body should seek to withdraw, leaving support increasingly to official sources, and to use its own resources at some fresh point on the frontiers of knowledge.

The dilemma which the Foundation and other such institutions are increasingly likely to face does not appear as clearly in this review as it did in its annual report two years ago, and also in that of the Carnegie United Kingdom Trust. The dilemma lies in choosing between helping, for example, academic activities during a time of public economy, and encouraging novel proposals which find it even more difficult to command a hearing. Yet the review, like Dr. Raymond Fosdick's recent review of the first forty years work of the Rockefeller Foundation, leaves us in no doubt where the primary responsibility of the independent institution lies.

It is encouraging to find that the principles and policies on which these two Foundations have been administered have so much in common. The Nuffield Foundation has less to say than Dr. Fosdick about those principles, but its policies are manifestly inspired by the same ideas of pioneering responsibility and willingness to risk capital adventurously on projects that the State will not or cannot support; and by the belief that promising men and creative ideas are the first essential. Judged by the ideas and practices set forth by Dr. Fosdick and also by Lord Beveridge, the Nuffield Foundation has acquitted itself well. The admirable record here so modestly told should stir more than the scientist to fresh thought as to the ways and means by which in the society of to-day the freedom of such bodies to continue their activities can best be ensured and the fullest use made of their services.

# TREATISES ON PHYSICAL CHEMISTRY

## An Advanced Treatise on Physical Chemistry

By Prof. J. R. Partington. Vol. 3: The Properties of Solids. Pp. ix+639. (London, New York and Toronto: Longmans, Green and Co., Ltd., 1952.) 70*s.* net.

## A Treatise on Physical Chemistry

Edited by Prof. Hugh S. Taylor and Samuel Glasstone. Third edition, in 5 Vols. Vol. 2: States of Matter. Pp. v+701. (New York: D. Van Nostrand Co., Inc.; London: Macmillan and Co., Ltd., 1951.) 75*s.* net.

THE general characteristics of Prof. J. R. Partington's "Advanced Treatise on Physical Chemistry" were well established by the first two volumes, and there is little new which a reviewer can say about the third. It maintains all the virtues of the earlier two: scrupulous care over detail and historical attribution, a clear and critical account of experimental methods, and a wealth of references (15,511 in the present volume) and numerical tables. These qualities appear all the more remarkable when one considers the sheer mass of material to which they have been applied in the three volumes of the treatise, and it becomes increasingly clear that staying-power is not the least of the author's qualifications for his task.

Those readers who disliked certain features of the earlier volumes will probably react in the same way to parts of the present one. For example, I am still unconvinced of the value of reproducing so many empirical equations: they are admittedly of no theoretical significance, and it may be doubted whether their inclusion is of much practical assistance, since it is impossible in the space available to give a critical account of their scope and accuracy. Similarly, some may feel that scant space is given to certain recent theories which are still in a fluid state—for example, the basis of hysteresis phenomena, or the mechanism of crystal growth. However, both these criticisms apply with less weight to the present volume than to the preceding one on liquids. This is not because of any change in Prof. Partington's approach, but because we understand the behaviour of solids much better than that of liquids. The need for empirical relations is therefore less: similarly, much more of the theory has stood the test of time and experiment, and thus escapes the somewhat severe censorship which the author applies to speculative and incomplete theories.

A number of particular points may be mentioned. The chapter on isomorphism is probably unique, and, although much of it is of purely historical value, it makes interesting reading. On the other hand, the whole subject of atomic and ionic radii in crystals is given a most inadequate treatment in four pages at the end of this chapter. The section on the elastic properties of solids gives an admirably clear exposition of a subject which often offers difficulties to physical chemists with a chemical upbringing. An excellent account is given of the thermal properties of solids, and the comparison of theory and experiment is critical and well-balanced. The whole book abounds with items of recondite information such as we expect from Prof. Partington, many of them presented with a certain dry humour. Thus, it is intriguing to be referred (p. vii) to a work entitled "Gelehrtenmentalitätsbesonderheiten psychologisch-pathologisch betrachtet" (though tantalizing to be told that it is now unobtainable), and it would be interesting to know whether there is any foundation for the author's surmise (p. 266) that American writers are reluctant to use the name "specific heat" because it has for them a double meaning unknown to the rest of the world.

The first volume of the treatise edited by Prof. H. S. Taylor and S. Glasstone appeared in 1942, and the Second World War has delayed until now the publication of the second. If we accept the dictionary definition of 'treatise' as "a literary composition dealing systematically with a definite subject", then it is doubtful whether the present compilation can claim this title. The second volume contains five uncorrelated articles by different authors, each on a particular topic connected with states of aggregation, and there are naturally wide differences in the method of treatment. In this notice each will be discussed separately in turn.

"The Kinetic Theory of Ideal Gases" (187 pp.), by K. F. Herzfeld and H. M. Smallwood, builds up the subject progressively from the simplest foundations, great care being taken to explain the physical meaning of the expressions derived. The extension of the theory to imperfect gases is frequently indicated, and ultimately complex problems such as thermal diffusion and radiometer phenomena are dealt with. The exposition is throughout excellent, and there are many useful formulæ and tables of data. There is little direct account of experimental work, but numerous examples are given of the application of kinetic theory to practical problems.

In "The Thermodynamics and Statistical Mechanics of Real Gases" (166 pp.), by J. A. Beattie and W. H. Stockmayer, no account is given of experimental work, though some of the tables give data derived from experiment. The first two-thirds of the article consists mainly of a very thorough compilation of thermodynamic formulæ for single gases and gas mixtures in terms of the first four virial coefficients. It will certainly be useful to specialists wishing to tackle particular problems involving imperfect gases (though much of it has already appeared in an article in *Chemical Reviews*), but will be of little interest to anyone else. The remainder of the article, dealing with intermolecular forces, has more general appeal. A clear account is given of the theoretical interpretation of these forces, and of the way in which information about them can be obtained from observed equations of state. On the whole, this section is considerably more advanced and specialized than the remainder of the volume.

"The Liquid State" (68 pp.), by G. E. Kimball, has a misleading title, since, in fact, it contains only a description of some of the current statistical treatments of pure liquids. The theoretical exposition is clear; but there is little reference to experiment, and the reader might well end up with no conception of the real achievements or deficiencies of the theories described.

A successful treatment of a limited field is given in "X-Ray Analysis of the Solid State" (88 pp.), by J. G. White. The descriptions of the theory and practice of X-ray analysis are well designed for reading by the non-specialist, and are followed by a large number of examples ranging from simple ionic crystals to sterols and polymers. At times one sees (as in other articles) the disadvantage of a treatise consisting of separate articles on specialist topics: thus the short section on hydrogen bonding suffers in interest and in accuracy because no reference is made to the information obtainable from electron diffraction, spectra, or thermodynamic properties. In the main, however, this section gives a well-balanced and lucid account of the subject.

The final section, "The Colloidal State and Surface Chemistry" (183 pp.), by E. O. Kraemer, J. W. Williams and R. A. Alberty, covers a wider field than any of the other articles in this volume. Colloidal systems are not relegated to a mysterious domain obeying rules of its own, but are related to ordinary solutions, on one hand, and to macroscopic surfaces, on the other. The material is well chosen, with a judicious blend of theory and experiment, and although adequate attention is given to modern theories and physical methods of investigating colloids and surfaces, the classical experimental background is not neglected. The exposition is good, and this section should be valuable to students of chemistry in general.

Now that the compilation by Taylor and Glasstone has again got under weigh, we have in progress two major works on physical chemistry of comparable size, and it is of interest to attempt a general comparison of the two publications to date. Partington's treatise is characterized by its thoroughness and uniformity of treatment, and by the particular attention given to the experimental and historical aspects of the subject. Any scientific worker who wishes to obtain a complete and unbiased knowledge of what has been done in a particular field of physical chemistry will be well advised to consult Partington. (He may find relatively little about current theoretical views; but he will certainly find references to these.) On the other hand, the average student needs his information pre-selected (if not also pre-digested) to a greater degree, and he would be overwhelmed by the wealth of learning to be found here. Because of its multiple authorship, Taylor and Glasstone is much more uneven in its nature and quality, and must inevitably contain overlaps and omissions. Its general aim appears to be to present the current position of physico-chemical theory, rather than to describe the experimental or historical foundations of the subject. Some sections (for example, the last two in the volume under review) are well suited for reading by students, but others are too specialized and advanced for this purpose. The latter will be useful to research workers who wish to extend some branch of physical chemistry along its present lines of development, but they must turn to Partington if they seek the unorthodox view or forgotten observation which might transform the subject.

Both books should be in any well-equipped chemical library.

R. P. Bell

## PRESTRESSED CONCRETE

### Prestressed Concrete

By Prof. Kurt Billig. Pp. x+470. (London: Macmillan and Co., Ltd., 1952.) 36s. net.

Engineers first had to build with materials as provided by Nature such as timber, stone and earth. The coming of the industrial age has seen the application of man-made materials such as steel and concrete and their combination in reinforced concrete. For the past fifty years engineers have been building composite structures in which the weakness of concrete in tension is made good by the addition of steel reinforcement. The two materials are not ideally suited for working in harmony, for the low ductility of concrete limits the allowable steel stress to a fraction of that possible with high-strength steels.

The ingenuity of man, therefore, conceived the idea of self-straining the materials by putting the concrete under an initial compression in equilibrium with an initial tension in the reinforcement. This corresponds to a change in the origin of the concrete stress/strain curve, and the concrete can take differential stresses due to applied loading by reductions in the applied initial strain before getting into the danger zone of cracking due to tensile strains. It corresponds on an engineering scale to what the metallurgist does on a molecular scale when he cold-works metals. A new industry, that of prestressed concrete, has therefore come into being and is rapidly approaching maturity. Its adolescence is here chronicled in this book by Prof. Kurt Billig. The author is well qualified for such a task, for he has devoted many years to the subject and observed its growth in many countries.

The first part of the book is an almost encyclopædic account of the development to date. The pioneers did not foresee the loss in prestress due to shrinkage and creep of the concrete and creep of the steel. It was not until Freyssinet in 1928 obtained a solution by the combined application of high-tensile steel and high-grade concrete, with initial stresses so great that after all losses the effective prestresses were still adequate, that real success was obtained. Prof. Billig gives a full and well-documented account of the early attempts, the subsequent success, and even of developments that have not yet been brought to a commercial stage. As development proceeds, subsequent books will have to exercise a more selective method; but here we have a very useful source book for the future, although the material is not such as one would, in Great Britain, expect to find in what is described as a text-book. There is much to convince the engineer, interested in saving steel, that this new medium will have a definite place in the economy of the future.

It is noteworthy that the greatest development has taken place in countries which have to make sixpence do the work of a shilling, and that extra design costs are faced in order to make material savings. Britain has played its part in this development, but the United States have been able to adopt a somewhat more lavish attitude to materials and, despite their greater number of available technologists, are still relatively behindhand in the matter of prestressed construction.

The second and third parts of the book are more of the character of a text-book. Part 2 consists of a review of the general principles of design, and Part 3 deals with actual design problems, full numerical examples being given. Owing to the number of stages of loading to be considered in design, the book (and the subject) suffers from a multiplicity of symbols which does not make for easy reading. It is to be hoped that the Gothic symbols will not be perpetuated.

Data that have obviously cost Prof. Billig much effort—for example, tables of properties of sections—are put at the service of other designers. The book has much in it for those prepared to work hard, and, if necessary, to use their imagination; a chapter on the design of a radio tower does not include a single illustration to help the lazy. The publishers are to be congratulated on the quality of their work.

W. Merchant

## THE CIVIL SERVICE IN BRITAIN

### How the Civil Service Works

By Bosworth Monck. Pp. vi+258. (London: Phoenix House, Ltd., 1952.) 25s. net.

To a large extent the steadily growing number of books on the Civil Service in the ten years or so since the publication of H. E. Dale's "The Higher Civil Service" and E. W. Cohen's "The Growth of the British Civil Service" have been concerned with the reform of the Civil Service and its adaptation to the problems of a society in which the Civil servant is required to take much more positive action than even a generation or so ago. Moreover, the range of the Civil servant's activities has widened immensely and in widening has made it much more important that there should be a far clearer general public understanding of what the Civil Service is, how it works and how the range and character of its activities depend upon the duties placed upon it by Parliament and, therefore, ultimately by the ordinary elector.

To a limited extent this task was attempted by T. A. Critchley; but he too was more concerned with the appropriateness of the Civil Service to the needs of to-day, and while much of his book is factual and descriptive, it is scarcely likely to appeal to, or be read by, the ordinary citizen who most needs to be enlightened as to the character of the Service and the way he conditions its activities. For some, Sir Edward Bridges's Rede Lecture two years ago might suffice, or again, Sir Frank Tribe's articles describing typical days in the life of a Civil servant. None of these is really addressed to the ordinary citizen, and the task of interpreting the Civil Service to him has not yet been accomplished. It is assayed once again by Mr. Bosworth Monck in the present work, but for all its merits—and they are considerable—the book can scarcely achieve this all-important objective.

Mr. Monck's main purpose is to provide an account of some of the methods by which Great Britain is governed, and the particular responsibilities of the major departments of the State. He is aware of the desirability of encouraging a clearer understanding between the taxpayer and the Civil servant whose work to-day touches so intimately so many sides of the taxpayer's life, but he seems a little too preoccupied with the Civil Service he is describing and to give insufficient consideration to the reader or class of readers for whom he is writing. The result is a book which covers too much ground and is unlikely to grip the reader whom it is most desired to attract.

The book is in five parts. First, it describes the general structure of the Civil Service and the character of those who work in it. An account of the way in which the estimates are prepared, the money voted and control exercised over expenditure follows. Next comes a survey of the whole process of government in which the Civil Service is set in its appropriate perspective with regard to the Government, to Parliament and to the ordinary citizen. The relations between the public service and the government of the day are discussed in a fourth section, before in the fifth and final section of the book Mr. Monck describes in some detail the activities and responsibilities of most of the major departments. Some omissions in this section, which occupies almost half the book, are obvious to the man of science. Nevertheless, it is admirably written and, while purely factual and descriptive, is informal, though it makes no attempt at giving such snapshots of a few

Civil servants at their daily work as Mr. Critchley did. The size and complexity of the Service have in no way hindered a clear exposition of the purposes and functions of the departments, but what has gone before has diverted Mr. Monck from the popular exposition that is our primary need to-day and the first justification for a new book on the Civil Service.

It is perhaps too much to expect one who was chairman of a group which five years ago produced for the Fabian Society a report on the reform of the higher Civil Service to refrain from discussing proposals for reform, but popular exposition and serious discussion of reform are ill consorts. Nevertheless, the book would have been more likely to achieve its declared purpose had the author practised such self-denial and eschewed the suggestions for reform which are made especially in his introduction but which are scattered through the first four parts. His sensible suggestions deserve more space than could be given, but Mr. Monck also brings in some questions like that of public ownership which are less relevant to the exposition of the nature of the Civil Service and how it works. The task of popular exposition must therefore be judged as an undertaking still to be accomplished. R. Brightman

## THE TREES OF UGANDA

**The Indigenous Trees of the Uganda Protectorate**
By Dr. William J. Eggeling. Revised and enlarged by Ivan R. Dale. (Published by authority of the Government of the Uganda Protectorate.) Pp. xxx+491+76 plates. (Entebbe: Government Printer; London: Crown Agents for the Colonies, 1952.) 42*s*. net.

The first edition of this work, published in 1940, was designed to be of service both to the botanist and the layman. Mr. Ivan R. Dale, who has prepared the revised and enlarged second edition, states that he has striven wherever possible to ease the difficulties of the layman, especially of field workers in government departments and sawmills. The book is very much more attractively produced than the first edition and is a credit to both printer and publisher. It is enhanced by the addition of coloured plates by 'Joy' (Mrs. Adamson), of twenty-one line-drawings previously published by the Imperial Forestry Institute, and of some more excellent photographs by Dr. W. J. Eggeling.

The appearance of this second edition is evidence of the very real need that exists in tropical countries for simple handbooks which will enable the field worker, without a specialized knowledge of taxonomy, to identify the trees he is likely to meet within his country. A handbook such as this can be made much simpler than a Flora by dealing only with the trees of one particular territory. Some authors have tried to simplify similar books by describing only the trees they regard as the commonest. This is most unsatisfactory, as the field worker is frequently thwarted or misled when the tree he is trying to identify is not in the handbook. Dr. Eggeling has, however, wisely used the term 'tree' in a wide sense and deals with all the trees recorded from Uganda, including those which appear to be rare or which are still unnamed. Rather more than seven hundred species are described; this figure conveys some idea of the immense botanical problem which confronts the forester in tropical countries.

The descriptions of the species on the whole are very good and include characters of bark and 'slash'. Such characters are of great value in tropical rain-forest where the leafy shoots and flowers of the timber trees are usually a hundred feet or more above one's head. At this time, when Floras are being prepared for tropical East Africa, for the Belgian Congo and for Angola, and the Flora of West Tropical Africa is being revised, many botanists, as well as field workers, will find these field descriptions most useful.

There is great scope in a work such as this for really vivid and practical keys. It is therefore disappointing to find that so much of the material has been borrowed, sometimes uncritically, from other works. For example, in the key to the genera of Moraceæ, the umbrella tree (*Musanga*), which has large digitately lobed leaves unique among Uganda Moraceæ, can only be keyed out by the following characters: "stamens erect in bud", "ovule erect from the base of the ovary-cell", and "male flower with 1 stamen". Forest officers are among the first to complain when such characters are used in Floras, and it is remarkable that they should be used unnecessarily in a book which has been written, used and revised by the forest officers themselves. As another example of the unsatisfactory borrowed keys one may cite *Capparis*, which is keyed out correctly as having the sepals in two series, but the only species in the book has the sepals in a single series and should, in fact, be transferred to another genus.

The descriptions of the families which have been added by Mr. Dale are sometimes useful, but too often will, one feels, confuse the field worker who is interested only in Uganda trees; if he has a wider interest there are other works to turn to. The fruit of the Apocynaceæ is, for example, described as "usually a pair of large follicles, but occasionally a berry"; then follows the description of fifteen species, twelve of which have berries (sometimes incorrectly referred to as "drupes" in this book). In the Violaceæ, a description of the only arborescent genus in Uganda—*Rinorea*—would have been more helpful than a description of the family.

Several corrections in nomenclature and taxonomy which have been made recently by botanists have been adopted in the new edition; but others have been overlooked. Some valuable original work has been contributed by H. C. Dawkins and G. Leggat, of the Uganda Forest Department, and by Dr. G. Cufodontis.

In this book the information which is derived from the author's and revisers' personal acquaintance with the trees they describe is of real value; but the material obtained from other sources is too often inapplicable to Uganda trees, and the book is consequently marred by a number of avoidable mistakes.

One cannot help feeling that the nomenclature, taxonomy and, above all, the keys of this edition would have been greatly improved if the reviser could have undertaken his work in one of the large British herbaria. It is time Colonial Governments realized that their botanists could serve them far more efficiently if they were allowed to spend at least one-third of their working-time at Kew or the British Museum, in the herbaria and libraries of which the British Commonwealth possesses a unique and incredibly rich heritage. As it is, the Colonial botanist must make the unsatisfactory choice between hurried visits and sacrificing a large portion of his leave. R. W. J. Keay

# THE FLOOR OF THE ATLANTIC OCEAN

A DISCUSSION on "Floor of the Atlantic Ocean" was held by the Royal Society on February 26, at which the session during the morning was concerned with sedimentation, and during the afternoon with the deeper structure below the layers which can be sampled. The principal contributions during the morning were made by Dr. E. C. Bullard, Prof. P. H. Kuenen, Dr. J. D. H. Wiseman, Mr. B. C. Browne, Prof. F. P. Shepard, Prof. W. B. R. King and Dr. G. M. Lees. In the afternoon the discussion was opened by Prof. M. Ewing, and he was followed by Prof. J. P. Rothé, Dr. M. N. Hill, Dr. J. L. Worzel, Prof. H. H. Hess, Dr. T. F. Gaskell and Dr. G. P. Woollard. Those in the chair were, in order, Sir Cyril Hinshelwood, Prof. W. B. R. King, Dr. E. C. Bullard, Dr. R. Stoneley and Dr. E. D. Adrian.

In his introductory remarks, Dr. Bullard emphasized the importance of determining the methods of sedimentation in the deep sea; whether slow deposition over the whole area of the oceans, or whether cataclysmal slumping is the more important feature. He also stressed that, from the point of view of determining the climatological history of the earth from the study of the layering within a deep-sea core, it is essential to know whether in any sample the depositional sequence was exact.

Prof. P. H. Kuenen outlined the improvements in finding the characteristics of the surface layers of the deep oceans. He directed attention, in particular, to the great advances in coring methods, as shown by the largest core in the *Snellius* expedition of 1931 being only 2 m. in length in comparison with the 20 m. obtained by Kullenberg by means of his piston corer in the *Albatross* expedition, and longer cores than these are now being obtained. Further valuable contributions to the study of sedimentation from work at sea comes from the bottom photography which has been undertaken by Prof. M. Ewing and from the improvements in deep-sea echo-sounding. The latter can locate such buried surfaces as, for example, have been found by the Shell Oil Co. in shallow water at depths of 0–40 m. below the bottom. Prof. Kuenen directed attention to the necessity for international co-operation in the work of exploration of the bed of the deep sea on account of the high cost, and welcomed the existence of the International Joint Commission on Oceanography which has been formed under the auspices of the International Council of Scientific Unions. The Commission is organizing a new journal of research on the deep-sea floor (to be published by the Pergamon Press, Ltd.), and Mr. C. D. Ovey, the secretary of the Commission, is one of the editors.

With reference to the theoretical aspect of sedimentation, Prof. Kuenen directed attention to the large discrepancy which has arisen between the estimates by Twenhofel and others of the total sediment thickness and the measured values obtained by seismic methods. These indicate that, instead of an overall oceanic sediment thickness of 2–3 km., as was previously supposed, there is, in fact, much less. As a particular example, there is the ½ km. of sediments measured by Raitt in the Pacific. Low values such as these are difficult to reconcile with the accepted values of the sedimentation-rate and the estimated age of the oceans.

Prof. Kuenen next discussed the transport of sediments in the deep sea by turbidity currents. These currents—at one time known as density currents—have not been observed in the oceans, but have been observed in the laboratory and in lakes. It is believed that they can be of sufficient velocity to transport the deep-sea sands, and are characterized by the graded bedding they produce and by the interstratification of deep-sea and shallow-water sediments in such regions as the mouths of submarine canyons. The distinction between turbidity currents and slumping or sliding lies in the ability of an individual particle to move freely in the former, whereas in the latter the material moves in bulk. Turbidity currents are sufficiently mobile for their momentum to carry them far beyond the slope, but slumps, on the other hand, stop at the point where the slope becomes small. Evidence for the existence of turbidity currents is not confined to the oceans but can be found in some continental rocks. For example, the graded bedding, and the interstratification of lutite in the ripple- and flow-marked graywackes of the Ventura Basin in California and elsewhere, can be attributed to this mechanism.

The turbidity currents can be of vast size and can extend to the middle of the ocean basins, but Prof. Kuenen found it difficult to believe that the cable-breaks on the continental slope and in the deep water off the Grand Banks following an earthquake in 1929 could have been caused by them. Ewing and Heezen collated the times at which the breaks occurred and concluded that, on the upper parts of the slope, velocities of the turbidity current had reached 55 knots. Later in the discussion other speakers showed doubts of this explanation of these breaks in the cable, but Prof. M. Ewing expressed confidence that these intuitive criticisms would prove incorrect. Prof. Ewing also mentioned that turbidity currents are not only confined to the regions of steep slope but are also found to exist on slopes as low as 1 in 500, and samples of undisturbed sedimentation can be obtained most satisfactorily on submarine hills of, for example, three thousand feet in height and five miles across. Prof. Kuenen later in the discussion noted that the turbidity currents are unable to cause erosion since they are in general overloaded, although they tend to be channelled down existing canyons. There is, he believed, no single origin from the submarine canyons, and they cannot all have been formed by subaerial erosion.

Prof. F. P. Shepard gave further evidence for the existence of turbidity currents from submarine canyons along the Californian coast. The Scripps Institute has particularly good opportunities for studying these canyons in shallow water, for at La Jolla there is one within five minutes sailing from the laboratory. Sediments are deposited in these canyons, and about every eight months the amount becomes unstable and disappears seawards. It is probable that small earthquakes can initiate this process. The material is undoubtedly transported to the deep water since, for example, foraminiferal material of shallow-water origin exists at the mouth.

Straightforward slumping cannot account for the transport, since the material is not uniformly layered in the area of deposition, and turbidity currents are the only explanation. Prof. Shepard agreed that these currents, while of primary importance in keeping the canyons clear, cannot account for their origin since their powers of erosion are inadequate.

Dr. J. D. H. Wiseman spoke of methods by which the climatic changes of the past can be detected in undisturbed deep ocean sediments. The first method is that of determining the total quantity of planktonic foraminifera in any level of the core by measurement of the percentage of carbon dioxide. These foraminifera act as temperature indicators rather than as indicators of the food supply, as is shown by their absence from antarctic waters, and consequently the quantity of carbon dioxide deposited depends directly on the temperature. Another method of determining the temperature depends upon the proportions of warm-, temperate- and cold-water forms of foraminifera found at any level in a deep-sea core, and a third method is the measurement of the proportion of the oxygen-18 isotope. This last method, which has been developed by Prof. H. C. Urey in Chicago, has been checked by investigations of Recent sediments. Dr. Wiseman showed there is agreement between the oxygen-18 and the carbon dioxide maxima down the length of a core. The rate of sedimentation of a core can be obtained by assuming that the rate of sedimentation of iron or titanium is constant and that, as would be expected on this hypothesis, there is a reciprocal relationship between the ferric oxide content and the carbon dioxide content.

Mr. B. C. Browne described the gravity results obtained by himself and those obtained by Prof. Vening Meinesz in the eastern Atlantic and in the English Channel. The scatter in the regional isostatic gravity anomalies is considerably greater in the deep water than in the shallow, the mean value for the Atlantic being + 11 ± 19 mgal. in comparison with + 7 ± 10 mgal. in the Channel. This increase in variation in the ocean can probably be associated with changes in the sedimentary thickness such as have been found by seismic refraction shooting. Mr. Browne considered that the rugged topography found in some areas is caused by the basement rocks protruding through pools of sediment, and he urged that there should be a combination of seismic and gravity observations to determine the extent of the association between the anomaly variations and the sediment thickness.

Dr. G. P. Woollard and Dr. J. L. Worzel agreed that many of the gravity anomalies at sea can be accounted for by the variations in sediment thickness and gave as known examples the sediments which accumulate in the depressions caused by elastic bending of the crust around oceanic volcanoes, the sedimentary layers of the continental shelf, and the great thickness of sediments found in the Puerto Rico Trench. Prof. Ewing later reported that, owing to the great magnitude of this thickness, attempts at measurement have three times failed. It may be deduced, however, that it is at least 9 km., which is enough to satisfy the gravity field, and for this reason it appears that there is no deep root of lighter rock such as is required by the Vening Meinesz theory of the formation of geosynclines. Dr. Woollard said that the association between sediment thickness and gravity anomaly does not always exist on the continents, and gave an example of a trough filled with sediments denser than the surrounding rocks, which nevertheless possesses a large negative free-air gravity anomaly.

Dr. J. L. Worzel described briefly the results obtained from six hundred gravity stations in the Atlantic, and explained that the common belief that the average free-air anomaly for the oceans is slightly positive is incorrect. If those stations at which the water depth is less than 3,000 m. and greater than 6,500 m. are rejected, the average free-air anomaly is − 3·2 mgal. The number of stations with a negative free-air anomaly was 258 and the number with a positive anomaly 195.

Prof. W. B. R. King described pebbles which have been obtained in cores in the eastern Atlantic in about the latitude of 50° N. These pebbles include several of basalt with the corners showing glacial scratches, some limestone pebbles with trilobite shell fragments, some coarse sandstones and mica schists. These, and the clay in which they were embedded, are all of glacial origin and indicate the importance of ice as a method of transportation of deep-sea sediments. How far this method extends to the south in the Atlantic is not known.

Dr. G. M. Lees objected to the prevalent concept of the oceans as static units and referred to the downwarping which has been known to occur and would sink the continental surface to oceanic depths. He said that he has no confidence in the deductions from the measurement of gravity at sea which lead to the belief in fundamental differences between oceans and continents, and, as an example of the uncertainty of interpretation of gravity results, he quoted measurements from north-west Africa where there is a discrepancy of 20,000 ft. between what is supposed to exist from the gravity results and what is found in seismic prospecting. The conception of the permanence of the oceans is so firmly thrust upon the geologists that they have arranged their interpretation to fit and have rejected any hypothesis which allows the extension of geological structures into the deep sea. Later in the discussion this last point was again raised, and it was apparent that geophysicists generally agree that the earth movements producing the continental surface features can extend without break into the oceans; an example of this is the continuation of the San Andreas fault for two thousand miles into the Pacific.

The session on the deep structure of the Atlantic was opened by Prof. M. Ewing, who outlined the areas investigated by himself and his colleagues by coring and seismic refraction shooting. These areas include the continental margin of the western Atlantic, the Caribbean area and the deep North Atlantic. All the deep stations have shown the same general structure for the earth's crust; it consists of about 5 km. of water overlying ½–1 km. of unconsolidated sediments, and below this there are 4–5 km. of crystalline rocks which are probably basaltic. This interpretation of material is based on the known compressional wave velocities and on the existence of olivine basalt on the mid-Atlantic ridge and islands. At the base of the basaltic layer is the Mohorovičić discontinuity, and below this the earth's mantle extends to great depths and is probably of the nature of peridotite. The work in the Caribbean indicates that, contrary to earlier beliefs, this sea is by nature representative of the deep sea and not of a sunken continent.

Sections across the continental shelf and slope show that the Mohorovičić discontinuity slopes upwards from about 200 miles inside the coast-line, where it lies at a depth of 30–40 km., to about 100 miles out to sea where, as under the deep ocean, it lies at a depth of 10–12 km.

The configurations of the layers lying above the Mohorovičić discontinuity are similar on all sections across the continental shelf and slope, although there are changes in the horizontal scale. They show the continental basement rock sloping seawards with wedge-shaped sedimentary layers lying on it.

Prof. Ewing next discussed the dispersion of surface waves in the sea bed produced in earthquakes. The information agrees with the theoretically derived dispersion for a layer of water overlying the rock and indicates a similarity of structure for the beds of the Atlantic and Pacific Oceans. In spite of the sediment thickness in the Pacific being half that of the Atlantic, this cannot be observed from the dispersion, and it is apparent that for these surface waves the sedimentary layer acts as water.

Dr. M. N. Hill showed the results he and Mr. A. S. Laughton have obtained with seismic refraction shooting in the eastern Atlantic during 1952. These, while small in number compared with those obtained by Prof. M. Ewing, confirm that the Mohorovičić discontinuity lies at a depth of about 11 km. below sea-level. Above this level the velocities are such as would be expected for basaltic rocks, and there is no evidence for the existence of any lower-velocity rocks between this layer and the base of the unconsolidated sediments. The sediments are variable in thickness; in some areas of rugged-bottom topography there appears to be none, and in other areas there is as much as 2·6 km. The average thickness is about 1 km. This thickness is greater than that found by Ewing in the western Atlantic, but the difference can, in part, be attributed to different assumptions concerning the velocity of compressional waves in the sedimentary layer.

A section from the central English Channel to the deep water of the Atlantic indicates that there is a slope of the basement rocks below the semi-consolidated sediments which is more gentle than that found by Bullard and Gaskell in a line farther to the north, and it suggests that the latter happens to coincide with an extension of the structure forming the south coast of Devon and Cornwall out towards the edge of the shelf. It is possible that this structural feature extends down the continental slope, since in this region the topography of the slope is exceptionally rough.

Dr. T. F. Gaskell described the three types of crustal structure which he and Mr. J. C. Swallow have obtained by refraction shooting in the Pacific Ocean during the recent world cruise of H.M.S. *Challenger*. It appeared that these three types are also to be found in the Atlantic. The first type is typical of the deep ocean and consists of about ½ km. of sediments lying on a layer in which the velocity corresponds to, although it is slightly lower than, the basaltic layers referred to by Ewing and Hill. The second type is similar to that of the deep ocean except that interposed between the sediments and the basement rock lies a layer in which the velocity is such as would be expected for volcanic material. This interpretation is supported by the existence of volcanic islands and sea mounts in those regions where this succession is found. The volcanic cores themselves are such that the velocity of compressional waves is similar to the basement rock. The third type, which is typified by stations on the landward side of the andesite line, shows basement velocities less than those in the other types and similar to those in the continental surface layers.

The Atlantic results of H.M.S. *Challenger* were mostly in the Bermuda region, and these show the second type of structure. The sea depth is about 5 km., and the unconsolidated sediment depth ½–1 km. Below the sediments there are lavas 1½–2½ km. in thickness lying on the basement rock. There is only one result from the Atlantic which belongs to the deep ocean type.

Prof. J. P. Rothé described the distribution of recent earthquake epicentres in the Atlantic and Indian Oceans and the Mediterranean Sea. The line of activity extended from the Red Sea to the Carlsberg Ridge and thence to the south of the Cape of Good Hope, joining with the mid-Atlantic ridge which passes northwards through Tristan da Cunha, St. Paul's Rocks, the Azores and thence to Iceland. The Mediterranean line of earthquake activity extended westwards as far as the mid-Atlantic ridge. Within the area roughly bounded by these lines of activity there are continental rocks, and outside there exists the typical oceanic structure. Prof. Rothé suggested that perhaps there is not the clear-cut distinction between the velocities of compressional waves in the continental type of surface-rocks and those in the basaltic layer. In support of this, he quoted an example on land where there is an obvious and typical continental surface and yet giving high velocities which Ewing associated with basaltic rocks. In spite of the evidence from seismic experiments at sea, it is therefore still possible that the sialic rocks form the sea bed below the sediments within the area bounded by the earthquake belts. This hypothesis is supported by the velocities of surface waves from earthquakes which traverse this area.

Prof. H. H. Hess stated the importance of obtaining pieces of rock from below the Mohorovičić discontinuity and believed it to be not impossible that these would be different if obtained from under the continents rather than from below the oceans. Peridotitic bombs from oceanic volcanoes probably represent the material of the mantle, although it is possible that they are aggregations from basaltic rocks. It is also probable that the periodotites obtained from St. Paul's Rocks are representative of the layers below the Mohorovičić discontinuity.

Prof. Hess discussed the problem of guyots. He explained that, contrary to previous suppositions, their top surfaces were all of later origin than pre-Cambrian, and these surfaces must have sunk many thousands of feet below sea-level in post-Palæozoic times. This is demonstrated by the existence of Cretaceous and Eocene fossils in the surface layers. He believed the Pacific guyots, which lie on lines, represent the upward edge of convection cells in the earth's mantle and that the island arcs represent the downward edge.

Dr. E. C. Bullard described the significance of the measurements of heat flow which are being made at sea. On land, measurements have been carried out for many years in mines and boreholes and have demonstrated that, within a factor of 2, the value of the heat flow is $10^{-6}$ cal. cm.$^{-2}$ sec.$^{-1}$. This heat flow is commonly supposed to be accounted for by the radioactivity of the continental surface rocks. Hence, it was deduced that the heat flow under the oceans would be less and that this differential heating between the oceans and continents could account for convection currents in the mantle and thereby many of the earth's structural features. Measurements by Maxwell and Revelle in the Pacific, and by Bullard in the eastern Atlantic, have shown that these conclusions are incorrect, the heat flow for the Pacific being roughly equal to the continental value and that for the Atlantic being slightly less and about 0·7 times the continental value; the expected heat flow, on the old hypothesis, was about 0·25 times the continental value. Explanation of this value for the heat flow is difficult, but might be accounted for by the total quantity of radioactivity in any vertical column being independent of the location of that column, in the same way as there is an equality of mass between columns.

In reply to a query by Dr. Lees concerning the heat flow from the oceans and continents being approximately the same, Dr. Bullard expressed the firm belief that this does not indicate that continents could have existed where now there are oceans, since the measured differences in structure are too great. There is, however, the irreversible possibility of continents extending into regions where there are now oceans. M. N. Hill

# HATHERLY BIOLOGICAL LABORATORIES, UNIVERSITY COLLEGE, EXETER

By Prof. JOHN CALDWELL

On April 23 the Hatherly Biological Laboratories of University College, Exeter, were formally opened by Sir Edward Salisbury, director of the Royal Botanic Gardens, Kew, in the presence of a gathering representative of the universities and learned societies, as well as of local and national bodies. In his address on the "Place of Biology in the University Curriculum", Sir Edward dealt with the value of the discipline of biology in a liberal education and the part that universities can play in developing a broader and more general approach to the whole subject of biology and its implications, deploring the narrow specialization which tends to isolate the biologist, and not only biologists, from the sympathy and understanding of the community. The chair was taken in the absence of the president, the Most Hon. the Marquess of Salisbury, by the deputy president, Mr. B. G. Lampard-Vachell. The thanks of the company to Sir Edward Salisbury was expressed by the principal of the College, Sir Thomas Taylor. Thereafter, before the company moved off to inspect the laboratories and the demonstrations set out in them, a brief account of the building was given by Prof. J. Caldwell, director of the laboratories. Plans were prepared for the laboratories after the College received a bequest from Mrs. Ellen Heath, of Exeter, towards the erection of a building to be associated with the name of Hatherly. The additional money was obtained through the generosity of the University Grants Committee, and the foundation stone was laid by the president of the College on July 28, 1948 (see *Nature*, **162**, 505; 1948).

The laboratories, which were built to the design of Mr. E. Vincent Harris, consist of a central block with entrance hall and private rooms for members of staff and two wings facing south-east. From this there project to the west five bays, each two stories high, with the main laboratories in them. The advantage of this arrangement is that the north-facing sides of the laboratories are almost completely of glass, plate-glass sheets 11 ft. by 7 ft. in the lower floor and 7 ft. square on the upper. These ensure that there is excellent natural light in the laboratories and the orientation of the laboratories shields these windows from direct sunlight.

Three Departments are housed in the building—Botany, Geology and Zoology. The first has two large junior laboratories each approximately 60 ft. by 30 ft., and one advanced laboratory 60 ft. by 25 ft.; the two former have preparation and store rooms attached. The mycology laboratory, with an annexe as a sterilizing room, is 30 ft. by 25 ft., as is the lecture room above it and a fifth laboratory and reading room above that. These are in the wing to the front of the building on the south side. There are, in addition, private laboratories for the members of staff, an office and three research laboratories roughly 20 ft. square. The Department of Zoology has its laboratories in the third and fourth bays. There are two laboratories, one on the ground floor and one on the upper floor, and a series of research

Hatherly Biological Laboratories. Main laboratories with north lights

Hatherly Biological Laboratories. Central block

rooms for members of the staff and postgraduate students. The Department also has in the north wing to the front of the building a small animal room, an aquarium room (corresponding to the mycology laboratory in the other wing), a lecture room and a laboratory equipped for physiology.

The Department of Geology, which, though new, is rapidly developing, has one large laboratory and research and private rooms. The fifth bay has on the ground-floor the lecture-theatre, which accommodates 110, and above that the museum–reading room, common to all three Departments. In addition, there are dark-rooms, constant-temperature rooms with controlled humidity and temperature, a workshop and store-rooms. Provision has been made for a resident caretaker and for a technician.

The exhibits included, in the Department of Botany, herbarium material of Devon plants, especially of Dawlish Warren, and a collection of floras and books dealing with them. There was also a representative collection of Coniferæ from the College arboretum. Cultures and material illustrating the survey of animal mycoses being undertaken with the support of the Agricultural Research Council by Dr. G. C. Ainsworth and Mr. P. K. C. Austwick were on show, as was material dealing with chrysanthemum, broccoli and narcissus virus diseases, with a range of host plants, and cytological studies of the nuclear aberrations which are associated with them. This work is carried out by Prof. J. Caldwell, Dr. J. Wilkinson and Mr. D. A. Govier. There was a very extensive collection of drawings and photographs illustrating the larger fungi of sand dunes, the ecology of which is being studied by Mr. T. J. Wallace. Further material illustrated Dr. T.-T. Chan's work on the developmental morphology of the narcissus plant, and there was in addition a laboratory devoted to specimens of the current work of the undergraduate members of the Department.

In the Department of Geology there was displayed material illustrating the work being carried on, which includes Mr. A. Stuart's study of the Pleistocene of the Bideford Bay area, and of the terraces of the Lower Exe Valley and the petrology of the Carboniferous Igneous Rocks of Bantry Bay, Ireland. Dr. D. L. Dineley is working on the geology of a part of Spitsbergen and on the Conodonts and Ostracoderms of the Devonian and Carboniferous rocks of the south-west, and of the Welsh Border, while Dr. R. N. C. Bowen is studying the Foraminifera and Ostracods of the Tertiary rocks.

In the Department of Zoology exhibits illustrated Dr. R. J. S. Hawes's work on the parasitic Protozoa of invertebrates, Mr. G. G. Vicker's studies on the ticks of south-west England and Mr. I. J. Linn's studies on the ecology of small mammals. In addition, there was material representative of Mrs. C. Harvey's work on fertility problems and Miss R. A. Manwaring's ecological studies on the fauna associated with certain marine algæ. Further material illustrated Mr. M. J. Delaney's taxonomic and ecological studies on the Thysanura, Mr. P. D. Gabbutt's ecological study on the wood cricket and Prof. L. A. Harvey's ecological survey of Lundy.

# RELATION OF ADRENOCORTICOTROPHIN (ACTH) TO THE MELANOPHORE EXPANDING (B) HORMONE OF THE PITUITARY*

By Prof. H. WARING and B. KETTERER†
University of Western Australia

TWO laboratories[1,2] have recently claimed that adrenocorticotrophin (ACTH) is identical with the melanophore-expanding hormone (B) of the pituitary. This claim has obvious academic interest; but it also raises an issue of importance for those concerned with research technique and clinical practice, because the assay for melanophore-expanding properties is simple and reliable[3], while the currently used ACTH assays are not.

Consideration of this claim demands, as a preliminary, a brief survey of the relevant information about both excitants.

## Adrenocorticotrophic Hormone(s)

Information from hypophysectomy, injection of extracts, and clinical observation shows that the pituitary in mammals controls adrenal cortical size, lipoid distribution, ascorbic acid content and, indirectly through the release of cortical steroids, it controls eosinophil numbers and lympholytic activity[4]. We do not know whether all these effects are mediated by one hormone (ACTH) manufactured in the gland, or by several. In particular, we do not know the significance, if any, of ascorbic acid depletion in relation to steroid release. It is important to emphasize this because ascorbic acid depletion has been arbitrarily chosen as the popular assay for ACTH activity and by sheer weight of words has become almost synonymous with it, to some people. It is certain that, by various procedures, extracts can be produced with one or other activity preponderant. So without further consideration the question before us must be more precisely phrased as: Is B hormone identical with all, or only part of the totality of ACTH, or entirely independent of it?

With regard to the seat of origin, cytological evidence[5] is sufficient to show that the anterior lobe of the pituitary is involved; but we have found no evidence based on surgery to show that the intermediate lobe is not involved and, in this context, we note that the pituitary grafts which have maintained the adrenal with greatest success have contained intermediate lobe as well as anterior lobe of the pituitary[6].

A considerable amount of work has been done on the chemistry of ACTH. In 1943 Li *et al.*[7] and Sayers *et al.*[8] independently prepared similar proteins which exhibit ascorbic acid-depleting, adrenal cortical size-maintaining and other properties. These proteins appeared pure when judged on physico-chemical criteria, and for some time it was thought that they were the adrenocorticotrophic hormone. However, biological assay of the Li preparation showed 0·02 I.U./mgm. pressor activity[7], and the International Standard powder (ACTH), which is prepared similarly, contains 0·35 I.U./mgm. B activity[9]. So it appears that the 'pure protein' contains contaminating material of considerable biological potency but insufficient in bulk to manifest itself in physical determinations for purity.

Some and perhaps all ACTH activity in simple extracts, or in purified protein, is relatively stable to partial hydrolysis with hydrochloric acid and pepsin. In 1948 Li[10] demonstrated that in digested extracts the ascorbic acid depleting activity resided in a peptide. Attempts to purify the peptide activity have resulted in material with up to 300 times the ascorbic acid depleting potency of standard powder[11]. A similar preparation of Lesh *et al.*[12] had an average molecular value of between 2,500 and 10,000. The isolation of a large molecular peptide material with such a high potency suggests that the activity of the 'protein hormone' might simply be due to slight adsorbed contamination with material of this type. Dr. Stanford Moore's work, as recorded by Stack-Dunne and Young[13], is consistent with this. Moore subjected Sayers's protein to ion-exchange column chromatography and got a separation into a major component, acid and inert, and a trace component, basic and very potent. (The alternative proposition, that a molecule such as Brink's, which we have assumed has a molecular value similar to Lesh's preparation, is actually a part of the parent molecule and is released by various procedures, would mean that weight for weight its activity must be increased at least 30 times by the simple act of separation. Furthermore, one would expect at least a 10 per cent yield of such an activity, but Stanford Moore's experiment produced it only as a trace (on a weight basis).) Apparently oxycellulose is another adsorbent which can separate ascorbic acid depleting activity from the protein. Li and his associates[14], by a combination of adsorption and chromatography with oxycellulose, have obtained a basic material within the same activity range as Lesh's and Brink's fractions. When this material was hydrolysed, only eight different amino-acids were found in the hydrolysate.

In all this recent work, adrenal ascorbic acid depletion has been used for measuring ACTH activity and at present it appears highly probable that total ACTH activity is dependent upon more than one chemical entity. Thus Reinhardt and Li[15] found that when a protein ACTH preparation was subjected to peptic hydrolysis its ascorbic acid depleting activity was doubled, adrenal weight increasing activity reduced and its lympholytic activity increased several fold. When an acid hydrolysate was used and the undigested protein removed, the ascorbic acid depleting activity was greatly increased and the adrenal weight maintaining activity was greatly reduced. An even more striking separation between two activities considered to be adrenocorticotrophic has been reported by Stack-Dunne and Young[13]. They prepared crude alkaline extracts of anterior lobe and purified growth hormone with adrenal weight maintaining/ascorbic acid depleting ratios up to 5,000. It could be objected that an interpretation of separate chemical entities for each biological activity must be treated with caution because changes in the physical aggregation of injected material can modify the several responses differentially. Hayashida and Li[16] showed that precipitation of protein preparation in alum solution increased both adrenal weight and lympholytic activity twofold; similar precipitation of a peptide increased the lympholytic activity several fold, but the adrenal weight activity remained unchanged. However, this type of phenomenon could scarcely account for the result of the Stack-Dunne and Young fractionation.

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* Substance of a paper read at the 1952 meeting of the Australian and New Zealand Association for the Advancement of Science.

† On salary from the Australian National Health and Medical Research Council.

### Melanophore-expanding Hormone (B)

In colour-changing vertebrates, notably Amphibia, there is completely satisfying evidence that a hormone (B) is produced in the intermediate lobe of the pituitary, and its liberation into the blood-stream evokes darkening of the skin[17] both by expanding melanophores and potentiating the formation of more melanin; there is new unpublished evidence that the presence of endogenous B antagonizes adrenalin hyperglycæmia in intact toads[18]. In warm-blooded animals that do not change colour, B hormone, although present, has not so far been shown to subserve any function, although experiments at the pharmacological level show that in these animals also it has anti-adrenalin properties[19] and there is a *prima facie* case for further investigation of its potential role in hyperpigmentation.

There has been no comparable systematic work on the chemistry of B to parallel that on ACTH outlined above. There has, however, been work at the pharmacological level and the relevant parts of this are considered below.

### Is B Identical with the Totality of ACTH or Part of It ?

There is factual information only for assessing whether or not B is identical with ascorbic acid depleting activity; any attempt to equate B with total ACTH, or another part of it, is pure speculation. Even for consideration of this more limited objective there is a major qualification to all the points that can be made in favour, or against, the proposition. There is evidence[20] for some pituitary control of cortical tissue in Amphibia, but there is, as yet, no information about the measurement of ascorbic acid depleting activity in these animals. Equally, ascorbic acid depleting activity can be measured in mammals, but no measurement of B activity can yet be made in them. Until this is resolved—and it is probably resolvable—there will always remain the doubt as to whether the same molecule will have comparable biological effects in the two animal groups. This suspicion is not just fanciful. A number of discordant data from posterior lobe studies are most plausibly explained in this way and, more specifically to our present problem, although there is ample evidence for some ACTH control of cortical activity in birds[21], pituitary extracts containing mammalian ascorbic acid depleting activity have no effect on the ascorbic acid content of bird adrenals[22]. With this qualification, the relevant data are here assessed:

(*a*) The only parallel assays on separated pituitary lobes which have been performed with the intention of showing whether or not B measured in Amphibia, and ascorbic acid depleting activity measured in mammals, have a separate origin are those of Reinhardt *et al.*[23] on the anterior and intermediate lobes of *Rana catesbiana*. These assays show that activity which depletes the rat adrenal of ascorbic acid is more concentrated in the anterior lobe than in the intermediate lobe and vice versa for B activity.

(*b*) Sulman[24] reported a rise of both ascorbic acid depleting and B activities in the blood of human patients exhibiting hyperpigmentation, Cushing's syndrome, Addison's disease, pregnancy, and operational stress, etc. Johnsson and Hogberg[1] give similar information. According to the authors, this evidence shows that B activity stimulates the adrenal cortex on the basis of the well-known check-balance system of pituitary excitants with their target-organ secretions, but another interpretation is possible. The relationship of the pituitary to its various target organs is not a simple one, and the following well-known examples show that a pituitary hormone is sometimes affected by steroids not under the control of that particular pituitary excitant. (i) The adrenal cortex secretes minero-corticoids (of deoxycorticosterone acetate type—DCA) and gluco-corticoids (of cortisone type). ACTH stimulates chiefly gluco-corticoid release, and hypophysectomy does not inhibit minero-corticoid production. Yet injections of DCA, as well as cortisone, inhibit the release of ACTH[24]. (ii) Œstrogen injections potentiate melanogenesis correlated with hyperplasia of the intermediate lobe[25], but B is not gonadotrophic. (iii) Castration increases pituitary antidiuretic hormone (ADH)[26], but the latter is certainly not gonadotrophic.

(*c*) Both B and ACTH, unlike other pituitary hormones, are heat stable over a wide *p*H-range, and both are more stable to peptic than tryptic digestion[17].

(*d*) Johnsson and Hogberg[1] found that both B and ascorbic acid depleting activity occupied the same position on a paper chromatogram using the phenol/water solvent system. This is not a specific test, since a number of proteinaceous substances behave similarly[27].

(*e*) Sulman[28] was able to get a melanophore response to 0·01 gamma of a commercial 'ACTH' preparation. He argued that such high activity could not be due to a contaminant; but actually a preparation need only contain 0·3 per cent by weight of a peptide like that of Brink *et al.* to be as active as standard powder in ascorbic acid depleting activity. The only kind of investigation along these lines which will have any real meaning is a series of parallel ascorbic acid and B assays on a quantitative basis. Reinhardt *et al.*[23] have done this, although they do not give any information which enables us to assess the reliability of their B assay technique; no correlation between the two activities was found.

(*f*) Reinhardt *et al.*[23] state that caustic soda treatment destroys ascorbic acid depleting activity but increases B activity (potentiation). This is a generalization which requires further comment. Material prepared by adsorption on to, and elution from, charcoal or oxycellulose (which would remove much protein), when treated with caustic soda, loses both ascorbic acid depleting activity and B activities at a similar rate. On the other hand, if a simple pituitary extract, or material which has been purified by *some*, but not all, fractional precipitations, is treated with caustic soda, its B activity is potentiated and its ascorbic acid depleting activity is destroyed. This B-potentiation is only shown by Amphibia which have been in use a short while; those which have been in use longer give the same response to caustic soda treated extracts as they would to untreated extracts[20]. It appears that, in the presence of pituitary protein, B activity is protected from destruction by alkali, and further, that an extra activity is produced which is detectable only by Amphibia which have been in use a short time. This seems clear evidence that B and ascorbic acid depleting activity are not referable to an identical configuration. The new observation[9] that when *Xenopus* has become insensitive to potentiated B from posterior lobe pituitary extracts it still reacts to potentiated B in ACTH extracts will inevitably lead to speculation about the possibility of a hydrolysate of ACTH having melanophore excitant properties, but such speculations are premature.

(g) Morris[29] claimed that Landgrebe and Waring methods for obtaining B by carbon adsorption eliminated the ascorbic acid depleting activity. We cannot confirm this, nor can Reinhardt *et al.*[23].

(h) Deliberate attempts have been made to bring about a complete separation of B and ascorbic acid depleting activity. Morris[29] used counter-current distribution, and Reinhardt *et al.*[23] used oxycellulose column chromatography and filter paper electrophoresis; the separations achieved were substantial but not complete.

## Conclusion

From the foregoing, B and ascorbic acid depleting activities appear chemically similar but are separable in certain circumstances. This probably means that these activities reside in different molecules in the gland and bear a close but fortuitous chemical relationship; their apparently different anatomical origin, and in particular the evidence from *Rana*, are consistent with this. However, even if B is not identical with ascorbic acid depleting activity, the evidence to date neither favours, nor precludes, B from a part in the pituitary adrenocorticotrophic system which appears to be complex.

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# NEWS and VIEWS

## Prof. R. Courrier, For.Mem.R.S.

Prof. Robert Courrier is a graduate in medicine and in natural science of the University of Strasbourg, of which he became a member after serving in the front-line throughout the better part of the First World War. Bouin was then the head of the Department of Histology, and Ancel of Embryology, and Courrier was among the first of a distinguished line of investigators whose work derives from the union of interests of these two great pioneers of the scientific study of the physiology of reproduction. In 1927 he went to Algiers, where he was given charge of histological teaching in the Faculty of Medicine. He became a full professor in the Faculty in 1936, and two years later was invited to the Collège de France as professor of experimental morphology and endocrinology. Appointments to the Collège are not determined by the interests of previous holders of chairs, and new professors are chosen, essentially as research professors, on the basis of their eminence in the field of study they pursue. In the fifteen years since he has been in Paris, Courrier has established a magnificent department which is known to endocrinological research workers throughout the world. In 1941 he was made a member of the Academy of Medicine, and in 1944 of the Academy of Sciences. Election to the foreign membership of the Royal Society is the most recent of a series of national and international honours which he has received.

Courrier's first work was concerned with the control of secondary sexual characters in mammals, and with the regulation of the oestrous cycle, and his early papers reveal a maturity and an originality of approach which have continued to mark all his subsequent work. After some very detailed studies of reproduction in the cat, Courrier took the opportunity offered by his post in Algiers of extending his inquiries to the monkey of North Africa, *Macacus inuus*—a species which he is still investigating in his Paris laboratories. Among the many original observations dating from this period was his demonstration that the epithelium of the uterus masculinus in the male monkey responds to oestrogen in the same way as does the vaginal epithelium in the female—a discovery which was simultaneously reported in Great Britain and the United States, and which forms the basis of many of our present ideas about homological relations between the male and female reproductive organs. About this time, Courrier also became greatly interested in the functional and quantitative aspects of the synergism and antagonism of androgenic, oestrogenic and progestational hormones. As a result, his attention became focused more and more on the biological properties of the corpus luteum, and on the endocrinological factors which underlie the changes of gestation. A book he published on this subject in 1945 remains one of the most valuable and up to date on the subject. More recently, Courrier has become interested in the properties of a variety of synthetic chemicals which reproduce the behaviour of biological hormones; and he has also used radioactive substances in the study of hormonal action.

Courrier's considerable output of scientific work has not prevented him from playing a big part in scientific administration, and his election in 1948 to the office of Secrétaire Perpétuel of the Academy of Sciences not only reflects the favourable light in which the administration of his own Department is viewed by his colleagues, but also the impetus which, as a member of the Conseil supérieur de la Recherche Scientifique, he has given to the post-war development of French science. Men of science outside France will remember with gratitude the lead he has taken in organizing international colloquia at the Collège de France on various subjects, especially those relating to the physiology of reproduction.

### Dr. H. J. Muller, For.Mem.R.S.

Another distinguished man of science who has just been elected a foreign member of the Royal Society is Dr. H. J. Muller. Hermann Joseph Muller was one of the three collaborators of T. H. Morgan whose co-ordinated experiments on *Drosophila* between 1910 and 1916 established the chromosome theory of heredity. Muller was especially responsible for working out the principles of crossing-over between chromosomes or strings of genes, principles now believed to be universal in sexually reproducing organisms, extending even to bacteria and viruses. In 1927 Muller perfected the measurement of spontaneous mutation which enabled him to prove the effect of temperature. It also enabled him to prove the effect of X-rays. Muller's method first made it possible to show that mutations had been induced, and that those, therefore, which were apparently 'spontaneous' might in fact be regarded as determined. It revolutionized genetic technique by providing an artificial source of variation in any organism where it was needed. It led to the discovery that chromosomes could be broken and recombined, first by ionizing radiations and later by chemical reagents, a discovery equally important in plant breeding and cancer research. This work put the study of genes, chromosomes and evolution on an experimental basis. In all the developments which followed, Muller has taken a leading part. Of the greatest importance have been his examination of the genes as units of physiological action and of X-ray breakage, his analysis of the physiological properties of different classes of mutations, his demonstration of the existence of 'inert' genes, and his physiological interpretation of Fisher's theory of dominance. Muller's discussions of the theory of genetics are no less significant than his experimental work. He first suggested the importance of chromosome balance in sex determination. He first (in 1918) showed how the mutations of *Oenothera*, on which De Vries's theory of evolution was based, could be regarded as due to Mendelian segregation, an explanation established in the following fifteen years. He first (in 1921) pointed out the analogy between virus and gene and its practical significance. Briefly, Muller's work and ideas, always in advance of the times, moulded the development of genetics in the critical years between 1916 and 1936, and it was in recognition of this achievement that he was awarded the Nobel Prize for Medicine in 1946.

### Directorship of the Meteorological Office: Sir Nelson Johnson, K.C.B.

The Air Ministry has announced that Sir Nelson Johnson is to retire in the autumn from the post of director of the Meteorological Office. Sir Nelson received his scientific training at the Royal College of Science, London, joined the Meteorological Office in 1919 after war service as a pilot, and formed the new meteorological office at the War Office Chemical Defence Research Establishment at Porton in 1921. The investigation at Porton of the meteorology of the lower layers of the atmosphere gave full scope to his capacity for experimental research; he devoted himself especially to the vertical gradient of temperature, devised new methods for its measurement, and, in Geophysical Memoirs 46 and 77 of the Meteorological Office and elsewhere, he published work which has become classic in this field. He left the Meteorological Office in 1928 for service in the War Office, and in September 1938, on the retirement of Sir George Simpson, returned to the Meteorological Office as director. The Second World War brought a large expansion in the work and size of the Office and a corresponding increase in the director's responsibilities. In spite of a heavy load of day-to-day administration, Sir Nelson continued the planning, begun in 1938, of a new research organization for meteorology, and in 1941 the Air Ministry Meteorological Research Committee was set up. After the War he carried out a major reorganization of the Meteorological Office, including the setting-up of the planned research organization. In 1946, at the first post-war international conference on meteorology, he was elected president of the International Meteorological Committee, and in that capacity he presided over the Washington Conference of Directors in 1947, which established the Convention of the World Meteorological Organization; in 1951 he became the first president of the new Organization. Great progress in meteorological organization has been made under Sir Nelson's guidance and his services were recognized by the award of a K.C.B. All who have served under Sir Nelson, either in British meteorology or in the international field, will wish him good health during his retirement for many years to come so that he can actively pursue his many and varied interests.

### Prof. O. G. Sutton, C.B.E., F.R.S.

Prof. O. G. Sutton, at present dean and Bashforth professor of mathematical physics in the Royal Military College of Science, Shrivenham, who has been appointed to succeed Sir Nelson Johnson, is an expert of world-wide authority in the dynamics of the lower atmosphere. He graduated in mathematics from the University College of Wales, Aberystwyth, and was a lecturer there before joining in 1928 the staff of the Meteorological Office. He was posted to Porton in 1929 and soon showed his powers by his work on the mathematical theory of turbulent diffusion in the atmosphere. In 1942 he was appointed superintendent of research in chemical defence at Porton, and during 1943–45 was superintendent of tank armament research. He went to the Radar Research and Development Establishment in 1945 as chief superintendent and in 1947 was appointed Bashforth professor in the Royal Military College of Science. He was scientific adviser to the Army Council in 1951, and is now chairman of the Atmospheric Pollution Research Committee of the Department of Scientific and Industrial Research, as well as serving on other meteorological committees. Prof. Sutton has written a large number of papers on the structure of the lower atmosphere and turbulent diffusion and their applications to such practical problems as evaporation from free water surfaces and the dispersion of smoke from factory chimneys. His recently published text-book, "Micrometeorology", is an exhaustive survey of knowledge on the atmosphere at breathing level. He was elected to the Royal Society in 1949 and awarded a C.B.E. in 1950.

## Royal Meteorological Society: Symons Memorial Medal Award

THE Symons Memorial Gold Medal for 1953 of the Royal Meteorological Society has been awarded to Prof. Carl-Gustav Rossby, director of the Meteorological Institute, University of Stockholm, and lately professor of meteorology in the University of Chicago, in recognition of his outstanding contributions to meteorology. The citation states: "He has placed his permanent impress on the fundamental branches of the science from the small-scale turbulence of the lower atmosphere to the dynamics of the large-scale currents and their relation to the general circulation of the atmosphere. We esteem Professor Rossby most of all perhaps for the vigorous lead he has given to scientific meteorological research and for his inspiration and encouragement of meteorologists in all parts of the world".

## Diffusion of Knowledge

SPEAKING in Washington on February 13 at a dinner given in his honour, Dr. L. Carmichael, the incoming secretary of the Smithsonian Institution, referred to the tribute which had been paid by Americans on January 16, 1879, to the memory of the first secretary of the Institution, Joseph Henry, who had died eight months previously. That tribute to a great scientist was also a unique official tribute to science itself; but nevertheless Dr. Carmichael wondered whether any real progress has been made in the past seventy-five years in diffusing an understanding of science. In a farewell address to the American Philosophical Society in 1796, Washington had urged, as an object of primary importance, the promotion of institutions for the general diffusion of knowledge, adding that, in proportion as the structure of a government gave force to public opinion, it is essential that public opinion should be enlightened. James Smithson, in bequeathing his property to the United States of America for the founding of the Smithsonian Institution, defined it as "an establishment for the increase and diffusion of knowledge among men", and Andrew Carnegie, who for many years placed the motto "Let there be light" in all the libraries he established, is said to have believed that enlightenment is the one general remedy for the ills that beset the human race. Although pure and applied science to-day find unequalled public and private support in many sections of the nation, Dr. Carmichael believes it is still necessary to defend research expenditure by referring to the immediate practical utility of the investigations. We still need a society for propagating the understanding of the true place of science in society. The great human advantages which the world would derive through the proper support of science must be told and told again in clear and popular language. Washington, Smithson and Carnegie envisaged a happy marriage between research and public information, and Dr. Carmichael thinks that scientists should see that neither selfishness nor inertia prevents their participation in the task of interpreting science to the millions and assisting the expert science writers in a task to which they have already brought intelligence, enthusiasm and dedicated service.

## *Journal of Rational Mechanics and Analysis*

IN the first four numbers of a new quarterly, the *Journal of Rational Mechanics and Analysis* (published by the Graduate Institute for Applied Mathematics, Indiana University, Bloomington, Ind.), there are, in all, some twenty papers running to about six hundred and fifty pages of print, and it is now possible to review the *Journal* during the first year of its existence. The editors are Profs. T. Y. Thomas and C. Truesdell, and the eminent editorial board, numbering twenty-six, is drawn in about equal proportions from United States universities and institutes of technology and from the corresponding institutions in various countries of western Europe. The purpose of the *Journal*, as stated on the inside front cover, is "to close the rift between 'pure' and 'applied' mathematics and to foster the discipline of mechanics as a deductive, mathematical science in the classical tradition. Its scope comprises those parts of pure mathematics or other theoretical sciences which contribute to mechanics; among the included fields are all branches of analysis, differential geometry, analytical dynamics, elasticity, fluid dynamics, plasticity, thermodynamics, relativity and statistical mechanics. Engineering applications, numerical work, perturbation procedures, etc., are acceptable only as incidental illustration in a paper devoted to sound mathematical theory". The papers published to date are fully consistent with this point of view, being primarily pure mathematical in character and outlook, and having the explanation of natural phenomena as but a secondary objective. In this respect, the *Journal* is in marked contrast to the *Quarterly Journal of Mechanics and Applied Mathematics* (Oxford University Press). That there is a place for the publication of papers of the kind just described is beyond doubt, but the extent of the interest which such papers are likely to arouse is open to question. With regard to subject-matter, there have so far been nine papers on fluid dynamics, three on elasticity or plasticity, one on relativity and one on analytical dynamics, while the remaining six have ranged over a wide variety of topics. The subscription price of the *Journal* is 6 dollars a volume for individuals engaged in research or teaching, but 18 dollars for everyone else; by British standards, the latter figure is distinctly high.

## Recruitment of Scientists and Technologists in Great Britain

IN reply to a question in the House of Commons on April 28, the Chancellor of the Exchequer, Mr. R. A. Butler, stated that the number of scientists and technologists coming from the universities and technical colleges of Great Britain with degrees, Higher National Certificates and Higher National Diplomas, or their equivalent, during the academic year 1951–52 was estimated to be one in about 2,600 of the population. Mr. Butler added that the Government is doing its best to improve the facilities for technological education; he concurred with the suggestion that there is still great difficulty in persuading engineering and other firms to employ the scientists and technologists in the works, and that industry requires a great deal more encouragement to make use of the highest and best form of knowledge.

## A Model Rehabilitation and Training Centre

IN May 1952 the President of the Austrian Republic performed the opening ceremony of what is probably the finest rehabilitation and training centre to be found in Europe. It is situated at Tobelbad, about nine miles from Graz, and has been built on the site of a former spa (*Rehabilitation*, 7; January 1953). Extensive new buildings have been erected over the site of the hot springs affording ample accommodation for 250 patients as well as the staff of the centre. The centre is owned by the Allgemeinen Unfallversicherungsanstalt (United Accident Insurance Corporation). The Corporation's decision to establish this centre for the rehabilitation of accident cases occurring anywhere in Austria was largely influenced by the views of two young orthopædic surgeons who were members of the first rehabilitation course held in Great Britain under the auspices of the British Council. When completed, the training centre, which is directly connected to the rehabilitation centre, will be used for short courses of training in carpentry, metalwork, wood-carving, leather work, shoe-making, tailoring and dressmaking. It is not intended to use them for long or complete vocational training courses, such as are available in Government training centres, but rather as a means of giving both work therapy and vocational guidance to those undergoing physical and industrial rehabilitation before returning to their former employment or undertaking new courses of training.

### "The Behaviour of Engineering Structures"

Prof. A. J. S. Pippard writes: "In my article published in *Nature* of May 2, I made the statement that it was not until 1947 that exact theoretical solutions for the stresses in masonry dams had been obtained. It has since been pointed out to me that Dr. L. F. Richardson dealt with this subject in a paper entitled 'The Approximate Arithmetical Solution by Finite Differences of Physical Problems involving Differential Equations, with an Application to the Stresses in a Masonry Dam", published in *Phil. Trans.*, A, 210, 307 (1911). I regret that I overlooked this reference".

### Announcements

The Alexander Pedler Lecture of the British Association is to be given this year by Sir Harold Hartley; he will speak on "The Life and Times of Sir Richard Gregory". The Lecture will be given in the Royal Institution on May 28 at 6 p.m.; applications for tickets should be sent to the Secretary, British Association, Burlington House, Piccadilly, London, W.1.

The Council of the Royal Society of Edinburgh has awarded the Gunning Victoria Jubilee Prize for the period 1948–52 to Prof. A. C. Aitken, of the University of Edinburgh, for his distinguished contributions in the field of pure mathematics; and the Makdougall-Brisbane Prize for the period 1950–52 to Prof. E. M. Wright, of the University of Aberdeen, for his papers in the field of pure mathematics published within the period of the award in the Society's *Proceedings*. The Prizes will be presented by the president at the meeting of the Society on July 6.

Dr. Joseph Junkes, *S.J.*, has been appointed director of the Astrophysical Laboratory of the Vatican Observatory, in succession to Dr. Alois Gatterer; Dr. Ernest Salpeter, *S.J.*, is assistant director of the Laboratory. It is hoped that the first volume of the "Atlas of Molecular Spectra" ("Spectra of Diatomic Molecules, the Oxides"), undertaken by the Observatory at the request of the International Astronomical Union, on which Father Gatterer was engaged until shortly before his death, will be ready by the end of this year.

The Royal Sanitary Institute, in collaboration with the Ministry of Agriculture and Fisheries (Infestation Control Division), is organizing a rodent control exhibition, open to the general public, to be held in the Institute's Museum of Hygiene, 90 Buckingham Palace Road, S.W.1, during May 26–June 20 (Monday–Friday, 10 a.m.–5 p.m.; Saturday, 10 a.m.–noon).

A summer school in the use of electrons for the examination of metals will be held during July 20–31 in the Cavendish and Goldsmiths' Laboratories, University of Cambridge, in co-operation with the Institute of Metals. This will consist of lectures, demonstrations and practical classes in the principles of the electron microscope (including reflexion techniques) and electron diffraction camera and their practical applications to the study of metals. Application forms (to be returned by May 30) and further information can be obtained from G. F. Hickson, Secretary of the Board of Extra-Mural Studies, Stuart House, Cambridge.

Two interesting articles are contained in Vol. 1, Part 2 of the *Journal of the National Museum of Bloemfontein*. The first is by Dr. A. C. Hoffman and describes a dug-out canoe in use in Vendaland. It would seem to be the first of its kind to be found south of the Limpopo, and the first bark canoe to be described from southern Africa. The second article is by Dr. A. J. D. Meiring and describes some polished-edge bone implements found in the coastal strip from Great Brak River in the west to Matjes River in the east. The age may be Wilton.

The summer provincial meeting of the Physical Society will be held in the Department of Physics King's College, Newcastle upon Tyne 1, during July 13–14, the subject being optics and ultrasonics. The meeting will include visits to the Grubb–Parsons Optical Works and Pametrada Research Station. Hostel accommodation is available. The meeting is open to all on application to the offices of the Physical Society, 1 Lowther Gardens, Prince Consort Road, London, S.W.7.

The Present Question Conference this year will be on "Springs of Action" and will be held at Lady Margaret Hall, Oxford, during August 8–15. A number of lectures will be given in the mornings by leading experts, the subjects being tradition, the evidence of biology, politics, creative action, the longing for truth, knowledge, communication, moral judgment, productivity, leisure and personal decision. In the late afternoons and evenings, study groups and discussions will be held. The fee for the conference is 2 guineas (students 1 guinea). Accommodation is available in Lady Margaret Hall. Further information can be obtained from the Secretariat, Present Question Conference, 37 Middleway, London, N.W.11.

The second British Plastics Exhibition and Convention will be held at Olympia, London, during June 8–18. The Exhibition will cover a wide range from the raw material to consumer goods, and more than eighty firms and organizations will be represented. The Convention is designed this year especially for the plastics technologist, and a comprehensive programme of papers has been drawn up by representatives of the British Plastics Federation, the Plastics Institute, the Society of Chemical Industry (Plastics and Polymer Group) and the journal *British Plastics*. The Convention is open to all, admission being by ticket only, obtainable from the organizers, British Plastics, Dorset House, Stamford Street, London, S.E.1.

# NUMERICAL METHODS AND AUTOMATIC COMPUTING IN ATOMIC THEORY

A SYMPOSIUM on the application of automatic computing machines to the problems of extra-nuclear atomic theory was held in the University Mathematical Laboratory, Cambridge, on December 9 last. The subject was introduced by Prof. D. R. Hartree (Cavendish Laboratory, Cambridge), who began by pointing out that problems in this field are usually concerned with the solution of Schrödinger's equation, $H\Psi = E\Psi$, subject to appropriate boundary conditions. For many-electron systems it is necessary to resort to approximation in attempting to obtain solutions of this equation. Two important classes of problem are those of an electron in a bound state and in a free state: the former is characterized by $E$ being negative and assuming a discrete, unknown value corresponding to each bound state; in the latter problem, $E$ is positive and known for the phenomenon being studied, such as elastic or inelastic collision of an electron with an atomic system. Prof. Hartree continued with a more detailed account of the solution of the stationary-state equation for complex atoms along the lines of a previous paper of his (*Rep. Progr. Phys.*, 9; 1946–47). In particular, he outlined the defects of the Slater–Fock approximations in failing to express correlations between the positions of individual electrons in an atomic structure, and possible means of including, in the approximate wave-function adopted, terms expressing these correlations.

This introduction was followed by an account by A. S. Douglas (Mathematical Laboratory, Cambridge) of some recent work on improved approximations to stationary-state solutions using electronic computers. For the class of configurations consisting of a 'core' of closed shells of electrons and a single series electron, the Hartree–Slater–Fock approximation for the wave function of the series electron can be improved by including a polarization potential term in the equations. It is possible to determine by trial an empirical addition to the potential function in such a way as to bring the calculated energies of all terms of the optical spectrum into close agreement with the observed values; the agreement with experiment does not define the additional potential function uniquely. This has been done for $Si^{+3}$, using the EDSAC to compute the integrals involved in treating the additional potential as a first-order perturbation, and also to solve directly the equation, with exchange, including the additional contribution to the potential. The Runge–Kutta step-by-step method of integration developed by Gill for use on the EDSAC has been adapted for this purpose. An empirical rule for determining the additional potential for other structures has been postulated and is now being tested for $Ca^{+}$.

A second problem investigated by Mr. Douglas concerns the computation of an approximate wave-function for two-electron structures, such as helium, in the ground-state. Schrödinger's equation for helium can be reduced to a partial differential equation in three variables, and this can be solved approximately by solving a related parabolic equation involving an auxiliary independent variable $t$, the solution of which tends asymptotically to the required function as $t$ increases. The related equation can be replaced by its finite difference form and solved step by step in $t$. Exploratory work on the equation for the stationary states of hydrogen by this method indicates that a large number of steps in $t$ may be required, and has disclosed some anomalies in the process of convergence, which are under investigation.

In the afternoon, Dr. R. A. Buckingham (University College, London) gave an account of the use of variational methods of solving two-body and three-body collision problems. For slow electrons the only important contribution to the cross-section for elastic scattering is dependent on the asymptotic phase of the scattered electron. It can be shown that for small, restricted variations of the wave function, this phase is stationary, and this can be used for determining an approximation to the phase by one of the variational methods devised by Hulthén (1944) or Kohn (1948). These methods both involve solution of sets of simultaneous algebraic equations, those of Hulthén's method being quadratic, and those of Kohn's method being linear.

Even comparatively simple approximations to the wave functions for inelastic scattering lead to the necessity for solution of two simultaneous integro-differential equations. Such equations can be solved by the 'distorted wave' method used by Erskine and Massey (1952) in studying the inelastic scattering by hydrogen. Moiseiwitsch (1952) has shown that a variational method of solution is possible, and a finite difference method is at present under investigation. The application of electronic computers to the last two methods is likely to be of special value, in view of the very lengthy computations required. It is interesting that all these procedures have been successfully used in treating collisions between simple nuclei, such as the scattering of neutrons by protons, which have been studied by Swan (1952).

After a short discussion of Dr. Buckingham's paper, Dr. V. E. Price (Department of Theoretical Chemistry, Cambridge) described the use of the EDSAC to compute atomic wave-functions by the variational method due to S. F. Boys (1950–52). The required wave-function is considered expanded as a linear combination of 'serial products' of a complete set of chosen functions, the coefficients of the expansion being determined by use of the variational principle. For stationary-state solutions, the energy-levels are the eigenvalues of a matrix, the elements of which are found by evaluating certain integrals. Each one of these integrals contains not more than four members of the set of functions, and can be evaluated from a recurrence relation, provided a suitable set of functions is chosen. On the EDSAC such an evaluation takes about four seconds. To find the matrix elements from the integrals requires considerable algebraic manipulation, such as matrix multiplication, which can also be done on the machine. The eigenvalues of the resulting matrix, too, can be found by the machine. By taking a sufficiently large matrix, it is possible, in principle, to obtain any required accuracy for the solutions. This is not practicable, however, and it is necessary to choose the few particular members of the set of functions included in the calculation so that a good approximation is assured. A relatively simple calculation can be made to test the probable importance of omitted terms. Calculations on this principle have been carried out on a number of atoms and ions, including chlorine and sulphur, for which thirteen functions were used.

In the ensuing discussion, Dr. Boys (Cambridge) pointed out that the method used can be extended to find molecular wave-functions, the integral evaluation technique being largely applicable to this problem also. In reply to questions by Prof. Hartree and Dr. O. Bunemann (Cambridge), Dr. Boys said that the method is not likely to be of assistance in the nuclear field at present, since the accurate equations are not known with certainty. In answer to Dr. Buckingham, he said that electron affinities calculated by the method have so far shown disappointing lack of agreement with experiment.

After tea, two short contributions were given by visitors. Mr. W. A. Runciman (General Electric Co., Ltd., Wembley) described a problem connected with the fluorescence of a structure consisting of a potassium chloride lattice, in which some of the potassium ions are replaced by thallium. A first approximation to solution of this problem can be obtained by assuming the thallium ions to be in a free state, and an approximate evaluation of the wave functions by the self-consistent field method has been carried out on the EDSAC.

The final contributor was Dr. R. H. Garstang (University College, London), who mentioned a problem he had met in the analysis of departures from Russell–Saunders coupling; this involved the determination of the diagonal elements of a matrix, given its non-diagonal elements and its characteristic values.

A. S. DOUGLAS

# PHYSICAL FACTORS IN RELATION TO BIOLOGICAL ACTIVITY OF INSECTICIDES

A MEETING of the Crop Protection Panel of the Agriculture Group of the Society of Chemical Industry was held in the rooms of the Chemical Society in London on February 16, when papers on "Physical Factors in Relation to Biological Activity of Insecticides" were read. Dr. R. A. E. Galley was in the chair.

Mr. C. T. Lewis (Imperial College of Science and Technology, London) discussed factors affecting the adhesion of dry particles of uniform size to active insects. Experiments with selected dyestuffs have shown that dry lipoid-soluble particles adhere more readily to the cuticle of blowflies, and to leaf wax, than do lipoid-insoluble particles possessing polar groups. Presumably the presence of polar groups lessens the attraction at the solid–solid interface due to Van der Waals forces. The phenomenon has an appreciable influence on the rate of accumulation of particles by flies exposed to deposits. Parallel experiments with insecticidal dusts have yet to be performed; but significant effects may reasonably be expected since contact insecticides are lipoid-soluble and most diluent dusts are calcium or magnesium silicates.

Mr. Lewis also considered the effect of the 'cleaning' reactions of a treated fly on the retention and location of accumulated particles. Particles are picked up from a surface on ventral tarsal spines and chemoreceptors, and transferred in cleaning movements to less exposed parts of the body. The frequent cleaning movements result in a balance between the weights of particles at different locations, the head at all times retaining about 7 per cent of the total, the legs 48 per cent, the wings 13 per cent and the abdomen 28 per cent. The pulvilli are not important sites of accumulation, retaining about 2 per cent, and experiments have shown that they are not preferred sites of entry of DDT.

The rate at which fine particles are discarded by a contaminated fly depends largely on the rate at which the continued cleaning movements deliver particles back to the tarsal spines, from which they are returned to the substrate. The rate of loss is rapid until the quantity retained by the fly falls to 20 μgm., but is very slow below 10 μgm.

Dr. A. H. McIntosh (Rothamsted Experimental Station) dealt with the effect of certain conditions of test on the toxicity of a single insecticide, illustrated by reference to experiments in which insects were treated by dipping in aqueous suspensions of DDT. The weight retained depends upon the particle size, being greater for needle-shaped crystals than for colloidal particles. Temperature has a notable effect on toxicity, and the temperature coefficient, usually negative, varies with particle size and with humidity. High humidities accentuate the difference between the temperature coefficients of large and small particles.

The fact that poisons do not always have the same speed of action is an additional complication. The values obtained in relative toxicity tests may vary with the time at which observations of kill are made.

Dr. McIntosh also discussed the relation between the contact toxicity of insecticides and their fat-solubility. The first stage in the entry of a contact insecticide is assumed to be solution in the wax layer, and it is often implied that the higher the lipoid-solubility the more effective the poison is likely to be. An opposite conclusion can be deduced from Ferguson's principle of drug action, which indicates that different compounds have equal biological activity if applied at the same percentage saturation in the surrounding medium. Dr. McIntosh suggested that if this idea applied to the wax surrounding an insect, compounds of low fat-solubility should be the more effective. He pointed out, however, that there is no relation between the absolute toxicity of DDT and its analogues and lipoid-solubility. The view now held is that some degree of lipoid-solubility is necessary but it need not be high.

Experiments still in progress lead Dr. McIntosh to conclude that the difference in speed of action between colloid particles and crystals for a range of compounds of the DDT type may be related to the rate of solution of crystals in oil *in vitro*.

Dr. F. Barlow (Colonial Insecticide Research Unit, Porton) enumerated and discussed some factors of importance in the control of adult mosquitoes by residual spraying of houses. Mosquitoes are stimulated to flight after a short time in contact with insecticidal surfaces, and this fact increases the importance of physical factors affecting the availability of deposits.

The best formulation for deposits on absorbent walls is a wettable powder; the dispersing medium is absorbed, leaving insecticide particles freely exposed. On all types of surface, toxicity is inversely related to size of particle, because smaller particles are more easily picked up and retained by insects.

Dr. Barlow then dealt with factors affecting the persistence of deposits on various types of surface. Volatile insecticides exhibit decreasing residual action for a range of substrates from non-absorbent to absorbent. Increasing rates of evaporation and sorption into the substrate are responsible. Loss of insecticide has been found to be extremely rapid on certain adsorptive substrates and is due almost entirely to sorption; for example, on mud-blocks prepared from lateritic earths used for hut-building in several tropical countries.

Insecticides possessing fumigant action, for example, BHC and 'Aldrin', are effective for long periods after sorption, but others are ineffective after sorption, for example, DDT and 'Dieldrin'.

Finally, Dr. Barlow considered residual deposits of oil solutions. These deposits can be employed on non-absorbent surfaces, when formulations which do not crystallize are to be preferred because the recumbent crystals produced on such surfaces are not readily picked up by insects. By way of contrast, on fibrous absorbent surfaces, oil solutions are not available at first; but after crystallization has occurred the crystals project from the superficial fibres and are readily detached by insects.

Opening the discussion, Dr. A. B. P. Page observed that all three speakers had dealt with rate-determining processes. While there are big differences between fumigation and contact action, in each process accumulation and penetration of the toxicant are continuously occurring alongside toxification and detoxification within the insect. With fumigants, one measure of toxicity is the product of the concentration of the fumigant multiplied by the period of fumigation. In the same way the toxicity of a contact poison may be expected to be some integral function of the net amount of toxicant on the insect and the period of contact.

In certain fumigations a better measure of toxicity appears to be the amount of fumigant sorbed by the insects, and this relation implies dependence of toxicity on the shape of the concentration–time curve as well as on the area under it. An analogous relation may be found for contact poisons where large amounts of insecticide accumulated initially by the insect may greatly influence toxicity despite their rapid removal by cleaning movements.

Dr. Page remarked that Dr. McIntosh had concerned himself with the solubility of poisons in the epicuticular wax layer, but had not mentioned the possibility of preferred sites of diffusion through the cuticle and access to specific sites of action. Such considerations are important. Referring to Dr. Barlow's account of the fumigant action of certain solid insecticides absorbed into porous substrates, he recalled an analogous case of absorption in bagged stored products treated with an insecticidal dust; wheat, for example, can absorb enough DDT in the seed coats to enable the insecticide to act as a contact and stomach poison, whereas with BHC the fumigant action is all-important.

In reply to a question from Dr. J. R. Booer, Dr. McIntosh said that his colloidal suspensions were prepared in a standard way but he had not measured the size of particle.

Dr. J. C. McGowan pointed out that Ferguson's theory cannot be related to the system described by Dr. McIntosh. If insects are treated with aqueous solutions of insecticide, then the theory can be used; but the solubility of DDT in water is so low that a lethal dose cannot be applied by such a method. Mr. G. F. H. Whitney observed that Ferguson's theory applies to substances showing 'physical' toxicity; a substance showing a toxicity greater than that expected by the application of Ferguson's theory invokes 'chemical' toxicity. Dr. McIntosh commented that he had not stated that Ferguson's theory is valueless, but that it is not useful in the case of DDT and its analogues. In answer to Mr. P. S. Hewlett, he agreed that he considers the action of DDT to be physical.

Mr. F. H. Rae asked whether Dr. Barlow advocated whitewashing huts before spraying, which he considered would not be a practicable procedure. Was sodium silicate useful and could Dr. Barlow suggest any other substance which might reduce losses due to sorption? Dr. Barlow said that the ideal would be to incorporate a substance in the spray which would block the capillary spaces in the substrate and thus reduce sorption. Size is not suitable for tropical use. The problem is being studied; but he had no practical recommendations to make at present.

Mr. P. Bracey asked if it is known whether BHC in the vapour phase enters an insect through the integument or through the spiracles; Dr. Page thought that no information is available.

Closing the discussion, Mr. W. H. Read stressed the practical importance of work in this field.

# THE PLACE OF UNIVERSITY GRADUATES IN INDUSTRY

TWO most interesting points are featured in the report of the Universities and Industry Conference, organized by the Federation of British Industries and by the Committee of Vice-Chancellors and Principals of the Universities of the United Kingdom, and held at Ashorne Hill during October 24–26, 1952*: the first is the further support which is forthcoming for the argument advanced in the last report from the Advisory Council for Scientific Policy that a new attitude towards industry and technology is desirable on the part of the schools and the universities; and the second is the large measure of agreement in addresses and discussions to the effect that, in consequence of the large proportion of talent which is now entering the universities, industry must necessarily rely to a much greater extent on recruitment from the universities to provide its future leaders (its chances of recruiting the requisite ability from those leaving school direct has been greatly diminished). The published report contains the addresses by the following: Sir John Maud on the use of the university graduate in the Civil Service and the qualities of the graduate which have proved most useful; Sir Ewart Smith on the qualities industry requires in the university graduate and his role in industry; Dr. Eric Ashby on the ability of the universities, consistently with their other obligations, to turn out men with the qualities required by industry; and

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* Report of the Universities and Industry Conference, organized by the Federation of British Industries and the Committee of Vice-Chancellors and Principals of the Universities of the United Kingdom, and held at Ashorne Hill, Leamington Spa, 24–26 October, 1952. Pp. 87. (London: F.B.I., 1953.) 5s.

Mr. A. D. Bonham-Carter, Mr. Ralph Colman and Mr. A. G. Grant on industry's use of the university graduate. Also included are Sir Robert Wood's reflexions on the conference at its final session, and a summary of the main points which emerged, by Sir Norman Kipping, Dr. C. R. Morris and Mr. D. R. O. Thomas.

Sir John Maud, in a very frank and stimulating address, made it clear that the Civil Service is looking for essentially the same qualities of integrity, courage, readiness to work, straight and original thinking and the capacity to make up one's mind as is sought by industry; nevertheless, he thought, while the Civil Service requires a larger proportion of first-class graduates than it has been receiving, it is of importance to the national interest that, during the next ten years at any rate, the claims of industry for first-rate men should receive priority. It is a matter of national importance that the university graduate should come to regard industry and commerce not merely as careers which offer a reasonable chance of a livelihood and of satisfying ambitions but also as opportunities of doing something in the nature of service in which they can take pride. Sir John earlier in his address had commented pointedly on some of the objectionable qualities to be found in the university graduate—qualities such as bad manners, inaudibility, and excessive specialization, which are not by any means limited to those who elect to enter the Civil Service.

Sir Ewart Smith likewise referred to the importance of influencing the general climate of opinion with regard to industry. He thought that wider recognition of the teaching of administrative studies in the universities would help to this end as well as to improve the quality of future management, but the idea that management should be taught in the universities found little support from him or other industrial representatives present, apart from Mr. N. G. McCulloch. The idea that management is a technology or a fit subject for university teaching was rejected forthright by Mr. A. G. Grant and Dr. Ashby, and Sir Ewart clearly voiced the general opinion of industrial representatives in his view that the first requirement is for men and women who have been trained to think, to understand, to be critical and to show initiative, and who have some understanding of wider aspects of life than can be gathered from one particular discipline. He thought that this wide outlook and capacity to think can be acquired through technology or science, as well as through the arts, if the subjects are properly taught, and at present, as Prof. J. A. L. Matheson reminded the Conference, the technological departments are not getting their fair share of first-class brains.

Dr. Ashby's address supplied the quantitative basis for the argument that industry must rely increasingly on the universities for its recruits for management. While, since 1912, the reservoir of persons eighteen years old has decreased by 74,000, the number from the reservoir who have entered universities has increased by 12,537, and during 1951 73 per cent of university students were receiving financial aid, mostly from public funds. The barrier to university education is now largely intellectual, not financial, and it is becoming difficult for a reasonably bright boy who remains at school to avoid going to a university. Already the universities are taking as much as a third or more of the educated high talent in the reservoir and may well take more as the machinery for separation becomes more efficient. This position makes it essential, continued Dr. Ashby, that the universities should discover the needs of industry; but he urged that industry should itself do much more to make known both its needs and its opportunities and to further a better understanding of the true purpose of industry, of its vital importance to the nation, and of the interest and satisfaction that it can offer to those who serve in its higher ranks.

That industry should do much more to explain its nature and purpose to the nation, and to persuade potential entrants that it provides a purposeful career with manifold opportunities for using good brains in essential work, was a main point which emerged at the Conference. This task should begin with the schools and the universities by publishing well-written literature designed to stimulate the imagination of young persons. The proportion of the ablest grammar-school boys who go to the universities has continued to increase, but the increase in the university population has not led to a corresponding increase in the number of men obtaining first-class honours degrees. Accordingly, even if industry were to recruit its due proportion of high ability of this kind, it might still fall short of its requirements, since the nation's total needs must be met from this strictly limited supply. This necessitates the fullest use being made of those with high ability wherever they are employed, and opinion was expressed that neither industry nor the Civil Service is yet making the best use of the specialist graduates it recruits.

Much remains to be done to broaden the education of the university graduate, and it is as clear from this conference as from the regional conference at Nottingham during the previous month that industry is critical of excessive specialization in first-degree courses and looks, above all, for those qualities on which Sir John Maud and Sir Ewart Smith laid emphasis. There is no evidence of a desire to stipulate a particular content of university education or, as already noted, to advocate the teaching of administrative studies at the undergraduate level. The universities would make their most effective contribution in the broader educational field by helping industry to continue the education and training of the graduates and men of equal ability it recruits. Reference was made to several experimental courses designed jointly by industry and the universities for men of this type who have been several years in industry and are twenty-five to thirty years of age. It was also noted that there has been no great industrial support for the postgraduate courses in technology which the universities have organized in response to a request made by industrialists at the conference held in 1949.

One further point needs to be emphasized by industry in its approach to the schools and universities regarding careers in industry. Although industry requires more men of high ability, the opportunities it can offer graduates are not unlimited. For most technical industries it is estimated that 4 per cent of the total employees fill scientific, administrative and management posts for which a graduate could appropriately compete. Only a few graduates could hope to reach the highest positions; but industry requires many more good men for the tasks of middle management, and these offer a full and interesting life. In this connexion the three papers on industry's use of the graduate led to a discussion in which Prof. A. R. J. P. Ubbelohde, supported by others, stressed the need for more quantitative information about industry's intake of arts or non-specialist graduates as compared with the intake of specialists of all kinds, the average industrial life of the graduate in any one firm, and the migration of specialists to non-specialist occupations in industry. Information of this kind would go far to assist in dealing with the problem presented by the arts graduate, particularly if, as suggested by Prof. H. S. Kirkcaldy, the arts graduate avoids specialization and acquires the ability to make intelligent use of experts.

## SARDINE FISHERY OF CALIFORNIA

THE fishery for sardines, *Sardinops cœrulea*, is a major industry in California; but there was a disastrous failure of the fishery during the 1947–48 season, and, although slight improvements have taken place in succeeding years, there seems at present little hope of a major recovery before the 1954–55 season at the very earliest. The area of profitable fishing has contracted to the region of southern California, resulting in extensive land transport of fish from there to the processing plants at Monterey and San Francisco.

As an emergency remedial measure the Sardine Industry Advisory Committee introduced a temporary programme of control and management for the 1948–49 season, but this proved unsuccessful and was dropped. Resulting largely from the undiminished initiative of the industry itself, a co-ordinated programme of sardine research by five scientific bodies has been brought into being. The agencies concerned are the California Academy of Sciences, the California Department of Fish and Game, the Stanford University (Hopkins) Marine Station, the United States Fish and Wildlife Service and the University of California (Scripps) Institute of Oceanography.

A progress report covering the period January 1, 1951–June 30, 1952, has recently been published[*]. The picture that emerges from the work to date is not encouraging. The fish population appears to be so reduced, and the possibility of significant recruitment of young fish so small, that unless the factor of availability operates to increase the normal catch of older fish, the sardine fishery must expect for at least another two seasons the smallest catches for a generation.

Data upon eggs and larvæ, young fish, food and feeding, growth- and mortality-rates, behaviour, schooling patterns and oceanographical conditions are being collected as rapidly as conditions allow—but long-term forecasting is not yet possible.

This important programme of co-ordinated research upon a vast and baffling problem is financed in part by funds from the industry in the form of a tax on landings, in part by a grant from the Federal Government and in part by a grant from the State of California, which makes the largest contribution.

The appearance of further reports on this very ambitious programme is awaited with keen interest, for it represents one of the most intensive combined assaults upon marine biological problems that has anywhere yet been made.

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[*] California Cooperative Sardine Research Program. Progress Report 1 January, 1951, to 30 June, 1952. Pp. 51. (Marine Research Committee of the State of California Department of Fish and Game, 1953.) n.p.

## OVERSEAS FOOD CORPORATION

### REPORT FOR THE YEAR 1951–52

THE annual report of the Overseas Food Corporation for the year ended March 31, 1952[*], differs in form from previous reports. Throughout the year the Corporation had been engaged in implementing the terms of the White Paper issued in January 1951, involving the running down of the vast organization built up for the mechanized production of groundnuts in East Africa, and also in an attempt to establish the economics of clearing and mechanized, or partly mechanized, agriculture under tropical conditions. The Corporation is thus now engaged in a large agricultural experiment, and, apart from the chapters on policy, organization and finance, respectively, the bulk of the report deals with the agricultural experiments in the three regions; the chapter on the work of the scientific department is likewise presented on a regional basis. The run-down in the Kongwa area is described in a separate report, appended to the main report, as are the accounts for the year.

The running-down operation has been effected with marked success and without serious detriment to the agricultural work. By March 31, 1952, the Corporation had handed over to the East African Stores Disposal Board about 80 per cent of its surplus stores and equipment, while transfer of the surplus fixed capital assets was virtually complete. The reduction of the European staff by 50 per cent to 636 and of the non-European staff by 18 per cent, giving a ratio of Europeans to non-Europeans of 1 : 23 in place of 1 : 14, proceeded smoothly, and a high proportion of Europeans leaving the service of the Corporation found satisfactory alternative posts in East and Central Africa. The London office has been reduced to a small agency, the Nairobi agency closed, and the Dar-es-Salaam agency incorporated with the general headquarters administration, which moved to Dar-es-Salaam during November 1951. Each region is now administered by a general manager, directly responsible to the chairman in his capacity as chief executive. With the exception of the chief health adviser, who was due to leave in July 1952, the technical advisers had already left the Corporation.

Decentralization of the engineering services is complete, and decentralization of the health department was to be completed when the chief health officer left in July 1952, by which date a reduction in European staff to 38 from the 85 at March 31, 1951, was envisaged. In this final report on health services the opinion is recorded that the danger to the health of Europeans in this area was much exaggerated, and the hospital bed planning figure, originally 2 per cent of the population entitled to treatment, has been reduced to 1 per cent and is being further reduced. The most effective measure for adult mosquito control has proved to be spraying all buildings with 'Gammexane' at three-monthly intervals, and this is now compulsory in Urambo and Nachingwea. Malaria is the commonest disease affecting Europeans, and, although 'Paludrine' has not been used either as a prophylactic or for treating Africans, there is evidence of the emergence of 'Paludrine'-resistant strains of the malaria parasite.

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[*] Overseas Food Corporation. Annual Report and Statement of Accounts for the Year ended 31st March, 1952. Pp. iv+110. (London: H.M.S.O., 1953.) 3s. 6d. net.

The run-down of Kongwa, which has now been divided into four separate farms with a total area under crop of about twelve thousand acres, presented special problems as this small area could not support economically the large installations built up to support both a large executive headquarters and three agricultural units each of thirty thousand acres. An administrator was appointed to run-down Kongwa and provide all the necessary services for the farms until they could be made self-sufficient. Kongwa has been declared a township by the Tanganyika Government, and on October 1, 1951, the Public Works Department assumed responsibility for the supply of water and electricity and the maintenance of roads. A small hospital has been retained and receives some contribution to its upkeep from the Tanganyika Government.

Although promising results have been obtained on the Kongwa farms since the Kongwa Working Party reported, experiments must continue for at least one or two seasons before conclusions can be drawn. Nevertheless, there are grounds for believing that a rotation in which groundnuts play an important part can be found. It is also evident that the estimated crop yields in both the Southern Province and in Urambo, especially in respect of the groundnuts, which is the main crop, cannot be obtained until much more is learned of the basic agricultural principles to be applied in these difficult areas. Groundnuts appear to be unlikely to play an important part in any rotation for these two areas, at least for several years to come, and accordingly the Board has recommended the slowing-down of the tempo of its operations in both these regions until the economics of the agricultural practices are fully established. Alternative cash crops, which have already stood the test of two seasons, are promising; and provided that due caution is exercised, it is anticipated that an agricultural pattern will be evolved and a mass of data accumulated which will make a real contribution to the development of these previously uninhabited areas in Africa.

In the Kongwa farms, yields per acre for the 1950–51 season averaged 367 lb. for groundnuts, 1,750 lb. for maize and 1,070 lb. for sorghum, and the experience gained during the season indicated that groundnuts should be given priority over maize in the planting programme. Although all seed was treated with 'Agrosan', collar rot (*Aspergillus niger*) caused considerable seed-bed losses in nuts during periods of dry weather and long periods of wet weather: in trial plantings 'Fernasan' seemed to give better control over collar rot. While trials with giant castor indicated that a fair yield can be expected in almost any season, there is room for considerable plant-breeding work for standardization in size of seed, time of maturing, etc., while it appears that hibiscus seed can be treated successfully to improve germination.

In the Urambo area yields per acre for the season averaged 404 lb. for groundnuts, 1,132 lb. for maize, 557 lb. for sorghum, 512 lb. for sunflower, 504 lb. for soya bean, 53 lb. for dwarf beans, 395 lb. for tobacco and 3,363 lb. for an experimental crop of rice grown by the scientific department. Sleeping sickness constitutes a constant threat, although no further cases were discovered, and the elimination and control of *Glossina morsitans* is a problem of the greatest importance, demanding much further research. A technical committee formed to deal with tsetse control in the area has recommended an approach to the Secretary of State for the Colonies, the East African High Commission and the Government of Tanganyika with the view of formulating and financing a research scheme.

In the Nachingwea area the average yields per acre of the two main crops were 756 lb. of groundnuts (in shell) and 1,053 lb. of maize; but the results from the cotton crop were unsatisfactory, due probably to late planting and the use of an unsuitable variety. Endeavours are being made to obtain varieties of soya beans suited to the local environment and fit for combine harvesting. Good yields were obtained from different varieties of millet, especially golden millet.

Soil fertility studies by the scientific department in the Kongwa region during 1950–51 were almost wholly concerned with the yellow sandy loams of the Mtanana series. Limestone in exploratory experiments with maize gave a mean increase of yield of 280 lb. per acre, and phosphate and lime applied together were the only first-year treatments which raised the yield of maize in the second year. Other experiments were carried out on soil of the Chamaye series to measure the effect of superphosphate, applied to four different crops in the first year, on the yield of groundnuts in the second year and to determine the residual value of eleven different phosphatic fertilizers. Experimental crop studies include trials of different varieties of groundnuts and of the effects of different dates of harvesting, as well as trials of dwarf and semi-dwarf sorghums, Kenya yellow maize, varieties of safflower and dwarf Hungarian castor. Many organic and metallic compounds were tested as seed dressings for groundnuts, and a detailed experiment showed that seed which has been damaged in the slightest degree may fail to germinate. Lesions of *Cercospora personata* were only found where the disease assumed serious proportions; but it is suspected that viable spores can persist in crop residues and in the ground, and a residue disposal trial was laid down. Infestation of sorghum by stem borers caused considerable losses, and *Calidu dregei* was also a major pest of sorghum.

In the Urambo region pronounced pedological changes have occurred during the past three years. Accumulation of rainwater in the soils through the complete removal of the natural vegetation has rendered a considerable proportion of the sandy soils unsuitable for mechanized production of arable crops, while there have been heavy losses in reserves of soil nitrogen through the rapid mineralization of organic residues from the woodlands by microbiological activity and subsequent intensive leachings by heavy rains. Soil fertility studies were confined to groundnuts, maize and tobacco. Early planting and the eradication of volunteer groundnuts in the dry season are at the moment the only means in the control of rosette of groundnuts. Stemborer may become a major pest of maize, and infestation of sorghum is also serious. A survey of three thousand acres of groundnuts in the Nachingwea region showed that an average of 3 per cent was rosetted, and a single spraying with 0·5 per cent of a systemic insecticide at 40 gallons per acre appreciably reduced the incidence of the disease. Much attention was given to a study of the biology of the insect vector of the disease. Trials of the effect of two seed dressings on groundnuts suggest that hand-picking of seed before treatment would improve the plant stand. Further evidence has been obtained that the soils in the Southern Province are, in general, deficient in phosphates.

# ANALYSIS OF ENVIRONMENTAL VARIABILITY IN QUANTITATIVE INHERITANCE

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A LARGE fraction of the phenotypic variance of most quantitative characters is of environmental origin, even in populations maintained under carefully standardized conditions; but the nature of this non-genetic variability has received little attention, although it raises problems of fundamental importance in phenogenetics, particularly as the extent of variability may be very different for different genotypes[1]. The concentration of interest on genetic variations can be traced partly to the fact that statistical ideas borrowed from other fields have led geneticists to think of the environmental variance too much as an 'error variance'—a box into which all unexplained sources of variation can be conveniently dropped. The environmental variance is also difficult to study experimentally, since the factors responsible cannot usually be either controlled or measured, except when we are comparing two different environments. Some information can be gained about the nature of the variability within a single environment by examining the environmental correlations between different characters, and we shall illustrate this method of approach with two examples from *Drosophila melanogaster*, cultured under the conditions described previously[2], which appear to reduce non-genetic variability to a minimum.

Wing- and thorax-length both show a much lower variance in heterozygotes than in homozygotes[1], and we may ask how far this is due to differences in the effects of factors acting on both characters or on one alone. The common part of their variance may be taken as a measure of the variance of body-size, while the independent variations of each will be the result of errors of measurement, asymmetry of the two wings (one only is usually measured), and environmental factors acting on one character only. The problem can be given a simple statistical formulation, since both characters have about the same coefficient of variation in inbred lines, although the wings are twice as long as the thorax. We can therefore write (using percentage or logarithmic units) $w = c + i_w$ and $t = c + i_t$ for the two dimensions of any individual. $c$, $i_w$ and $i_t$ are uncorrelated variables measuring common ($c$) and independent ($i$) variations from the population means, and $i_w$ and $i_t$ have the same variance ($\sigma_i^2$). Then, for a population of given genotype:

$$\sigma_w^2 = \sigma_t^2 = \sigma_c^2 + \sigma_i^2 = \sigma^2 \text{ (say)}$$
$$\text{covariance } (wt) = \sigma_c^2.$$

In practice, $\sigma^2$ can be estimated as $\sigma_w\sigma_t$, so that the correlation between wing- and thorax-length is $\sigma_c^2/\sigma^2$, that is, the fraction of the variance due to common causes. This formulation allows us to compare the actual components of variance in inbred lines and their crosses. Table 1 gives the estimates obtained from two tests, the variances being expressed as squared coefficients of variation.

In both tests, the main cause of the reduced total variance in the crosses is the sharp drop in $\sigma_c^2$. The variance of body-size is actually more than twice as great in homozygotes as in heterozygotes, and the magnitude of the difference is under-estimated in comparisons using only one character, since there is a much smaller change in the independent variance ($\sigma_i^2$) than in $\sigma_c^2$. Errors of measurement have been found to cause only a small fraction of $\sigma_i^2$, so that environmental variables affecting only one character appear to differ less in their effects on homozygotes and heterozygotes than do those with general effects on body-size. As a result, the correlation between wing- and thorax-length is much less in the heterozygotes.

Table 1. COMPONENTS OF ENVIRONMENTAL VARIANCE IN INBRED LINES AND THEIR CROSSES (FEMALES)

| Comparison | | Nature of variance | | | Correlation coefficient |
|---|---|---|---|---|---|
| | | $\sigma_c^2$ | $\sigma_i^2$ | $\sigma^2$ | |
| *A* | Pure lines | 1·15 | 0·75 | 1·90 | 0·61 |
| | Crosses | 0·40 | 0·69 | 1·09 | 0·37 |
| *B* | Pure lines | 1·27 | 1·24 | 2·51 | 0·51 |
| | Crosses | 0·54 | 0·99 | 1·53 | 0·35 |

*A*, cross of two unselected lines; *B*, three crosses involving lines selected for small size

A different case is provided by the number of chætæ on the abdominal sternites of *Drosophila*, a character well known from the genetical work of Mather and his associates[3]. Males have three segments (No. 3–5) and females four segments (No. 3–6) with roughly equal numbers of sternal chætæ (typically about 20 and 25 in the two sexes). We thus have a serially repeated character in each individual, and it is of particular interest to examine the environmental correlations between the different segments.

One might expect both genetic and environmental effects to cause highly correlated variations of chæta-number on all sternites; and progeny tests on two wild stocks (to be described elsewhere) have shown that the genetical correlation between any pair of segments is close to unity. This means that gene differences mainly affect the general level of chæta production on all sternites and cause little or no local variations, so that one could expect little progress from selecting two segments in opposite directions. The environmental correlations have been estimated from nine inbred lines, each of which provides three correlations between pairs of segments in males and six in females, and the average correlations are given in Table 2.

Table 2. ENVIRONMENTAL CORRELATIONS FOR CHÆTA-NUMBER OF ABDOMINAL STERNITES

| | Adjacent segments | Non-adjacent segments | Average |
|---|---|---|---|
| Males | 0·075 | 0·087 | 0·079 ± 0·032 |
| Females | 0·050 | 0·063 | 0·056 ± 0·031 |

Adjacent segments are no more highly correlated than non-adjacent segments, and the average for all pairs of segments in both sexes is + 0·068 ± 0·022, a value in striking contrast to the high genetic correlations found (0·9–1·0). There is, in fact, virtually no non-genetic correlation, so that environmental variations must be extremely localized in effect. The non-genetic variability is, nevertheless, quite substantial, since the coefficient of variation for individual segments is about 8 per cent.

Another peculiarity of the variations of chæta is that the number of abdominal chætæ is extremely resistant to changes of environment, such as quality and quantity of food, humidity and temperature, which have profound effects on other quantitative characters[1,4]. It is, in fact, largely independent of external conditions. This has led to the suggestion that the variability is mainly due to "intangible accidents of development"[3]; but it may be argued that this does not really solve the problem, and the statistical facts need to be brought into relation with what is known about the morphogenesis of chætæ.

The relevant facts are as follows. A pair of small islets of embryonic cells, the hypodermal histoblasts, become visible four hours after formation of the puparium; they spread and form the ventral imaginal hypodermis of each abdominal segment during the next thirty hours. Towards the end of this period, the trichogen cells appear in the hypodermis, enlarge, and each gives rise to a chæta[4]. Each chæta is innervated by a bipolar nerve cell[5,6]. Various macrochætæ have a temperature-effective period in the late larva[7], and this has been taken to indicate that the trichogen cells are already in existence then, long before they can be seen[4]; but the temperature-effective periods for microchætæ do not appear to have been studied. What conclusions can we draw from these facts?

Since most of the external surface carries chætæ in more or less regular patterns, the tendency to produce them must be a general property of imaginal hypodermis; and, in view of the rapid development of the hypodermis from small groups of embryonic cells, it seems probable that the trichogen cells are induced shortly before they become visible, and do not exist earlier. It may be suggested that local irregularities in the newly formed hypodermis cause the induction of the trichogens and that some mechanism prevents them from forming too close together. This mechanism is almost certain to be connected with the rapid growth of the trichogen cells, which would exhaust certain materials in the immediate neighbourhood of each, and thus inhibit the formation of others near by. This leaves us with the problems of what could cause local irregularities in the hypodermis, and what could be responsible for the uncorrelated variations in numbers of chætæ.

Local irregularities could be caused by many factors, including the early presence of the nerve cells which later underlie the chætæ. But nothing is known of the history of these cells, and they may well be induced at the same time as the trichogens, or by them. It seems, in any event, far-fetched to attribute the regularity of the surface patterns to the regularity of underlying nerve cells. Any disturbance of the potential uniformity of the hypodermal tissue might be sufficient to set off the production of trichogen, and the regularity of the chætæ would then be maintained by the inhibitory mechanism postulated above. But we require some additional cause for the variability in number of chæta on each segment. The factors responsible cannot easily be equated with any known environmental variables, for the reasons given earlier, and must be very local in effect.

One agency which may contribute to this variation is somatic mutation. Genetic homogeneity of somatic tissue certainly cannot be assumed; and, since the hypodermis forming each abdominal sternite contains large numbers of cells, sufficient mutations might occur to affect the probability of production of chætæ at any point, and thus to vary the density of chætæ. Another possibility is that random disturbances acting on the newly formed hypodermis might destroy its homogeneity at a number of points, and so affect the siting of the chætæ. Thus, it has recently been suggested[8] that slight random disturbances could set off a chain of reactions in a homogeneous tissue leading to the production of a variable pattern, for example, dappling.

These suggestions are largely speculative, but may serve to encourage further study of the morphogenetic basis of production of chætæ. The facts put forward certainly reinforce our previous conclusion[2] that most of the non-genetic variation in number of abdominal chætæ, under normal culture conditions, is not an 'environmental' variability of the kind we meet in dealing with most quantitative characters. Such chance—or stochastic—variability may well be a property of many pattern characters. [Oct. 28.

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[6] Lees, A. D., and Waddington, C. H., *Proc. Roy. Soc.*, B, 131, 87 (1942).
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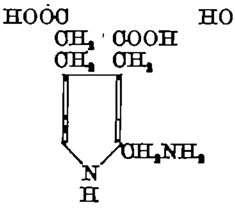
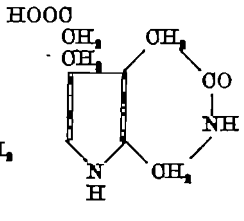
# PORPHOBILINOGEN

## Chemical Constitution

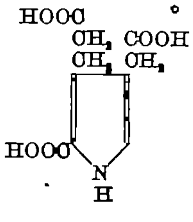
THE urine of patients suffering from acute porphyria contains a compound, porphobilinogen, which gives a positive Ehrlich reaction and which can be converted into a mixture of uroporphyrins on heating with acid[1]. Porphobilinogen was recently isolated in crystalline form by Westall[2], who kindly provided the material for this investigation. The reactions summarized below show that it probably has the structure (I). In an accompanying communication, Mrs. Kennard presents X-ray crystallographic evidence in support of a formula containing a single pyrrole ring.



(I)



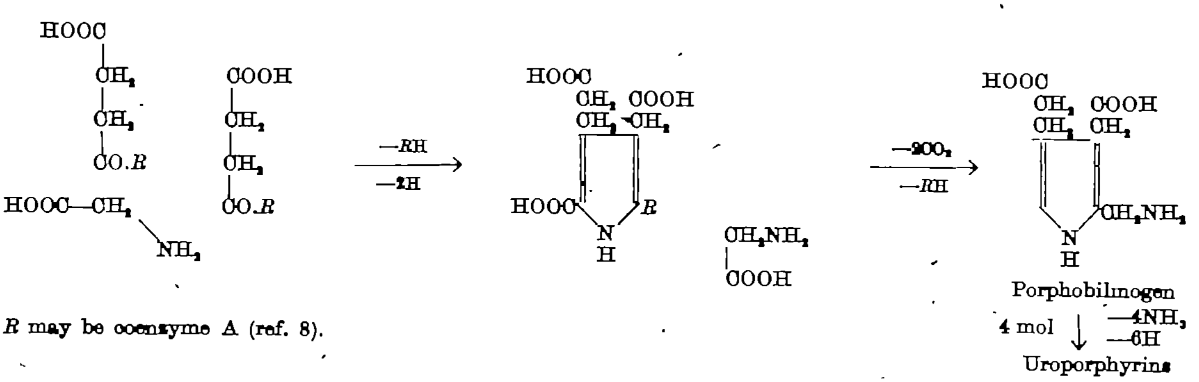
(II)



(III)

Porphobilinogen boiled with phosphate buffer ($p$H 8·5) loses ammonia but does not do so at 40° [3]. 2 : 4-Dinitroaniline has been isolated after treatment of a porphobilinogen solution at $p$H 8·5 and room temperature with 1 : 2 : 4-fluorodinitrobenzene.

When dissolved in strong alkali such as caustic soda or aqueous triethylamine, porphobilinogen gave, on treatment with acetic anhydride or benzoyl chloride, what were assumed to be the corresponding acyl derivatives; owing to their water solubility these could not be isolated. They were recognized on paper chromatograms run in butanol – 20 per cent acetic acid and developed with Ehrlich reagent (acetyl $R_F$ 0·79, benzoyl $R_F$ 0·92). However, when a solution of porphobilinogen in aqueous pyridine was treated with acylating agents, the major product was the lactam (II), which was unchanged by solution in caustic soda and further treatment with acetic



*R* may be coenzyme A (ref. 8).

anhydride. The lactam (II) ($R_F$ 0·65. Found: C, 57·6; H, 5·9; N, 12·9. $C_{10}H_{12}O_3N_2$ requires C, 57·7; H, 5·8; N, 13·45 per cent) with diazomethane gave its methyl ester, melting point 248–250° ($R_F$ 0·83. Found: C, 59·6; H, 6·6; N, 12·6. $C_{11}H_{14}O_3N_2$ requires C, 59·4; H, 6·3; N, 12·6 per cent). Both (II) and its ester showed a brilliant blue fluorescence under a Wood's lamp, but the only strong absorption in the ultra-violet was at *c*. 210 mμ, ε 7,500, as expected of a pyrrole with no conjugated chromophore[3].

The methyl ester of (II) underwent a Hoesch reaction with acetonitrile and hydrogen chloride to give its α-acetyl derivative. The product of the reaction, which was carried out on only 8·2 mgm., was investigated spectroscopically, the intermediate ketimine hydrochloride having $\lambda_{max.}$ 331 mμ and the acetyl derivative 306 mμ (cf. 2-acetyl-4-ethyl-3 : 5-dimethylpyrrole, 308 mμ[3]). 2·7 mgm. of the pure 2 : 4-dinitrophenylhydrazone were obtained (found: N, 19·2. $C_{19}H_{20}O_7N_6$ requires N, 18·9 per cent).

The infra-red spectra of porphobilinogen, the lactam (II) and its ester, which were kindly measured by Dr. L. A. Duncanson, of Imperial Chemical Industries Butterwick Research Laboratories, are in accordance with the structures assigned to them. The alternative structures with the positions of the β-substituents in (I) reversed, leading to a seven-membered lactam, have not yet been rigidly excluded.

The porphyrin formed when porphobilinogen was heated in acid solution yielded a crystalline octamethyl ester, melting point 255°. On paper chromatography[4] the major part of the material behaved as uroporphyrin III, but at least one other isomer was present. To explain the formation of a mixture of isomeric uroporphyrins *in vitro*, it has been suggested that porphobilinogen itself is a mixture[5]. We regard this as unlikely, X-ray (see accompanying communication) and chemical evidence being in favour of homogeneity. Other examples exist of the formation of mixtures of isomeric porphyrins from single compounds[6].

Isotopic tracer studies of hæm biosynthesis[7,8] have shown that natural porphyrins are synthesized from glycine and an unsymmetrical succinic acid derivative arising from the tricarboxylic acid cycle. Determination of the positions of the labelled atoms in the hæm led to the suggestion of (III) as an intermediate, which was then in some way converted to uroporphyrin, the methene bridges of which were derived from the α-carbon atom of glycine[9]. The structure of porphobilinogen which we now put forward can be immediately fitted into the scheme at the top of the page.

We are carrying out further work on this subject, and our results will be reported in full at a later date.

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[1] For summary of previous work, see Brockman, P. B., and Gray, C. H., *Biochem. J.*, 54, 22 (1953); and ref. 2.

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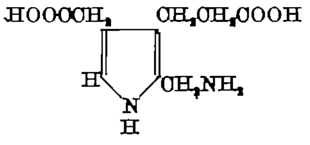
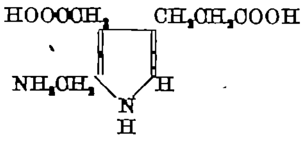
## X-Ray Crystallographic Determination of Molecular Weight

A PORPHYRIN precursor, porphobilinogen, was recently isolated by R. G. Westall in the form of the pure crystalline base[1] from the urine of patients suffering from acute porphyria. Chemical evidence by Westall[1] and by G. H. Cookson and C. Rimington (accompanying communication) suggests an empirical formula of $C_{10}H_{16}O_4N_2$ or $C_{10}H_{14}O_4N_2$ respectively. No molecular weight could, however, be assigned to porphobilinogen, and a crystallographic examination was undertaken to determine this and to differentiate between possible pyrrole or dipyrrylmethane structures, Waldenström and Vahlquist[2] having favoured the latter on the basis of diffusion experiments with porphobilinogen concentrates. In addition, it was hoped that the method would indicate whether or not two position isomers (*A* and *B*) were present. Intermediates of this type with unspecified α-substituents were postulated by Neuberger, Muir and Gray[3] in their theory of the biosynthesis of porphyrins.

Crystallographic methods were recently used to differentiate in a similar way between the various porphyrin isomers[4].



(*A*)



(*B*)

COMPARISON OF UNIT CELL DIMENSIONS

| Substance | *a* | *b* | *c* | α | β | γ | No. of molecules | Space group |
|---|---|---|---|---|---|---|---|---|
| Porphobilinogen HCl $H_2O$* | 13·9 A. | 17·9 A. | 5·34 A. | 97° | 97° | 89° | 4 | *B*1 or *B*$\bar{1}$ |
| α-Porphobilinogen HBr $H_2O$* | 14·0 | 18·0 | 5·34 | 97° | 97° | 89° | 4 | *B*1 or *B*$\bar{1}$ |
| β-Porphobilinogen HBr | 15·7 | 15·4 | 5·23 | 90° | 96° | 90° | 4 | $P2_1/n$ |
| Coproporphyrin I tetramethyl ester | 11·1 | 17·4 | 5·50 | 93° | 96° 40′ | 123° | 1 | *P*1 or *P*$\bar{1}$ |

* Referred to a *B* face-centred cell twice the volume of the primitive cell

*Porphobilinogen hydrochloride*. The free base was converted into the hydrochloride by treatment on a silicone-coated slide with cold 2*N* hydrochloric acid. The fine needle-shaped crystals appeared optically homogeneous. Centrifuged in a Linderström-Lang type density column[3] the crystals formed one sharp band at a density-level of 1·405 gm./c.c. The X-ray diffraction pattern of a number of separate crystals was identical.

Porphobilinogen hydrochloride was found to be triclinic. Cell dimensions, calculated from rotation and Weissenberg photographs, were $a = 7{\cdot}5$ A., $b = 17{\cdot}9$ A., $c = 5{\cdot}34$ A.; $\alpha = 96^\circ\,17'$, $\beta = 117^\circ\,8'$, $\gamma = 87^\circ\,27'$. Mass per unit cell (O = 16) calculated from the above data is 553·3 ± 25. Analytical values agree with the formula for the monohalide with one molecule of water; molecular weight calculated for two units of $(C_{10}H_{14}N_2O_4HCl,H_2O)$ is 561. Piezo-electric tests, as well as the Wilson statistical tests[6], failed to decide the presence or absence of a centre of symmetry. Accordingly the unit cell may contain one molecule of dipyrrylmethane, or two molecules of monopyrroles which may or may not be position isomers.

*Porphobilinogen hydrobromide*. When converted to the hydrobromide, porphobilinogen crystallized in two forms, the α-form, isomorphous with hydrochloride, and β, a monoclinic form, prismatic in appearance (see photograph). The two forms occurred together, in variable proportions, and attempts to produce one form alone were unsuccessful. To obtain fractionation, use was made of the difference in the specific gravity of the two forms, and complete separation achieved by centrifuging the material in a density column of suitable gradient.

Porphobilinogen hydrobromide, showing the long needle-shaped crystals of the α (hydrated) form and the prismatic habit of the β (anhydrous) form. Magnification × 80

The unit cell dimensions of the α-form were found to be: $a = 7{\cdot}5$ A., $b = 18{\cdot}0$ A., $c = 5{\cdot}34$ A.; $\alpha = 96^\circ\,14'$, $\beta = 114^\circ\,8'$, $\gamma = 87^\circ\,24'$. Observed density 1·587 gm./c.c. The total molecular mass (O = 16) calculated from X-ray data is 628 ± 25. The molecular weight calculated for $(C_{10}H_{14}N_2O_4HBr,H_2O)_2$ suggested by the analytical data is 649·8. Again no distinction could be made between space groups *P*1 and *P*$\bar{1}$.

The β-form has been examined chromatographically by Cookson and Rimington and found to be homogeneous and convertible to an octa-carboxyl porphyrin. It crystallized in space group $P2_1/n$. Absent reflexions: ($h0l$) if ($h + l$) is odd; $0k0$ if $k$ is odd. Cell dimensions are shown in the accompanying table. Density, 1·595 gm./c.c. The mass per unit cell (O = 16) is 1,211 ± 50, which agrees within experimental error with the presence of four formula units of $(C_{10}H_{14}N_2O_4HBr)$, $M_{\text{calc.}}$ being 1,227·6. Symmetry considerations require that the unit cell contains either groups of four identical molecules in general positions or groups of two identical centrosymmetrical molecules in special positions. Since the proposed dipyrrylmethane molecule is extremely unlikely to have a centre of symmetry, crystallographic evidence would favour the monopyrrole structure for porphobilinogen, and shows that an octa-carboxyl porphyrin can be produced from a compound containing molecules of one type of isomer only.

The mean molecular weight for the free base calculated from the three types of crystals examined is 221; molecular weight calculated for $(C_{10}H_{14}N_2O_4)$ = 226.

*Coproporphyrin I tetramethyl ester*. The unit cell dimensions of this substance have been determined and are included in the table. Similar measurements of a uroporphyrin could not be carried out for lack of suitable single crystals. Coproporphyrin I ester provides an interesting comparison with porphobilinogen as the unit cell contains one molecule, the equivalent of four pyrrole units only in a space group of *P*1 or *P*$\bar{1}$. The distribution of intensities in the X-ray diffraction pattern indicates that the molecule is not strictly centrosymmetrical and favours a space group of *P*1. The similarity between the unit cell dimensions of the porphobilinogen halides and this porphyrin ester suggests a common structure-type and lends indirect evidence for the proposed molecular structure of porphobilinogen.

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April 28.

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# LETTERS TO THE EDITORS

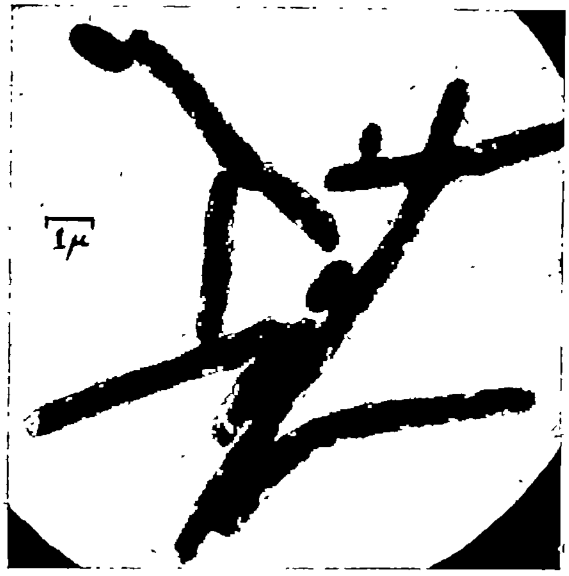
*The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications*

## A New Procedure for Bacterial Viability Counts and its Biophysical Applications

A BASIC problem in microbiology is that of determining the proportions of live and dead organisms in a bacterial culture. The standard procedure is to spread a known volume of diluted culture over a solid nutrient-medium and then, after incubation, to count the colonies which develop. On the assumption that each colony came from one bacterium, the number of viable organisms per millilitre of original culture can be calculated (but not the percentage viability).

We have found useful a completely different method which consists simply of counting in an electron microscope the live and dead organisms in a random sample of any culture. Live and dead bacteria cannot normally be distinguished from each other. However, if the culture is incubated for a few hours under conditions which permit cell-growth but inhibit cell-division, the live organisms will grow to many times the length of their dead companions and the two kinds can readily be differentiated and counted (see photomicrograph).

A convenient agent for inhibiting division but permitting growth is urea at a concentration of 3 per cent in nutrient agar[1]. The bacteria are grown on a collodion film supported on a stainless-steel electron-microscope specimen grid in a manner similar to that described by Brieger and Cosslett[2]. The grids are placed film downwards on a Petri dish of nutrient agar containing 3 per cent urea. A drop of bacterial culture is then placed on the centre of each grid and the whole incubated at 37° C. for 3 hr. (6 hr. for irradiated bacteria, to allow for the longer lag phase). The grids are then fixed in vapours of osmium tetroxide or formalin, cleaned by floating on distilled water, and finally dried and examined. The live bacteria in the drop will have formed long filaments, whereas the dead ones remain unchanged. Provided the distribution of bacteria on the grid is suitable, a count of the live and dead cells can then be made. Test-counts on suspensions containing known proportions of live and heat-killed bacteria gave answers correct to within the expected sampling error, which is small if several hundred cells are counted. Examination in an electron microscope is probably essential for making accurate counts—especially for distinguishing very short rods from particles of medium or detritus, and for including lysed cells.



A typical field of paracolon bacilli after 2½ hr. growth at 37° C. on division-inhibiting medium (3 per cent urea-agar), showing seven live and three dead organisms.

The 'urea method' is often less time-consuming and troublesome than the standard method. Its main disadvantage is that it cannot be applied to cocci, which do not respond to urea by developing into giant forms, or to cultures of organisms which always contain filamentous cells in spite of being cultured under conditions favouring short forms. But we have used it successfully with strains of *Bacterium*, a paracolon bacillus, *Chromobacterium*, and *Pseudomonas*. With suitable strains, counting by the urea method has several important advantages over the standard procedure: (*a*) it is not affected by bacterial clumping, which can entirely vitiate the standard procedure[3]; (*b*) it gives percentage viability, instead of only a total live count per unit volume; (*c*) the dead cells can be identified and examined; (*d*) only a very small sample is required.

The method has proved very useful in studying the resistance of bacteria to drying in fine droplets (as happens so often in Nature), and has also thrown new light on the effects of radiations on bacterial cells. In the latter case the counts may differ widely from those made by the standard procedure, since the urea method measures primarily radiation effects on the systems responsible for cell growth. It presumably does not detect effects on the systems responsible for cell division and heredity, which do, however, affect counts made by the standard procedure. Clearly, in most experiments on bacterial killing, fuller information can be obtained by using the two methods in parallel.

Further details of this and other work based on the urea method will be published elsewhere. One of us (R. C. V.) is indebted to the Agricultural Research Council for support during this work.

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March 10.

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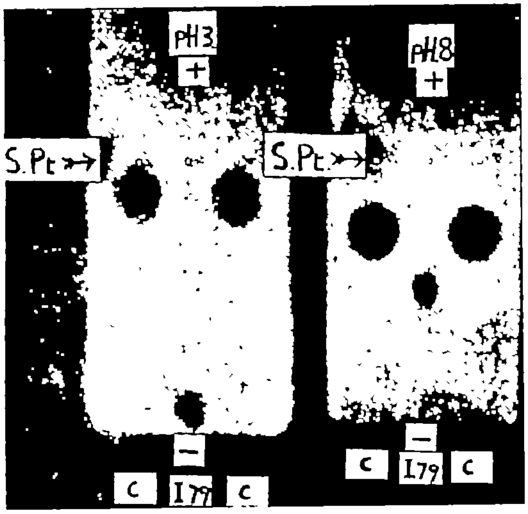
## Applications of Electrophoresis in studying New Antibiotics

THE application of paper electrophoresis to the study of new antibiotics[1] has been in use at these laboratories for some time. Our technique consists of applying spots of culture fluid, or a concentrate of it, to paper strips soaked in buffer, and subjecting the strips to electrophoresis by the technique of Kunkel and Tiselius[2]. Spots of chloromycetin are applied to the paper on each side of the spot of unknown antibiotic as a control for electro-osmosis. After migration, the position of the antibiotic is revealed by the microbiological technique as usual



Electrophoresis of antibiotic 179 relative to chloromycetin (C). S.Pt., starting point

in paper chromatography of antibiotics[3]. Thus it is possible to determine whether unknown antibiotics in culture fluids are acidic, basic or amphoteric, and to obtain an approximate measure of their isoelectric point as a guide to subsequent purification procedures. The migration of an unknown antibiotic 179, relative to chloromycetin, to the cathode at *p*H 3 and *p*H 8, with lessened mobility at *p*H 8, indicates a basic substance with an isoelectric point greater than *p*H 8, as illustrated in the accompanying photograph.

During the course of our studies, a number of apparently anomalous results were observed which proved to be the result of one or more of the following effects: (*a*) movement of spots during the drying process; (*b*) uneven distribution of electrolytes on the paper; (*c*) adsorption of the antibiotic by the paper.

*Movement of spots during drying of the paper.* When filter papers were dried at the conclusion of electrophoresis, definite movements of spots of dye (bromphenol blue) were shown to occur due to the flow of water during evaporation. The extent and direction of the movement varied surprisingly with the conditions of drying and the relative positions of the spots on the paper. Such movements and the contraction of the whole paper on drying are factors which limit the possible agreement between measurements made by paper and classical electrophoresis.

*Uneven distribution of electrolytes.* By incorporating an indicator in the buffer used for electrophoresis, it was shown that electrolytes added along with the substance under examination may separate during electrophoresis into discrete acid and alkaline areas which disperse only slowly. Considerations were, therefore, given to the choice of buffer concentration on the paper and the concentration of electrolytes in the sample submitted for electrophoresis. This observation stresses the need for considering the entire electrolyte concentration of a solution on which paper electrophoresis is contemplated.

*Adsorption of the antibiotic by the paper.* The chromatographic development on filter paper of a number of known and unknown antibiotics with buffers demonstrated a property in common, of strong adsorption at *p*H 8 and less so at *p*H 3, while chloromycetin showed little adsorption. With a knowledge of the relative adsorptions of an unknown antibiotic and chloromycetin, it was possible to interpret electrophoretic movements of the former even when strong adsorption on the paper occurred.

*Choice of a suitable control for electrophoresis.* Chloromycetin is a suitable control because it is little adsorbed, is indicated by the same methods as the antibiotic being studied, and shows electrophoretic movement on filter paper close to that of dextran, already established by Kunkel and Tiselius[2] as a suitable control for electro-osmosis.

We wish to thank the Director of the Commonwealth Serum Laboratories for permission to publish this communication.

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Nov. 21.

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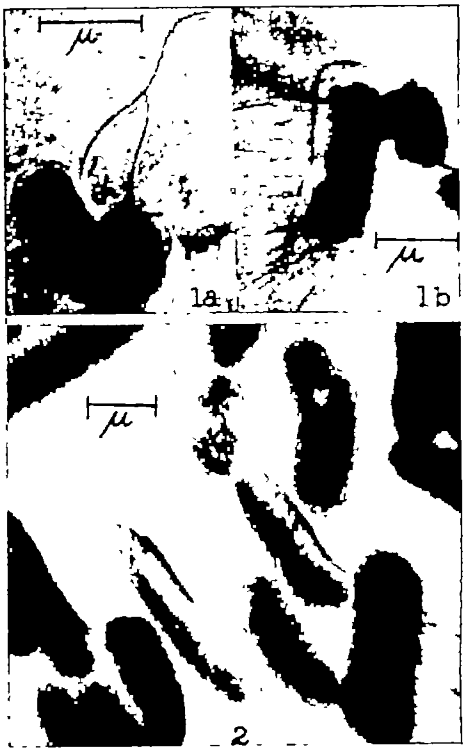
## A Variant of *Bacterium coli*

During an electron microscopic investigation of *Bacterium coli*, a variant form of this bacterium was observed with several interesting features. The accompanying electron micrographs 1(*a*) and 1(*b*) show the normal types of this bacterium usually obtained. In both cases bacteria were grown on



Electron micrographs of *B. coli* shadowed with 80 A. of chromium metal. 1(*a*) normal type fixed in 2 per cent osmic acid vapour (× 13,600); 1(*b*) normal type fixed in 5 per cent formalin (× 11,200). (2) Variant fixed in 2 per cent osmic acid vapour (× 8,800)

Morton–Engley's enriched agar medium[1] and incubated for $2\frac{1}{2}$ hr. at 37° C. Bacteria represented in Fig. 1(*a*) were fixed by exposure to vapour of 2 per cent osmic acid, whereas those of Fig. 1(*b*) were fixed in 5 per cent formalin. Those fixed in formalin always showed a greater shrinkage of protoplasm from the cell wall, compared to those fixed in osmic acid vapour.

In the normal type of this bacterium, the surface of the body is smooth; two types of flagella are usually observed, the long and thick variety (Fig. 1(*a*) ) which are few in number, and the narrow filamentous type (Fig. 1(*b*) ), which are more profuse and peritrichous in distribution. The flagella originate from the lateral surface of the body and extend right up to the cytoplasm, as may be seen through the collapsed cell membrane in Fig. 1(*b*). Except when the cytoplasm has shrunk considerably, the body of the bacterium shows unequal transmission of electrons, possibly corresponding to the nuclear and cytoplasmic regions[2].

In the variant form (Fig. 2), the body appears hairy, and in a few cases long hairy outgrowths are twisted together and resemble a twine. The hairs seem to be of surface growth and no normal flagella are seen. The bacteria are in general more transparent to the electron beam than the normal forms. Variants of *B. coli* have been observed before by different authors[3-5]. Vaureka[3] observed a hairy variant of *B. coli* under the phase-contrast microscope, when bacteria were treated with chloramphenicol and antiserum. In this case a hairy lining membrane appeared just before the death of the cell. Eisenstark *et al.*[4] observed a mottled variety of *B. coli* after treatment with X-rays. In our case, the hairy variety was found to occur spontaneously in the normal culture, and it maintained this characteristic through several subcultures.

We wish to thank Prof. M. N. Saha for his interest in this work. We are also indebted to the Ministry of Education, Government of India, for financial assistance.

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[1] Morton, H. E., and Engley, F. B., *J. Bact.*, 49, 245 (1945).
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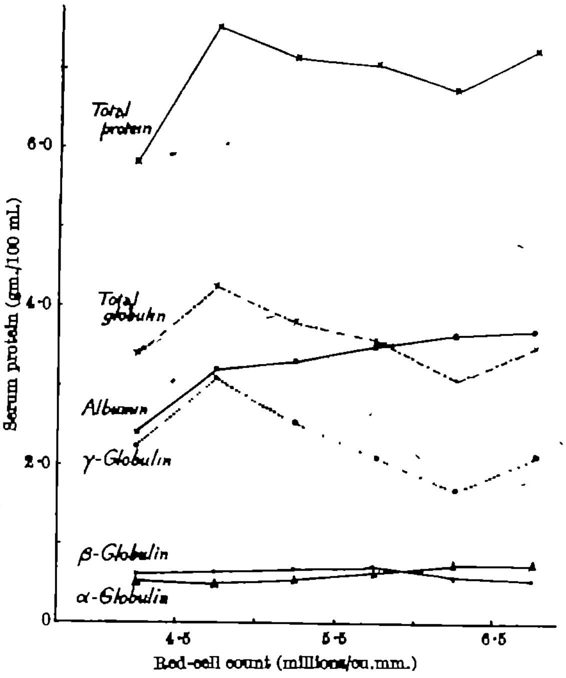
## Serum Proteins in Africans

It has frequently been observed[1] that the serum globulin-level of apparently normal Africans is higher, and the albumin-level somewhat lower, than that of Europeans. Moreover, workers in this laboratory[2] have shown that there is a relation between mean red-cell count and serum protein-levels. Those Africans with the highest red-cell counts have a higher mean albumin-level and a lower globulin-level than those with lower red-cell counts. In this work, chemical methods[3,4] for separating and estimating the serum protein fractions were used. By these methods it appeared that the variation of the β-globulin fraction accounted for the greater part of the change in total globulin in the different red-cell-count groups.

This work has now been repeated, and in the main confirmed, using a micro-electrophoresis (Antweiler) method for estimating the serum protein fractions. The proteins were measured in the ascending limb in barbitone buffer of $pH$ 8·6, ionic strength 0·12. By this method serum protein-levels of normal Europeans living in Africa were found to be close to those given in the literature for normal subjects; and the means for a group of seven African medical students were similar to those of the Europeans except for the γ-globulin-level, which was more than twice the European mean.

Blood samples were taken from fifty-five surgical out-patients who reported for minor or constitutional surgical conditions which could not *primâ facie* affect the serum proteins, or who required a physical examination for a health certificate. Serum protein measurements and red-cell counts were made on each sample. The figures for protein concentration were arranged in groups according to the red-cell count, and the means for each group were calculated. The results are shown in the accompanying graph. It is seen that there is a progressive increase of mean serum albumin from the lowest blood-count group (less than 4·5 million) to the highest (greater than 6·5 million). In contrast with our earlier findings, the mean α- and β-globulin-levels show little variation in the different blood-count groups, the variation of globulin occurring almost entirely in the γ-globulin fraction.

This discrepancy with the previous work is due to the fact that, in African sera, a proportion of the substances having the electrophoretic mobility of γ-globulins is not precipitated by saline ammonium sulphate, as used in the method[5] employed in our earlier work. Whereas in European sera which we have examined the figures for γ-globulin obtained by electrophoretic and chemical methods agree well, in African sera the chemical figure is always lower than the electrophoretic figure. By the method of Wolfson *et al.*, the β-globulin concentration is found



by difference, that is, the values for (albumin + α- + γ-globulin) are subtracted from the total protein; and if by this method the γ-globulin is under-estimated, falsely high figures for β-globulin must be obtained. It appears from our later experiments that the variation in the different blood-count groups occurs mainly in that part of the γ-globulin which fails to be precipitated by saline ammonium sulphate.

The significance of the raised γ-globulin concentrations of African sera is now being investigated.

I am indebted to Mr. John Kyobe for red-cell counts made in connexion with this work, and to Mr. John Croot for access to the subjects.

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# Inhibitory Effect of Malonate on the Respiration of Brain Tissue, with Special Reference to the Potassium Effect

IT has long been known that, in brain cortex slices, both aerobic glycolysis and respiration are enhanced markedly when potassium chloride (0·1 *M*) is added to the suspension medium[1], this metabolic effect of potassium being peculiar to nervous tissue[2] and abolished by grinding the material[3]. In view of the manner in which the increased aerobic glycolysis and respiration respond to various metabolic poisons such as potassium cyanide, malonate and mono-iodoacetate, it seems possible that the type of linkage of these two metabolic routes differs from that under normal conditions[4].

Although Dixon[5] and Dickens and Greville[6] have put forward a hypothesis to explain the underlying mechanism of the effect of potassium in terms of permeability, its nature is still obscure[4], if somewhat clarified by the recent work of Lipsett and Crescitelli[6]. In the present communication we wish to direct attention to the effect of malonate on the increased respiration caused by the addition of potassium.

Fig. 1 shows that the respiration in presence of potassium chloride is strikingly inhibited by the addition of malonate ($10^{-3}$ *M*), being depressed nearly to the level of the normal respiration, which is itself maintained steadily even in the presence of malonate[7]. If the concentration of malonate is increased to $10^{-2}$ *M*, respiration in presence of potassium chloride is completely inhibited, even to the level of the endogenous respiration of the brain tissue without added substrate, as seen from Fig. 2 (*a*) and (*b*). Again, the respiration in the normal saline medium remains substantially resistant to malonate, whether glucose is present or absent. Thus the respiration in presence of excess potassium is acutely susceptible to malonate as contrasted with the normal respiration, which is quite resistant to the same poison.

In view of these facts, bearing in mind that malonate tends to promote the increased aerobic glycolysis due to potassium and further that the potassium effect is reversible, the possibility suggests itself that in potassium chloride – saline, either the Krebs cycle is the main pathway of brain tissue respiration, or the Krebs cycle, which is masked in some way or other under normal conditions, is opened up and brought into operation by the addition of excess potassium. Even though the mode of action of potassium on these metabolic processes is at present still a matter of conjecture, it must be significant

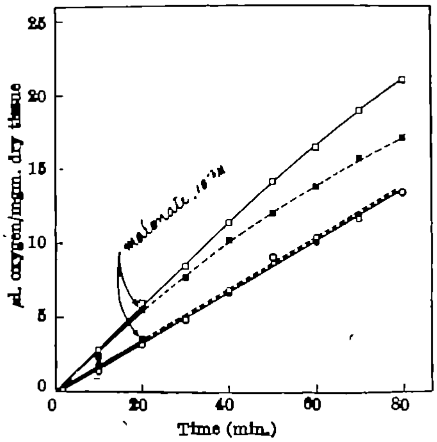

Fig. 1

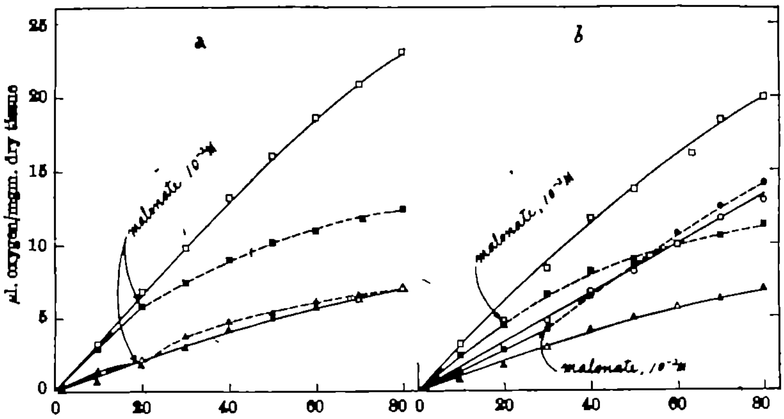

Fig. 2

Fig. 1 and Fig. 2 (*a*) and (*b*). Effects of malonate on the respiration of brain cortex slices of guinea pigs in presence and absence of excess potassium chloride; suspension medium, Krebs–Ringer phosphate solution.

□—□ control, ■—■ 'test' } glucose + 0·1 *M* potassium chloride;
○—○ control, ●—● 'test' } glucose alone;
△—△ control, ▲—▲ 'test' } no glucose

Broken lines represent respiration ('test') after addition of malonate; continuous lines the respiration in the corresponding controls without malonate that the increased respiration of brain tissue in presence of excess potassium is completely inhibited by malonate. This work is still in progress, and fuller details will be published later.

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## Nerve Fibres in the Adrenal Cortex of the Rat

IT is generally accepted that the adrenal medulla receives a predominantly pre-ganglionic nerve supply, reaching it via the great and lesser splanchnic nerves and by branches from the lumbar sympathetic chain[1-3]. Such fibres traverse the cortex in compact bundles (Fig. 1), without branching or relaying in the cortex, and are easily demonstrable by silver impregnation methods, as is the medullary nerve plexus which they join.

On the subject of an intrinsic nerve supply to the adrenal cortex, opinions differ widely. Thus Stöhr[4] believed the cortex to be richly innervated, whereas earlier, Hoshi[5] had stated that it possessed no nerve supply. Hollinshead[1] found no clear-cut example of a cortical innervation following silver impregnation; he did, however, describe single fibres and small groups of fibres distributed with the cortical blood-vessels and losing themselves upon these vessel walls. He assumed that these nerve fibres were postganglionic on the grounds that they persisted after section of selected ventral nerve roots. More recently, Kiss[3], using a silver impregnation method, has claimed that the outer cell layers of the cortex are innervated by collaterals from a rich subcapsular nerve plexus. This innervation, he states, comprises both postganglionic sympathetic and sensory fibres, and joins the "grundplexus" of Boeke[6]. He claimed, moreover, to have demonstrated occasional button-shaped nerve endings in relation to the cortical cells. Protagonists of a cortical innervation have not supported their work with photographs.

In recent work, adult male albino rats were injected intravitally with a 0·5 per cent solution of methylene blue in 0·3 per cent aqueous sodium citrate[7]. Using a transfusion apparatus and a broad-bore intravenous needle, the femoral vein was cannulated and a dose of about 40 mgm. of methylene blue was usually given before death ensued after twenty minutes. The glands were fixed in 8 per cent ammonium molybdate at 0° C. overnight, then washed in ice-cold saline, rapidly dehydrated, cleared and finally embedded in paraffin. Sections ranging from 6 to 20 μ thick were mounted in balsam.

Structures very suggestive of nerve fibres and nerve endings were observed in the outer layers of the cortex (Fig. 2). They were stained a deep purple colour, in contrast to the pale blue of the connective tissue. Two varieties of these fibres were present: (*a*) a fine plexus running with the cortical arteries (Fig. 2), with a possible extension over capillary walls; (*b*) branching systems of fine and frequently beaded fibres with occasional button-shaped endings in close relation with cortical cells. In Fig. 2 this relationship can be appreciated, since some of the cell nuclei have been stained by the dye. Both types of fibre distribution appeared to be derived from a subcapsular plexus in which small darkly stained ganglion cells could be occasionally discerned. The first type of nerve distribution, that is, along vessel walls, although most frequently seen in the subcapsular region, zona glomerulosa and zona intermedia, could often be found in the zona fasciculata, but not deeper in the

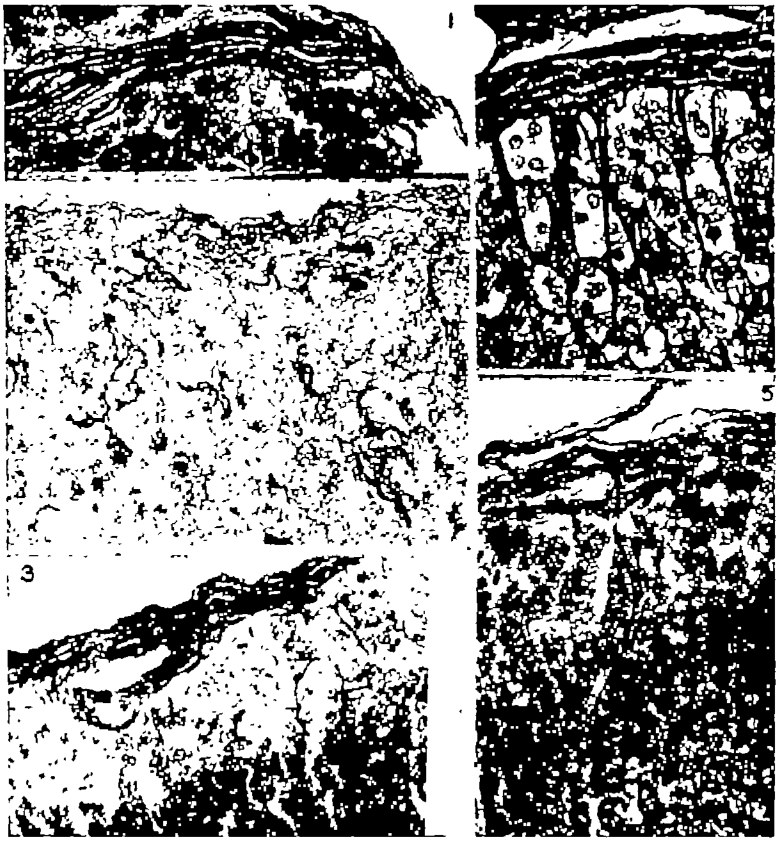

Fig. 1. A bundle of myelinated medullary nerves traversing the cortex, 12 μ. Silver stained. × 320

Fig. 2. Nerve fibres and nerve endings in the outer layers of the cortex. At bottom right is a nerve plexus around an arteriole. Stained intravitally with methylene blue. 12 μ. × 320

Fig. 3. Silver impregnation showing fine nerve fibres in the zona glomerulosa and also an arteriole transected deep to the capsule with a rich nerve plexus around it. 12 μ. × 320

Fig. 4. Silver impregnation to show glandular reticulum. 12 μ. × 320

Fig. 5. Silver impregnation showing a fine nerve fibre winding down into the zona fasciculata of the cortex. 12 μ. × 320

gland. The second type of distribution, as judged by recognizable buttons in relation to cells, was apparently confined to the zonæ glomerulosa and intermedia and the outermost zona fasciculata.

In order to follow up these findings, two silver impregnation techniques were used[8,9] for demonstrating reticulum (Fig. 4) and nerve fibres (Figs. 1, 3 and 5). While no absolutely convincing nerve endings were seen by silver impregnation, yet some of the appearances were very much akin to the buttons made visible by methylene blue preparations. However, fine nerve fibres were often seen, both as a network around small arteries (Fig. 3) and singly (Fig. 5) or in groups, in relation to the cells of the zonæ glomerulosa, intermedia and outermost fasciculata. All these fibres were much finer than the obviously myelinated fibres to the medulla which transverse the cortex in bundles (Fig. 1), and also finer than the strands of reticulum (Fig. 4).

These findings suggest therefore that, in addition to a possible vasomotor innervation, the adrenal cortex may possess a nerve supply to its outer cell layers. It would also seem that intravital injections of methylene blue provide a useful means of studying these nerves. Further work on this problem is being attempted.

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## A Possible New Principle in Taxonomy, and its Evolutionary Implications

In the course of studies on the taxonomy of Coleoptera, lasting many years and dealing with groups at all levels from sub-orders down to species, it has gradually been borne upon me that taxonomic groups are not usually to be distinguished from the nearest related ones by more than one really-constant character. Expressing the same concept in another form, if a taxonomic group is distinguished from related ones by the possession of character *A*, its constitution will not be quite the same as it would be if it were defined by the possession of character *B*. From superficial observation, the same principle appears to hold very generally in the animal kingdom, and quite probably among plants as well. Though this circumstance may well be familiar to many taxonomists, it does not appear to have been explicitly recognized as a general principle hitherto; if it is ultimately considered worthy of a name, I suggest 'the non-congruence principle'.

The implication of the non-congruence principle seems to be that differences of the sort used by taxonomists normally evolve one at a time. If any general statement can be made about taxonomic characters, it is probably that they exhibit more-or-less marked discontinuities but do not segregate like single gene mutants. The discontinuities are therefore presumably adaptive rather than genetical in origin, that is, they result from the relative inadaptiveness of the intermediate conditions; the evolutionary changes producing the differences were presumably relatively rapid. Genetical analysis of segregation in interspecific and intergeneric hybrids suggests that such differences involve changes in numerous genes.

To a non-specialist geneticist like myself, it seems quite plausible to assume that, if an adaptive change 'gets under way' involving a co-ordinated shift in a large number of separate hereditary factors, the genetical machinery of a species is liable to become 'tied up' in a way which would render it difficult or impossible for another change of the same type to be carried out simultaneously. If so, an explanation is provided for the apparent inability of selection to operate on more than one taxonomic character at a time, and the non-congruence principle would follow as a necessary consequence.

To take a familiar zoological instance of the possible application of the principle, we may consider some of the characters of the class Mammalia. The characteristic dentition, the secondary palate, the lower jaw suspension, the fur-clad skin, viviparity—in distinguishing Mammalia from Reptilia these characters are almost equivalent; but not quite, for the criterion of viviparity would exclude the Monotremata from the mammals, while the dentition alone would include a large number of Theromorph reptiles, and the secondary palate would include some of the later Theromorpha. According to D. M. S. Watson, there is some reason for supposing that the hairy skin first appeared with the small Ictidosauria (for example, *Oligokyphus*), that is, in succession after the dentition and secondary palate but before the truly Mammalian jaw-articulation. It may, of course, be objected that we know little or nothing of the adaptive significance of the changes involved in this instance, so that their serial occurrence might well be attributed to functional necessity, each change providing a necessary prior basis for the next. The account of the evolution of the horse given by G. G. Simpson seems to offer another example; the three major shifts—that from four toes to three in the Oligocene period, that from low to high molar teeth in the Miocene, that from three toes to one in the Pliocene—apparently occurred in regular succession though there is no evident adaptive reason why the first and second, or second and third, should not have gone on concurrently.

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## Physiological Forms of *Eucalyptus citriodora* Hooker

Since the discovery by Penfold and Morrison in 1927[1] of physiological forms in *Eucalyptus dives* Schau., many other examples of this phenomenon have been found in the Myrtaceæ and also the Rutaceæ[2]. The term 'physiological form' is applied to those plants in a naturally occurring population which cannot be separated on morphological evidence, but which are readily distinguished by marked differences in the chemical composition of their essential oils.

In 1948, the occurrence of a physiological form of *E. citriodora* was recorded[3] in which citronellal, the principal constituent of the 'type', had been almost entirely replaced by an equivalent amount of citronellol and its esters. The original tree in which this unusual oil was found gave a yield of 1·4 per cent of an oil containing 10·9 per cent citronellal, 33·7 per cent citronellol and 42·4 per cent esters calculated as citronellyl acetate.

Seed from open-pollinated flowers was collected from this tree, and from this seed 243 individuals were raised. Apart from a few stunted trees, the majority showed outstanding vigour and, when cut for distillation two and a half years after planting in the field (three years from sowing), averaged 16 ft. in height.

Whereas seed from the ordinary 'type' *E. citriodora* has always given progeny with a normal aldehyde oil similar to the original parent tree, in this case great variations in oil composition as well as yield were obtained on distillation and analysis. The yields varied from less than 0·1 per cent to 1·4 per cent (fresh commercial cut), and the aldehyde contents varied from nil to 82·2 per cent. Twenty-seven trees yielded insufficient oil for analysis.

It was found possible to group the oils obtained from the progeny into four series, as follows.

(1) Aldehydes 65–85 per cent, corresponding to a normal 'type' *E. citriodora*. Seventy-seven trees, equivalent to 40·1 per cent of the oils analysed, fell into this 'aldehyde inheritance' group.

(2) Aldehydes less than 30 per cent and very soluble in 70 per cent alcohol, corresponding to the original parent tree. Forty trees, or 20·8 per cent, fell into this 'alcohol – ester inheritance' group.

(3) Aldehydes less than 30 per cent but highly insoluble in 70 per cent alcohol. A total of 9·8 per cent of the oils showed this 'hydrocarbon inheritance'.

(4) Aldehydes 30–50 per cent. This group, which is intermediate between groups (1) and (2), accounted for 29·2 per cent of the oils analysed.

Before the progeny trees were ready for cutting, a further survey of the area where the original variant had been found led to the discovery of two forms corresponding to groups (3) and (4) above, as well as more trees with the alcohol–ester type of oil[4]. All these trees were found within a radius of 50 yd. from the original tree. Therefore, all four groups of oils obtained from the progeny trees have been found in Nature.

A similar occurrence to that recorded above has previously been noted in *Leptospermum citratum*[5]. The normal aldehyde oil trees always give progeny with aldehyde oils, the hydrocarbon form always gives a hydrocarbon oil; but the alcohol–ester form gives a variable progeny including alcohol–ester oils, intermediate oils and hydrocarbon oils.

Further breeding work is being carried out with the various forms in order to determine the actual mode of inheritance of these compounds. It appears likely that in both species a similar mechanism is in operation.

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Nov. 27.

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## Effect of Grafting on Nodulation of *Trifolium ambiguum*

THE clover *Trifolium ambiguum* is a perennial species which has a somewhat restricted natural range in the Caucasus region and the neighbouring steppes, extending westwards to about the Crimea. As an introduction in the United States, it has attracted much attention as a prospective pasture plant for more favoured northern sections because of its deep-rooting habit, capacity to spread by rhizomes and considerable degrees of both drought and winter hardiness. Furthermore, as it produces nectar freely and the corolla tube is shallow, it is of particular interest with respect to honey production. However, as a legume it has an outstanding weakness in that effective nodulation of this species has never been found. Parker[1] tested on it some thirty-five strains of *Rhizobium trifolii* and, although most of them produced a certain degree of nodulation, the nodules almost without exception were very small, quite withered, brown, unhealthy and obviously ineffective. In general, these nodules occurred at the point of origin of a small root, as though rhizobial infection of this species occurred as the result of the rupture of the root tissue by an emerging branch root, as reported by Allen and Allen[2] for *Arachis hypogea*, and not through root hairs. Normally, of course, the relationship between *Rhizobium* and plant is more positive, direct and symbiotic, the bacteria reaching the cortical tissue through an infected root hair and there causing a proliferation of cells and an appreciable development of healthy nodular tissue. In the case of nodulation effective in symbiotic nitrogen fixation, the nodules are comparatively large, plump and pinkish in colour owing to the presence within them of the product leghæmoglobin.

*Trifolium ambiguum* has been grown at this Institute under conditions which resulted in good plant growth with adequate development of root hairs and on soils in which *Trifolium repens* nodulated abundantly and well; but the former has never produced any nodules.

In view of the results obtained with *Soja hispida* by Bonnier, Hely and Manil[3], it was decided to investigate the effects of grafting *Trifolium repens* on the seedlings of *Trifolium ambiguum*. Four general types of grafts were used, and all methods gave a high percentage of successes. These comprised: (1) insertion of the growing point from a seedling or older plant of *T. repens* into the split hypocotyl of *T. ambiguum*; (2) similar insertion of a longer piece of older stem of *T. repens* which had some adventitious roots for its partial support originally; these were removed later; (3) various forms of inarch grafts on the hypocotyl of *T. ambiguum* seedlings; and (4) grafting of a complete and well-nodulated root system from a seedling of *T. repens* of about the same size on to a vigorous seedling of *T. ambiguum* in the upper root–hypocotyl region, with a reduction by pruning of some of the roots of the latter.

The findings from sixty grafted plants were as follows. (1) Grafting of either plant tops or roots of *T. repens* on to *T. ambiguum* resulted in the production of relatively large and healthy nodules on *T. ambiguum*. (2) The best results were obtained when the *T. repens* was made entirely dependent on *T. ambiguum*. (3) When a true graft was produced and the scion developed adventitious roots later, its nodules were of a large, irregular and very unusual shape for *T. repens*, and also tended to be partly green in colour although located well below the soil surface. (4) The nodules produced on *T. ambiguum* occurred on the main root and on branch roots, and either at the point of origin of a branch root or apart as though resulting from root-hair infection. (5) These nodules were comparatively large, spherical and closely resembling in form those of *T. repens*, but were white in colour and probably ineffective.

Ungrafted plants of *T. ambiguum* grown in the same pots with the above showed no evidence of nodulation in any case.

Isolations made from these nodules have been true rhizobia and have grown well on standard media; but it is not yet known if it is possible to get good nodulation directly by inoculation of plants of *T. ambiguum* grown in tubes under aseptic conditions, or whether the best results will be obtained when such material is used for inoculating plants of *T. ambiguum* again grafted with *T. repens*. However, in a late-season experiment, a small number of nodules were obtained on ungrafted *T. ambiguum* seedlings growing in pots by inoculation with material isolated from the *T. ambiguum* nodules on the grafted plants. This aspect will be investigated further.

It is considered probable that a fully effective strain of *Rhizobium* can be obtained for *T. ambiguum* by different techniques, notably by the method of successive passages through the host plant and selection of nodules obtained. However, since the development of new strains and their selection normally occur gradually in Nature, it is expected that quite a number of passages through *T. ambiguum* will be necessary before effective nodulation of this species becomes a practical possibility.

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Gembloux. Dec. 5.

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## The Respiratory Bubble of the Aquatic Beetle, *Potamodytes tuberosus*, Hinton

*Potamodytes tuberosus*, Hinton is an elmid beetle that inhabits fast-flowing water, and the present observations were made during 1952 on adult beetles occurring in a tributary of the River Densu, Gold Coast.

The bed of the river consists of large irregular rock slabs and boulders, and the fall in its level is quite rapid. During the rainy season torrential conditions prevail in the river, and the beetles were found widely distributed in the part kept under observation. During the dry season, however, the flow of water steadily decreases until the river becomes a series of rock pools and basins connected by little channels and waterfalls. It was found at this stage that although the rate of flow through the rock pools was very slow, it was comparatively fast in the connecting channels. The beetles collected in these channels, clinging to the rock surface and invariably facing the oncoming current. They were never found in slowly moving or still water, or more than an inch or two below the surface. They apparently fed on the microbiological slime that covered the submerged rock surfaces and, unless disturbed, they appeared to move but little.

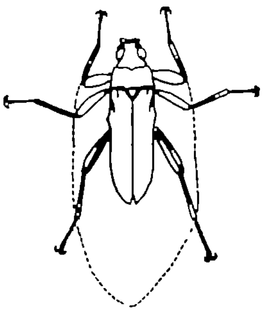

**Fig. 1.** Position of bubble, indicated by the dotted line, when the beetle is in a current of water

A conspicuous feature of the beetle is the respiratory bubble, clinging to its body and dragged out behind by the force of the current (Fig. 1). It would seem that certain characters of the beetle reduce the tendency of the bubble to be swept away by the current, and that under certain conditions it may extend for 1¼ in. behind the beetle. It was frequently noted that the water inhabited by the beetle was broken up with bubbles of air. These coalesced continually with the respiratory bubble and thus renewed its supply of air. Observation showed, however, that the beetles also inhabited flowing water which, although saturated with air at atmospheric pressure, did not contain any visible bubbles of air. It also seemed that, under these conditions, the bubble did not shrink, as might have been expected, but acted as a permanent physical gill. This was confirmed by laboratory experiments. In slowly circulating air-saturated water, the bubble gradually disappeared and the beetle died in a few hours; in an artificial current the bubble did not disappear, and on occasion, in fact, increased considerably.

The following hypothesis is put forward as a possible explanation of the permanent nature of the respiratory

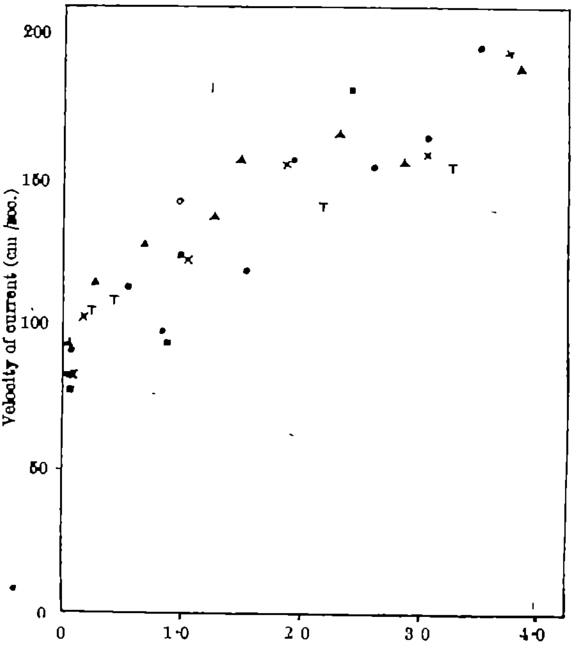

**Fig. 2.** Effect of the velocity of current on the pressure of the gas in the respiratory bubble. Observations were made on six separate beetles; each set of symbols refers to the results obtained from an individual beetle

bubble. The principle involved, which is most familiar in its application to the design of the aeroplane wing, is explained in elementary text-books on aerodynamics. Owing to the presence of the beetle, the velocity of the water immediately surrounding the beetle is increased relative to the velocity of the water in neighbouring regions. As a result, there is a reduction in pressure according to the Bernoulli equation $p + \frac{1}{2}v^2 =$ a constant. This reduction in pressure is communicated to the bubble. If the beetle is in a stream of water that has been saturated with air under atmospheric pressure, the water which enters the region of reduced pressure becomes temporarily super-saturated, with the result that some of its dissolved gases tend to pass into the bubble. The loss of nitrogen, postulated for the shrinking type of air bubble, does not apparently occur under these conditions.

The pressure of the air in the bubble was measured and the results are shown graphically in Fig. 2. It will be noted that above a certain critical velocity of the current, the pressure recorded in the bubble fell below atmospheric pressure. While not constituting absolute proof of the hypothesis put forward, it would seem that this result lends it a considerable support.

I thank Prof. J. E. Harris, University of Bristol, for discussions on this matter, and Mr. J. W. Balfour-Browne, British Museum (Natural History), London, for the identification of the beetle.

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Sept. 26.

## A Predator on *Creontiades pallidus*, Ramb.

The mirid *Creontiades pallidus* is widely distributed throughout the Anglo-Egyptian Sudan; it is also recorded from Egypt and the Belgian Congo, where in both places it is a pest of cotton. Wilcox[1] reports that no parasites or predators of *C. pallidus* were known to him in Egypt; while Madame Soyer[2] found a geocorid bug to be the only predator of this mirid in the Congo. Since Soyer's paper, there appear to be no other references to the insects which attack *C. pallidus*.

For a number of years *C. pallidus* has been thought to be a pest of cotton grown in the Tokar Delta; Tokar is about a hundred miles south of Port Sudan and about thirty miles inland from the Red Sea coast. The insect occurs all along the coastal cultivations, which stretch from the northern border of Eritrea to a point approximately 175 miles north of Port Sudan. In all those places where *C. pallidus* was found on the coastal stretch, the predator *Chrysopa carnea* Steph. also appeared.

On January 18, 1952, and on two subsequent occasions on Tokar cotton, *C. carnea* larvæ were seen attacking nymphs of *C. pallidus*. The nymphs, although generally active, have the habit of resting within the bracts of cotton buds, and it was in these sites that the attacked nymphs were discovered. When confined in a specimen tube, a larva of *C. carnea* will readily feed on nymphs of up to the fourth instar. Once the predator's jaws are fixed in the prey, both insects can be killed in a cyanide bottle without the larva relaxing its hold. Two specimens prepared in this way are deposited in the British Museum (Natural History), and two more are to be found in the Collection Room of the Gezira Research Farm.

When reared through the last larval instar on a diet of *C. pallidus* nymphs, the predator pupated normally and adults emerged from the pupæ. Each *C. carnea* larva ate an average of 6·1 nymphs in the last larval instar of two days; while the greatest number of nymphs consumed by such a larva was thirteen in the space of five days.

While it is unlikely that *C. carnea* in the field subsists wholly upon a diet of *Creontiades* nymphs, it is probable this predator does check to some extent the multiplication of the mirid at Tokar.

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## Purple Pigment and Protein in the Threads of the Sea Anemone, *Adamsia rondeleti*

The sea anemone, *Adamsia rondeleti*, produces coloured protein threads, from which a purple pigment can be extracted by means of distilled water. These protein threads are produced by special glandular cells of the body, and are excreted through special pores. They are used in obtaining food (small fishes or crabs), and perhaps for self-defence.

Up to now, it has not been possible to separate the pigment from the albumin with which it is conjugated without coagulating the protein, and at the same time replacing the purple colour by yellow. The purple pigment gives an intense blue fluorescence in ultra-violet light, the principal absorption maximum being at 555 mμ with smaller peaks at 465, 450 and 435 mμ. On heating, the aqueous solution becomes yellow. The purple pigment is unlikely to be 6-6′ dibromoindigotin, which has a quite different absorption spectrum. The pigment is changed to a colourless compound at pH 1·92 but persists at pH 12·36; addition of 0·1 *N* sodium hydroxide (pH 12·93), however, results in a yellow colour, and a smell of trimethylamine is noticed.

Vacuum desiccation transforms the aqueous solution into a micro-crystalline substance, and causes the purple colour to disappear, changing to yellow. In moist air the colour is restored.

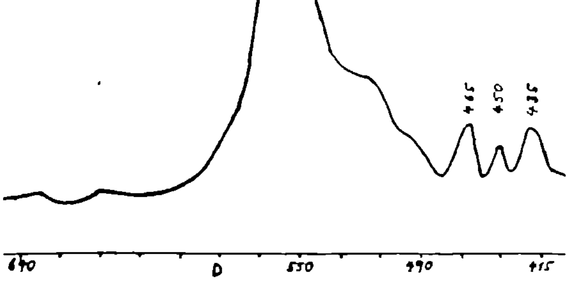

Fig. 1. Absorption spectrum of the purple pigment

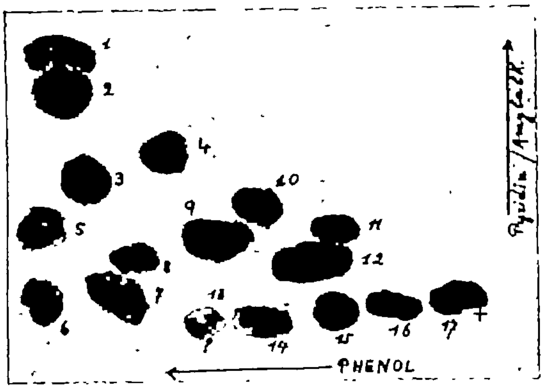

Fig. 2. Chromatogram of the purple pigment.
1, Tryptophane; 2, leucine, 3, valine; 4, tyrosine; 5, proline 6, arginine; 7, lysine; 8, histidine; 9, alanine; 10, threonine; 11, serine; 12, glycine: 13, unknown; 14, hydroxylysine?; 15, glutamic acid; 16, aspartic acid; 17, cysteic acid

The main pigment seems to belong to the group of the chromoproteins; but it might be a very intimate mixture with a protein. Further investigations are necessary.

Chromatography on filter paper shows the protein to contain the following amino-acids: cysteic, aspartic and glutamic acid, valine, alanine, histidine, threonine, serine, lysine, arginine, proline, tyrosine, tryptophane, hydroxylysine, and a further unidentified acid, together with tetramethylammonium-hydroxide (tetramin). The first three acids named are preponderant.

Fuller details of this work will be published in the *Bulletin of the Academy of Sciences, Athens*.

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## A Further Analysis of the Polymorphism of *Drosophila polymorpha*

THE tropical species of *Drosophila*, *D. polymorpha*, is polymorphic with regard to the pattern of pigmented abdominal bands. The polymorphism is a case of balanced polymorphism, as shown in a previous paper[1]. The types are inherited as if caused by two alleles of a single autosomic gene. The dark and the light types are the homozygotes and the intermediate type is the heterozygote. The heterozygote has an adaptive value higher than that of the homozygotes. The heterosis of the intermediate type ensures the maintenance of the two alleles in the populations. The probability that the pigmentation pattern is by itself an adaptive character is very small. Another possibility to be considered is that the two main genes responsible for the pigmentation are associated with other genes through an inversion. The differences in adaptive value could, then, be due to the genes carried in the inversion as a whole.

Using a combination of over-feeding the larvæ and a low temperature, it was possible to study the chromosomes in the salivary glands of *D. polymorpha*. A total of six inversions, three autosomic and three in the *X*-chromosome, was detected. In a total of 461 individuals from three different places, 119 were inversion heterozygotes.

No correlation was found, however, between the inversions and the pigmentation. The three pattern types may be homozygous as well as heterozygous for every one of the inversions.

The two possible explanations left for the differences in adaptive value of the three types are: (*a*) pleiotropic effects of the two genes; (*b*) genes very closely linked to the pigmentation genes. In either case, this is the first instance in the genus *Drosophila* of polymorphism not connected with chromosomal aberrations.

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[1] da Cunha, A. B., *Evolution*, 3, 239 (1949).

## Behaviour of Spider Crabs in the Presence of Octopuses

AT La Rocque, in Jersey, the spring tides go out about two miles leaving many large lagoons with sandy bottoms and depths of from two to four feet of water. Here we often spear flat-fish, plaice, soles, etc., sometimes getting as many as twenty in a tide; here also may be found spider crabs (*Maia squinado*), which are often taken in Jersey for food, but which are considered out of season in the autumn.

In September last, the catches of flat-fish were down to about half a dozen, owing to the number of octopuses that continually disturbed the bottom and kept the fish moving. The spider crabs had collected into large heaps, about two feet high and three feet in diameter, with their legs so entangled as to make it difficult to separate a crab from the heap. The octopuses captured some from the outside of the masses, but the greater number survived, and day after day the heaps remained. None of the fishermen to whom I have spoken of this behaviour on the part of spider crabs had ever noticed it previously.

The octopuses have now (October) moved to deeper water, and the crabs too have disappeared to their winter quarters.

H. J. BAAL
(Vice-president)

La Société Jersiaise,
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## Tertiary Ocean Bottom Temperatures

DURING the past few years, a method has been developed for determining palæotemperatures by measuring the ratio of oxygen-18 to oxygen-16 in the calcium carbonate of fossil shells[1,2].

This method is based on the fact that the relative rates of deposition of the oxygen isotopes in the calcium carbonate are a function of temperature. The temperature of deposition is thus determinable from a suitably accurate measurement of the relative abundances of the oxygen isotopes in a shell. To attain the required accuracy, mass spectrometers are employed in which carbon dioxide from the shell carbonate can be alternated at intervals of two minutes with a standard carbon dioxide gas. In this way only the difference $\delta$ in oxygen-18 concentration is measured, and an accuracy of ± 0·1 parts per thousand is attained. Experiments with shells grown at known temperatures in water of known isotopic composition[1,3] have shown that:

$$t = 16{\cdot}5 - 4{\cdot}3\,\delta + 0{\cdot}14\,\delta^2,$$

where $\delta = 1{,}000\left(\frac{R_{\text{sample}}}{R_{\text{standard}}} - 1\right)$ and $R$ is the ratio of concentration of oxygen-18 to oxygen-16. The measure of $\delta$ is relative to our carbon dioxide standard, derived from a powdered Belemnite of the Peedee formation of North Carolina.

To obtain fully reliable results, two conditions must be fulfilled: there must be equilibrium between water and the carbonate ion deposited by the animal, and the oxygen isotopic composition of the sea water must be constant in time and uniform in space.

The first condition was verified at the beginning of this project[1]. The constancy in time of the isotopic composition of the sea water may be rather safely postulated for the time being, and could possibly be verified later by analysing the oxygen isotopic composition of fossil phosphates, sulphates or silicates, of marine deposition. As for the uniformity in space, extensive analyses of different marine waters[1,3] showed that the oxygen-18 content of sea waters having a salinity range of 32–38 per thousand varies by 2·4 per thousand. This effect is more evident in superficial waters, whereas deeper waters are more uniform. Superficial differentiation in oxygen isotopes is due to the fact that the higher vapour pressure of $H_2{}^{16}O$ with respect to $H_2{}^{18}O$ favours the evaporation of the lighter water from warm seas, and its precipitation as rain, ice, or snow, in the higher latitudes[3]. A concentration of heavier water in the lower latitudes and of lighter water in the higher ones is therefore produced. This introduces an uncertainty of ± 5·5° C. in the temperatures obtained by analysing the calcium carbonate of Recent marine animals, if no correction is applied for the variations of the concentrations of oxygen isotopes in the marine waters.

Although a similar correction cannot be applied now for isotopic variations in the oceans of the past, the uncertainty of temperature measurements would be smaller if in earlier geological times ocean waters were more thoroughly mixed, so as to produce a greater uniformity in isotopic composition and, concurrently, in salinity, temperature, etc. Such a condition is thought to have been predominant in non-glacial times. In fact, in the absence of floating ice and superficial layers of cold water with lower salinity, the warm currents from low latitudes would extend to the highest latitudes. There, they would cool to some extent, sink to the bottom, and flow back to lower latitudes as deep currents. This extended activity would produce a more uniform temperature throughout, and also increase the temperature of the bottom of the oceans[4].

To verify these considerations, two samples of benthonic Foraminifera from a deep-sea core of Tertiary age were analysed for palæotemperatures. This core was obtained by the Deep-Sea Swedish Expedition of 1947–48 in the eastern central Pacific. The geographical co-ordinates of the locality are: 15° 34′ N., and 127° 11′ W. The depth of the ocean bottom is 4,725 m., and the length of the core 348 cm. The core represents a truncated sequence of Tertiary sediments[5], of probable Oligocene age. Truncation was caused by deep current abrasion or possibly by slumping. The missing part included at least 10 m. of Pleistocene and Late Pliocene sediments, and an unknown thickness of older deposits. The Foraminiferal fauna is poor. Benthonic Foraminifera are predominantly represented by Nodosariinæ in fragments and some Rotaliidæ. These Foraminifera are rather large and thick-walled, the average diameter of the larger Nodosariinæ being about 70 Dμ (1 Dμ, a length unit particularly convenient in micropalæontological work, is equal to 0·01 mm.). Pelagic Foraminifera include scarce, small Globigerinidæ.

Of the four samples from this core made available to us by Dr. G. Arrhenius, three contained enough benthonic Foraminifera for the analyses. The benthonic tests were treated according to our standard technique[6]. Microscopic examination of thin sections showed no indication of recrystallization.

The depths below the top of the core, the value of $\delta$, and the corresponding temperatures, are given in the accompanying table.

| Depth below top of core (cm.) | $\delta$ | Temperature (° C.) |
|---|---|---|
| 2–10 | 1·51 ± 0·10 | 10·3 ± 0·5 |
| 282–290 | 1·20 ± 0·10 | 11·5 ± 0·5 |
| 339–346 | 1·74 ± 0·10 | 9·4 ± 0·5 |

Post-depositional isotopic exchange between the calcium carbonate used in the tests and sea water does not seem to have occurred. In fact, if such an exchange took place, the much lower temperature of the deep sea water during the Pleistocene and the Recent would have increased the original values of $\delta$ in our material, with consequent lowering of the calculated temperatures; although probably not to the full extent, because of the influx along the bottom of polar waters having a lighter isotopic composition. Considering our results, however, it is apparent that the original temperatures could not have been much higher.

The results seem to show, therefore, that greater mixing of the oceanic waters occurred in non-glacial times and, for these periods, this gives more general validity to calculations of palæotemperatures based on our standard formula. It also adds weight to the point repeatedly stressed by geologists that the climate of the earth was much more uniform in non-glacial times.

We are indebted to Dr. G. Arrhenius for having made available to us the material from which the results presented here were obtained.

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G. Edwards

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University of Chicago. Feb. 19.

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[2] Urey, H. C., Lowenstam, H. A., Epstein, S., and McKinney, H. C., *Bull. Geol. Soc. Amer.*, 62, 399 (1951).

[3] Epstein, S., and Mayeda, T., *Geochimica et Cosmochimica Acta* (in the press).

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## Cosmic-Ray Intensity and the Temperature of the Upper Atmosphere

It is well known that the intensity of the hard component of the cosmic radiation at sea-level changes with changing atmospheric conditions. The existing correlation may be expressed by means of a linear equation:

$$(I - \overline{I})/\overline{I} = a(\overline{B} - B) + b(\overline{H} - H) + c(\overline{T} - T), \quad (1)$$

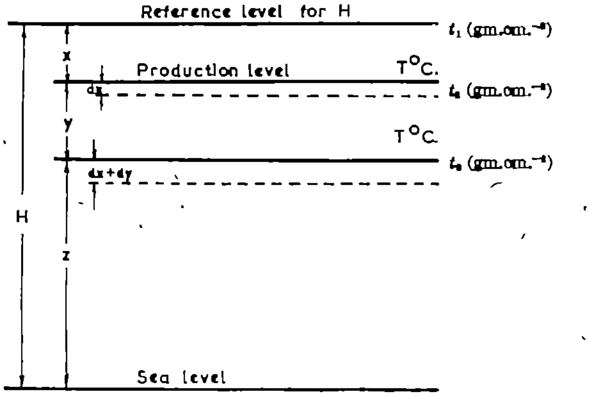
where $I$ is the intensity, $B$ is the air pressure at sea-level, $H$ is the height of the pressure level which is chosen to represent the average atmospheric depth of meson production, and $T$ is the temperature just below this level. A bar above a quantity denotes its mean value.

The first term of equation (1) is due to the absorption in the atmosphere. The second term is due to the decay of mesons in flight. The third term was first introduced by Duperier[1]. The observed positive correlation was interpreted as being due to competition between decay and capture of the π-mesons. The probability of decay into a μ-meson is:

$$P \approx 1 - \rho L_\pi / R_\pi, \qquad (2)$$

where ρ is the density of the air, $L_\pi$ is the mean range of the π-mesons before decay and $R_\pi$ is the mean free path for nuclear absorption. It is assumed that $\rho L_\pi \ll R_\pi$, as is the case in the upper atmosphere. Equation (2) shows that this effect must give rise to a positive correlation between $I$ and $T$. However, the corresponding temperature coefficient, $c_1 = dP/dT$, could not account for more than one-third of the observed effect[2].

I wish to point out and discuss two other effects which may together be responsible for the apparent discrepancy. In order to simplify the discussion, we will assume that all π-mesons are produced at the same atmospheric depth of $t_2$ gm.cm.$^{-2}$ (see diagram). Because of the short mean life of the π-mesons, most μ-mesons will be produced very close to the same level. The two other pressure-levels shown in the diagram will also be used in the discussion. The variable $H$ in equation (1) denotes the height of the level at $t_1$ gm.cm.$^{-2}$, and $T$ denotes the mean temperature between this level and that at $t_3$ gm.cm.$^{-2}$.



If the levels $t_1$ and $t_2$ do not coincide, the height of the meson-producing layer will be a function of both $H$ and $T$. This will give rise to an additional temperature coefficient:

$$c_2 = \frac{1}{L_\mu}\,\frac{dx}{dT}, \qquad (4)$$

where $L_\mu$ is the mean range of the μ-mesons before decay. If $t_2 > t_1$, then $c_2 > 0$, and vice versa.

When traversing the atmosphere, the μ-mesons lose energy, and their apparent mean life will decrease. Therefore, between the levels $t_2$ and $t_3$ the mean range $L_\mu'$ before decay will be greater than the mean range $L_\mu''$ between $t_3$ and sea-level. If now $T$ increases, the distance $y$ must increase while $z$ must decrease, which gives rise to a positive temperature effect. Hence

$$c_3 = \left(\frac{1}{L_\mu''} - \frac{1}{L_\mu'}\right)\frac{dy}{dT} \qquad (5)$$

will give an estimate of the order of magnitude of this effect.

As Duperier[2] has measured $c$ for the two cases $t_1 = 50$ mb. and $t_1 = 100$ mb., we will also calculate $c$ for these two values of $t_1$. For the same reason we chose $t_3 = 200$ mb. (1 mb. = 1·02 gm.cm.$^{-2}$). As the meson-producing radiation is absorbed exponentially[3], with a mean range of 120 gm.cm.$^{-2}$, the average depth of production is $t_2 = 120$ gm.cm.$^{-2}$. The value of $L_\mu$ has been calculated from Duperier's height coefficient[2], $b = 3{\cdot}48$ per cent per km., which gives $L_\mu = 28{\cdot}8$ km. From the known energy loss of the μ-mesons in the atmosphere, we then get $L_\mu' = 33{\cdot}4$ km, and $L_\mu'' = 28{\cdot}2$ km. Then we use the relation $L_\pi/L_\mu \approx \tau_\pi/\tau_\mu$, where $\tau_\pi$ and $\tau_\mu$ are the real mean lives of the two kinds of mesons, to obtain $L_\pi = 0{\cdot}363$ km. For $R_\pi$ we use the geometric mean free path, which is 60 gm.cm.$^{-2}$ in air. Thus we have certainly not under-estimated $c_1$. The values of $\tau_\pi$, $\tau_\mu$ and other necessary constants were taken from Rossi's recently published book[3].

The results are, in per cent per deg. C.:

|  | $t_1 = 100$ mb. | $t_1 = 50$ mb. |
|---|---|---|
| $c_1$ | 0·052 | 0·052 |
| $c_2$ | 0·019 | 0·090 |
| $c_3$ | 0·008 | 0·008 |
| $c$ | 0·079 | 0·150 |
| Duperier | 0·075 ± 0·010 | 0·143 ± 0·015 |

Duperier's results have been included for comparison. The agreement is very good. However, one must not forget that the calculations were based upon a very simplified model of the cosmic radiation. It is quite possible that the results of a more exact calculation would not agree so well with the experimental temperature coefficient; such a calculation is now in progress.

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March 5.

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## Scatter Fringes of Equal Thickness

It is possible to test an optical system by means of white-light interference between two or more wave-fronts which have been scattered by equivalent obstacles out of the same collimated beam.

Consider, for example, an optical system in which a small portion of the field is strongly illuminated with white light. If a screen of moderate scattering power (say, a microscope slide which has been aluminized while in contact with a piece of lens tissue) is introduced into the entrance pupil, then the observer sees the remainder of the field stop illuminated by a diffuse diffracted halo. If a second exactly conjugate screen is placed in the exit pupil so that it appears identical with the image of the first screen except for imaging errors and for some relative displacement, white-light fringes are formed on the field stop by the two scattered beams.

Where the first screen is seen imaged without sensible error, for example, by a plane mirror, the fringes observed are of equal inclination, well-known examples being Newton's diffusion fringes and Quetelet's rings. If, on the other hand, the first screen is being imaged by an imperfect system and is adjusted to nominal coincidence with its fellow, corresponding fringes of equal optical thickness are produced. Light scattered by the first screen suffers distortion by the system to form the error wave-front; but the second or reference wave-front is substantially free from error since its parent beam has traversed that system in concentrated fashion. The fringe pattern therefore represents the wave-front error with which the entrance pupil is being imaged on to the exit pupil, a bright achromatic fringe covering those portions of the field for which the transit time is the same as for the directly illuminated patch.

The practical possibilities of these fringes of equal thickness do not seem to have been explored. For optical testing they have one advantage in that they do not lose contrast in the presence of considerable tilt or asphericity. Of particular interest is their application to imaging systems of unit magnification such that one screen is (1) imaged by a through type or autostigmatic system on to an identical replica; (2) imaged back on to itself enantiostigmatically; or (3) repeatedly imaged on to itself in a multiple-beam arrangement.

Preliminary experiments on the first two types suggest that the fringes may be useful for testing large mirrors, camera lenses and microscope objectives, and possibly for interference microscopy. The fact that the fringes are self-compensating for path-length and, in the second case, for odd azimuthal errors suggests various engineering applications. Further investigation is taking place.

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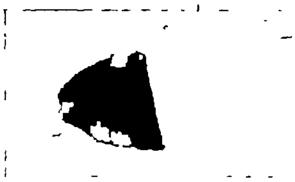
## Kramer and Russell Effects with Single Crystals of Zinc

A short while ago, Kramer[1] directed attention to the fact that abraded or worked metal surfaces emit negatively charged particles which can activate an open-ended Geiger–Müller counter operated in air. Kramer assumed the particles to be electrons, emitted owing to phase changes occurring on the freshly disturbed metal surface. Haxel, Houtermans and Seeger[2] confirmed these observations, but offered an explanation based on adsorption phenomena. Gobrecht and Barsch[3] brought forward evidence that changes of phase are not directly responsible for the phenomenon. Work at the Mechanical Engineering Research Laboratory confirmed the previous observations, but also established by measurements of ionic mobility that the particles triggering the counter are oxygen-molecule ions. It was further found that the 'active' areas behave essentially as having a lower work function than is usually ascribed to the particular metal. Abraded specimens or evaporated films gave thermionic counts at lower temperatures and photoelectric counts at longer wave-lengths than aged or unabraded surfaces of the same metal.

Experiments carried out with single crystals will illustrate this. Single crystals of zinc (kindly given to us by Dr. A. J. W. Moore) were cleaved in the (0001) plane. One of the cleaved surfaces was abraded, whereas the other was left undisturbed. Both surfaces were investigated by means of an open-ended Geiger–Müller counter operating at a pressure of 10 cm. of mercury (9 cm. mercury of air + 1 cm. mercury of ethyl alcohol). The response of the two surfaces to daylight through glass (with most of the ultra-violet wave-lengths cut off) was determined. Great care was taken to make the geometrical and illumination conditions identical in both experiments, and alternate counts were taken from the two surfaces in order to take account of the decay of the response. To eliminate stray fields from the counter, a zinc grid was interposed between counter and specimen and operated at a positive potential so that the field between the specimen and grid was 20 V./cm. Under these conditions, the cleaved surface gave 40 counts/min., whereas the cleaved and abraded surface gave 275 counts/min.

The cut-off wave-length for the photoelectric response of zinc lies normally well in the ultra-violet at about 3000 A. The fact that the cut-off wave-length had been shifted into the visible spectrum to about 5000 A. indicates that the abrasion process produces, on the surface, areas of low work function, possibly by the intermingling of oxide and metal phases.

The behaviour of the surfaces was further checked by means of the Russell effect, which, as has previously been suggested[4], is usually associated with surfaces giving Kramer counts. Another single crystal of zinc was treated as in the previous experiment. Both the cleaved and the cleaved and abraded surfaces were exposed to an Ilford *Q* plate for 20 hr. After development the image shown in the accompanying photograph was obtained. The cleaved and abraded surface gave a very dark image, whereas the cleaved surface gave scarcely any image.



(a) Cleaved (b) Cleaved and abraded

These and other experiments of similar nature lead us to believe that the abrasion of metals causes the formation of sites of low work function, and that these sites are responsible for the so-called Kramer effect.

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Dec. 10.

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## The New Classical Electrodynamics

Except for a gauge-fixing condition, Dirac's recent theory[1-3] corresponds to the natural form of Maxwell–Lorentz electrodynamics for very fine-grained streams of charged corpuscles all with the same constant mass $\mu$ and charge $\epsilon$; the velocity field in the stream is supposed to be continuous and differentiable. The ratio $\mu'/\epsilon$ is written $k$; here $\mu'$ is the measure of $\mu$ in energy units: $\mu' \equiv \mu c^2$. (We call this first special form of the theory the *superconductive theory*, since its equations will be seen to be entirely equivalent to those of the relativistic form of the Maxwell–London theory when only supercurrents are present. As not all electrodynamics is superconductive, this theory is insufficiently general.) It is evident intuitively that in the uniform stream theory[3], where $\mu$ and $\epsilon$ are everywhere constant, a non-trivial electrostatics is impossible; for example, it is not possible to describe as a static situation a charged dielectric, or any system with a space-charge which appears at rest macroscopically. For this and other reasons, connected with the existence of more than one kind of elementary particle, one is led to generalize the pre-quantum theory by allowing the mass $\mu$ and charge $\epsilon$ to be variable in space-time. Such a theory may be called the general stream theory, and will be considered elsewhere. Here we confine ourselves to discussing some characteristic physical consequences of (*a*) the equations of motion, and (*b*) the gauge condition of the uniform stream theory. These follow from the assumption of:

(*a*) Differentiability of the 4-velocity field $v^\alpha = dy^\alpha/ds$ under the Lorentz law of motion, that is,

$$A_{\alpha\beta}v^\beta = -k\,dv_\alpha/ds = -kv_{\alpha,\beta}v^\beta. \tag{L}$$

(*b*) The requirement that $A_\alpha - kv_\alpha$ be orthogonal to $v_\alpha$, that is,

$$A_\alpha v^\alpha = k. \tag{D}$$

Here $s$ is the proper time (in light-velocity units) along the world-line $y^\alpha$ of any corpuscle, $A_\alpha$ is the electrodynamic 4-vector potential, and $A_{\alpha\beta} \equiv A_{\beta,\alpha} - A_{\alpha,\beta}$ is the space–time curl of $A_\alpha$; the comma followed by subscript $\alpha$ indicates differentiation with respect to the space–time co-ordinate along the $\alpha$-direction.

(*a*) The expression of $dv_\alpha/ds$ as $v_{\alpha,\beta}v^\beta$ assumes that corpuscle velocities at neighbouring points in space–time have neighbouring values, and that first derivatives with respect to space and time exist (except possibly for special boundaries and points). It is interesting to note that, without some assumption of this type, grave difficulties are experienced already in the older theory when one tries to obtain the relations of macroscopic phenomenological electrodynamics by averaging over the classical electron theory in a relativistically invariant way[4].

It is convenient to introduce several abbreviations. With the ***kinetic field*** $V_\alpha \equiv kv_\alpha$, and the potential field $A_\alpha$, we may define the ***stream field***:

$$S_\alpha \equiv A_\alpha - V_\alpha. \tag{1}$$

By adding to (*L*) the expression $kv_{\beta,\alpha}v^\beta = 0$, which follows from $v_\beta v^\beta = 1$, we find that $S_{\alpha\beta}$, the space–time curl of $S_\alpha$, satisfies

$$S_{\alpha\beta}V^\beta = 0, \tag{L'}$$

while (*D*) may be written: $S_\beta V^\beta = 0$. $\quad$ (*D′*)

(*b*) The physically observable electromagnetic field $A_{\alpha\beta}$ is invariant under the addition to $A_\alpha$ of an arbitrary gradient $G_{,\alpha}$ and allows the freedom to impose a gauge condition. In the present theory, the chosen condition (*D*) relates the $A_\alpha$ to the $v^\alpha$ and hence to the observable 4-current density of classical electrodynamics. It seems most natural to interpret this current density $J^\alpha$ as the manifestation of concentration and velocity in the stream of corpuscles. Thus we may write:

$$J^\alpha = N\epsilon v^\alpha \equiv \frac{\lambda}{c^2}V^\alpha \quad \lambda \equiv c^2N\epsilon/k \equiv N\epsilon^2/\mu, \tag{2}$$

where $N$, the *corpuscle concentration*, represents at each point the number of corpuscles contained in a unit co-moving volume (that is, moving along with the local stream). $N$ (or $\lambda$) is a scalar density.

Though Dirac[1] considers that only the ratio $e/m$ $(\epsilon/\mu)$ should enter into a prequantum theory of electrodynamics, it seems rather more likely, as Born[5] has remarked, that "the classical radius of the electron" $e^2/mc^2$ should also appear; this quantity occurs in theories of phenomena which are generally regarded as classical, for example, in the (J. J. Thomson) scattering of long electromagnetic waves by loosely bound electrons. We see that, with our interpretation, the field variable $\lambda = Nc^2\,(\epsilon^2/\mu c^2)$ does indeed introduce the characteristic length $\epsilon^2/\mu c^2$ in a natural way. In fact, this length signifies the ratio of the current value associated with a moving corpuscle to its kinetic field value. In the superconductive theory, $V^\alpha = A^\alpha$, and $\lambda$ corresponds to $1/\Lambda$, where $\Lambda$ is the London parameter[6]. For an ordinary macroscopic superconductor, $\lambda \simeq 10^{31}$ sec.$^{-2}$, and, setting $\epsilon^2/\mu c^2 \simeq 3 \times 10^{-13}$ cm., we find

$$N \simeq 0{\cdot}4 \times 10^{22}\ \text{cm.}^{-3},$$

or the number of 'superconducting electrons' is of the same order of magnitude as the number of atoms in a volume element.

We turn now to the kinetic consequences of the stream theory. These may be described in the following geometrical way. Any bivector at a point in the 4-dimensional realm is representable either by a single plane patch of area or, at most, by two mutually perpendicular plane areal patches. (*L′*) means that the bivector $S_{\alpha\beta}$ is totally perpendicular to the time-like 4-vector $V^\beta$ and is therefore uniplanar and space-like. Now with the gauge condition (*D′*), $S_\beta$ is also made perpendicular to $V^\beta$. $S_\alpha$ then lies in the plane of its own curl, that is,

$$S_{\alpha\beta}S_\gamma + S_{\beta\gamma}S_\alpha + S_{\gamma\alpha}S_\beta = 0,$$

and this is the necessary and sufficient condition that, with an integrating factor, $S_\alpha$ becomes proportional to an irrotational vector:

$$S_\alpha = \xi\eta_{,\alpha}. \tag{D''}$$

This is the form which Dirac uses as the basis of his variational development[1]. It is evident that the surface $\Sigma$ determined by ($\xi$ = constant, $\eta$ = constant), at any point, is the integral manifold of (*L*) and of

$$S_\alpha dy^\alpha = \xi d\eta = 0 \tag{D'''}$$

taken together. In other words, all world-lines or path curves satisfying (*L*) and (*D*) passing through the given point lie on what formally appears to be a two-dimensional surface[3] $\Sigma$. There is an apparent difficulty here from a physical point of view in that this seems to restrict unduly the possible motions of corpuscles. This difficulty is removed when we remember that $\Sigma$ is definable by its property of being totally perpendicular to the space-like plane of $S_{\alpha\beta}$ at the given point. But $S_{\alpha\beta}$ at the given point does not define a unique plane in space-time, since it depends also on the components of the ***vorticity*** $V_{\alpha\beta}$, themselves determined by the velocity and its derivatives. In fact, in the general uniform stream theory, the variety of possible world-lines through a point is the same as that of the possible trajectories in the traditional Lorentz particle theory. The actual restriction brought in by the condition of continuity and differentiability of $V^\alpha$ appears in the initial conditions, that is, neighbouring corpuscles must be assigned neighbouring velocities, so that bundles of corpuscles may diverge or converge only in a gradual manner.

The case is otherwise in superconductive electrodynamics. The possible velocity distributions (and magnetic fields) associated with a given electric field are much more restricted. Here an eigen-function problem presents itself which will be dealt with elsewhere.

M. AVRAMY MELVIN

Palmer Physical Laboratory,
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Princeton, N.J.* Aug. 5.

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* Present address: Florida State University, Tallahassee.

[1] Dirac, P. A. M., *Proc. Roy. Soc.*, A, **209**, 291 (1951).

[2] Dirac, P. A. M., *Nature*, **168**, 906 (1951); **169**, 146 (1952). LeCouteur K. J., *Nature*, **169**, 146 (1952).

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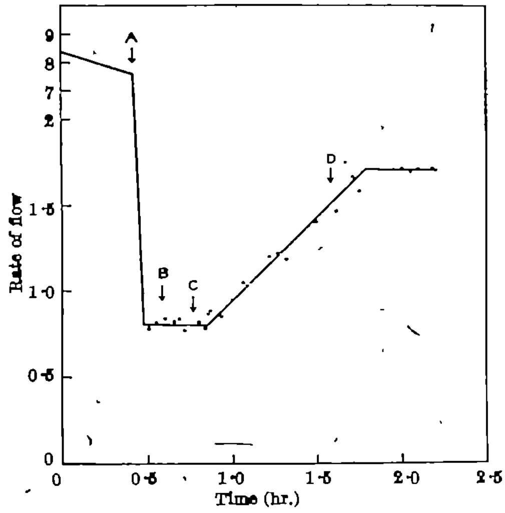
## Formation of Silicotic Tissue

ELECTRON micrographs of normal connective tissue reveal a very fine protein network superimposed on a much coarser network[1]. The interstices are filled with protofibrils and mucopolysaccharidic acids of high molecular weight. Fibrous connective tissue is produced when lung tissue is degenerated by silica particles, the silicic acid formed by the dissolution of the silica probably being involved, and the possible analogy between the role of silicic acid and that of the mucopolysaccharides is evident.

Day[2,3] has shown that the resistance of thin sheets of tissue to the passage of saline is markedly decreased when mucopolysaccharides are removed by hyalase hydrolysis, but that subsequent treatment with chondroitin sulphuric acid again reduces the tissue permeability. Using Day's technique, we find that dilute silicic acid solutions behave in a similar manner to chondroitin sulphuric acid.

The lower orifice of a vertical tube was covered with a membrane of loose connective tissue taken from a rat. Filling the tube with saline, the time required for the passage through the membrane of a predetermined volume of the solution was measured. The permeability of the membrane was low. The addition of hyaluronidase to the saline caused a considerable increase in flow; but subsequent addition of a dilute silicic acid sol restored the original low rate of flow or even rendered the membrane less permeable than it was originally. A typical result is shown in the accompanying graph.



*A*, Hyaluronidase added; *B*, saline added, *C*, silicic acid added; *D*, saline added

It is possible that when pathological changes are initiated by the inhalation of silica, silicic acid functions as an interfibrillary substance analogous to the mucopolysaccharides. The silica particle may thus take the role of the cell producing the macromolecules. In normal fibrous tissue, the mucopolysaccharides are being constantly destroyed by the mucopolysaccharases present in the tissue but are replaced by fresh mucopolysaccharides synthesized by fibroblasts[4,5]. Since there is no enzyme capable of hydrolysing the polysilicic acids formed, the polymers can be removed only by the slow process of physical solution, which is retarded as the silicic acid accumulates. Aluminium and beryllia, both producing macromolecules analogous to the polysilicic acids, can cause similar pathological changes.

We are indebted to the British Steel Founders' Association for financial assistance and to Benger Laboratories, Ltd., for gifts of hyaluronidase.

P. F. HOLT
S. G. OSBORNE

University, Reading.
March 4.

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[1] Wasserman, F., *Anat. Rec.*, **111**, 145 (1951).

[2] Day, T. D., *J. Physiol.*, 117, 1 (1952).

[3] Day, T. D., *Nature*, **166**, 785 (1950).

[4] Gersh, I., and Catchpole, H. R., *Amer. J. Anat.*, **85**, 457 (1949).

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## The Department of Scientific and Industrial Research and Aslib

THE leading article in *Nature* of April 25 points out that the report for 1951–52 of the Department of Scientific and Industrial Research does not include a justification for the Department's grant to Aslib, and suggests the possibility of overlapping between Aslib and the Intelligence Division of the Department. It is right to say at once that this possibility is constantly borne in mind by the Council of Aslib, which has the advantage of close and continual contact with the Intelligence Division. Part of Aslib's activity is as a clearing-house between its own members, who include those concerned with information and library techniques in scientific and industrial and also in other fields; part consists in organizing the exchange of information on methods of documentation and publishing the results of investigations into them; part again in the promotion of training in these techniques. These things, it is believed, are outside the present scope of the Intelligence Division. In other activities—some of them carried out under contract with the Department of Scientific and Industrial Research—there is danger of overlapping; but it has been kept in mind, and it is hoped with some confidence that it has been avoided.

G. WOLEDGE
(Chairman of Council)
LESLIE WILSON
(Director)

Aslib,
4 Palace Gate,
London, W.8.

# FORTHCOMING EVENTS

(*Meetings marked with an asterisk * are open to the public*)

## Monday, May 18

British Society for the History of Science, Philosophy of Science Group (in the Joint Staff Common Room, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Mr. Braithwaite: "Principles of Choice between Alternative Hypotheses".

## Monday, May 18—Wednesday, May 20

National Trades Technical Societies, Sheffield Section (at Cutler's Hall, Sheffield).—Exhibition of Laboratory Equipment.

## Tuesday, May 19

Society of Chemical Industry, Agriculture Group (in the Chemistry Lecture Theatre, Royal College of Science, Imperial Institute Road, London, S.W.7), at 2.15 p.m.—Annual General Meeting; at 2.30 p.m.—Dr. H. Greene: "Tropical Soils".

Institution of Electrical Engineers, Measurements Section (at Savoy Place, Victoria Embankment, London, W.C.2), at 5.30 p.m.—Prof. J. Z. Young, F.R.S.: "Measurement with the Flying-Spot Microscope".

Royal Statistical Society, Study Section (at the E.L.M.A. Lighting Service Bureau, 2 Savoy Hill London, W.C.2), at 6 p.m.—Mr. L. Moss: "Sample Surveys and their Use for Administrative Purposes".

## Tuesday, May 19—Friday, May 22

Institution of Gas Engineers (at Church House, Westminster, London, S.W.1).—90th Annual General Meeting.

## Wednesday, May 20

Physical Society, Colour Group (at the E.L.M.A. Lighting Service Bureau, 2 Savoy Hill, London, W.C.2), at 3.30 p.m.—Scientific Papers.

Royal Meteorological Society (at 49 Cromwell Road, London, S.W.7), at 5 p.m.—Scientific Papers.

Royal Society of Medicine, Section of Comparative Medicine (at 1 Wimpole Street, London, W.1), at 5 p.m.—Discussion on "Organic Manures and Fertilizers and the Production and Composition of Food for Man and Animals".

Institution of Electrical Engineers, Supply Section (at Savoy Place, Victoria Embankment, London, W.C.2), at 5.30 p.m.—Dr. E. C. Bullard, F.R.S.: "The Utilization of Solar Energy".

Society of Public Analysts and Other Analytical Chemists (at the Chemical Society, Burlington House, Piccadilly, London, W.1), at 7 p.m.—Scientific Papers.

## Wednesday, May 20—Friday, May 22

European Association of Exploration Geophysicists (at the Maison des Centraux, 8 Rue Jean Goujon, Paris).—Fourth Meeting.

## Thursday, May 21

Society for Endocrinology (at the Medical Society of London, Chandos Street, London, W.1), at 9.30 a.m.—Symposium on "The Determination of Adrenal Cortical Steroids and their Metabolites".

Physical Society, Acoustics Group (joint meeting with the Royal Aeronautical Society, at the Institution of Mechanical Engineers, Storey's Gate, St. James's Park, London, S.W.1), at 10 a.m.—Symposium on "Aeronautical Acoustics—in particular Jet Noise".

Ross Institute of Tropical Hygiene, Industrial Advisory Committee (at the Rubber Growers' Association, 19 Fenchurch Street, London, E.C.3), at 2.15 p.m.—Discussions on "Tropical Health Problems and their Connection with Industrial Relations" (Speakers: Mr. C. R. Harrison and Prof. G. Macdonald).

Class of History of Medicine (in the Physiology Class Room, The University, Edinburgh), at 5 p.m.—Dr. Douglas Guthrie: "Trends and Fashions in Medicine". (Further Lectures on May 25, 28, June 1, 4 and 8.)

London Mathematical Society (at the Royal Astronomical Society, Burlington House, Piccadilly, London, W.1), at 5 p.m.—Prof. C. Lanczos. "Convergent Differentiation of the Fourier Series".

Royal Anthropological Institute (at 21 Bedford Square, London, W.C.1), at 5.30 p.m.—Mr. J. W. Y. Higgs: "The Scope of Rural Collections".

Royal Society of Tropical Medicine and Hygiene (at Manson House, 26 Portland Place, London, W.1), at 7.30 p.m.—Dr. J. C. Broom: "Leptospirosis in Tropical Countries".

## Friday, May 22

Royal Institution (at 21 Albemarle Street, London, W.1), at 9 p.m.—Sir Lawrence Bragg, F.R.S.: "The Discovery of X-Ray Diffraction by Crystals".

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# APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Assistant Experimental Officer (with sound theoretical and practical knowledge of electronic and controlling instruments) in the Physics Department—The Secretary, National Institute for Research in Dairying, Shinfield, Reading, quoting 53/9 (May 23).

Chemists (Scientific Officer grade, Ref. F.185/53A, and Experimental Officer grade, Ref. F.186/53A) at Ministry of Supply Research and Development Establishments at Waltham Abbey, Sevenoaks, Farnborough, Salisbury, Westcott and Aldermaston, for work in physical chemistry, modern analytical techniques, explosives, radio chemistry, and bacterial chemistry—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting the appropriate Ref. No. (May 23).

Lecturer in Aircraft Structures, an Assistant "B" in Electrical Engineering, an Assistant "A" in Engineering Drawing, a Demonstrator in Electrical Engineering and Physics, and a Demonstrator in Mechanical Engineering—The Principal, Royal Aircraft Establishment Technical College, Farnborough, Hants (May 23).

Lecturer in Metallurgy (with a degree in metallurgy or A.I.M., together with teaching or industrial experience) in the Chemistry Department—The Principal, Derby Technical College, Normanton Road, Derby (May 23).

Physiologist (with good honours degree in physiology, or an equivalent qualification, and research experience preferably involving the perfusion of isolated organs) for research on the physiology of lactation—The Secretary, National Institute for Research in Dairying, Shinfield, Reading, quoting 53/3 (May 23).

Scientific Officer to assist with survey and research on soil fauna in the field and laboratory, at the Research Institute, Grange-over-Sands, Lancs—The Establishment Officer (Sc.), The Nature Conservancy, 91 Victoria Street, London, S.W.1 (May 23).

Senior Lecturer in Physics—The Registrar, College of Technology, Birmingham 1 (May 23)

Principal Scientific Officer at the R.A.F. Institute of Aviation Medicine, South Farnborough, to take charge of a small scientific unit concerned with effects of acceleration on man and animals, and to be responsible for detailed planning, from a fundamental aspect, of long-term programme of a physiological nature, dealing largely with changes in the circulation—The Civil Service Commission, Scientific Branch, Trinidad House, Old Burlington Street, London, W.1, quoting S.420/53 (May 28).

Assistant Lecturer (Grade B) in Botany—The Clerk to the Governors, Chelsea Polytechnic, Manresa Road, London, S.W.3 (May 29).

Mathematicians (Scientific Officer or Experimental Officer grades) in Ministry of Supply Research and Development Establishments at Sevenoaks, Farnborough, Amesbury and Malvern, for work in aerodynamics, aircraft structures, ballistics, radio or radar, high speed electronic calculating machines—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting A.117/53A (May 29)

Educational Psychologist—The Secretary for Education, County Buildings, Shrewsbury (May 30).

Lecturer in Civil Engineering (preferably with experience in structures or soil mechanics)—The Registrar, The University, Sheffield (May 30).

Lecturer in Physiology—The Registrar, King's College, Strand, London, W.C.2 (May 30).

Mechanical and Aeronautical Engineers in the Ministry of Supply Research and Development Establishments at Farnborough, Sevenoaks, Chertsey and Amesbury, for research work on (Ref O.240/53A) aircraft and associated equipment; (Ref. O.245/53A) gas turbine engines and design work on (Ref. O.246/53A) armaments; (Ref. O.247/53A) wheeled and tracked vehicles—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting the appropriate Ref. No. (May 30).

Scientific Officer (with a first- or second-class honours degree or equivalent in metallurgy) at a Ministry of Supply establishment in South-East London—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting F.159/53A (May 30).

Esso Studentship in Chemical Engineering—The Registrar, Imperial College of Science and Technology, South Kensington, London, S.W.7 (June 1).

Lecturer in Geology and Mineralogy—The Secretary, The University, Aberdeen (June 1).

Guinness Research Fellowship in Microbiological Chemistry—The Whitley Professor, Department of Biochemistry, The University, South Parks Road, Oxford (June 6).

Head of the Civil and Mechanical Engineering Department—The Clerk to the Governors, Woolwich Polytechnic, Woolwich, London, S.E.18 (June 6).

Lecturer in Agricultural Botany at the University College, Ibadan, Nigeria—The Secretary, Inter-University Council for Higher Education in the Colonies, 1 Gordon Square, London, W.C.1 (June 6).

Lecturer or Assistant Lecturer in Philosophy, and a Senior Lecturer or Lecturer in Chemistry, at the University of Malaya, Singapore—The Secretary, Inter-University Council for Higher Education in the Colonies, 1 Gordon Square, London, W.C.1 (June 6).

Scientific Officers (2) at the Forest Products Research Laboratory, Princes Risborough, for research on wood bending and seasoning—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting C.99/53 (June 6).

Chemist (with good honours degree, or equivalent) for analytical investigational work in the Coal Survey Laboratory, Chester—The National Coal Board, Establishments (Personnel), Hobart House, Grosvenor Place, London, S.W.1, quoting TT./630 (June 8).

Electronic Apprenticeships at the Telecommunications Research Establishment and the Radar Research and Development Establishment, Malvern—The Ministry of Supply, D.T.O. (Industrial), 66-72, Gower Street, London, W.C.1 (June 8).

Principal Scientific Officer in the Intelligence Division, Department of Scientific and Industrial Research, London—The Civil Service Commission, Scientific Branch, Trinidad House, Old Burlington Street, London, W.1, quoting S.4204/53 (June 10).

LECTURER IN CHEMISTRY (preferably with special knowledge of agricultural chemistry)—The Principal, Seale-Hayne Agricultural College, Newton Abbot, Devon (June 13).

ESSO STUDENTSHIP IN CHEMICAL ENGINEERING—The Registrar, The University, Birmingham (June 15).

CIVIL ENGINEERS in Government Defence Departments—The Civil Service Commission, Scientific Branch, Trinidad House, Old Burlington Street, London, W.1, quoting S.64–65/53 (June 30).

DAVID BROWN SCHOLARSHIP IN AGRICULTURAL ENGINEERING—The Registrar, King's College, Newcastle-upon-Tyne (July 15).

MYCOLOGISTS (3) (with good honours degree in botany, preferably with systematic mycology as a special subject, and some experience in identifying micro-fungi) at the Commonwealth Mycological Institute—The Secretary, Commonwealth Agricultural Bureaux, Farnham Royal, Bucks (July 15).

ASSISTANT LECTURER (primarily interested in microbiological chemistry or cell biochemistry) IN THE DEPARTMENT OF MICROBIOLOGY—The Registrar, The University, Reading (July 18).

ASSISTANT (graduate in metallurgy, physics, or chemistry) IN THE INFORMATION DEPARTMENT—The Secretary, British Non-Ferrous Metals Research Association, Euston Street, London, N.W.1.

ASSISTANT ENGINEER IN THE HYDROLOGICAL SURVEY DEPARTMENT, Uganda—The Director of Recruitment, Colonial Office, Great Smith Street, London, S.W.1, quoting CDE.189/9/01.

ASSISTANT ENGINEERS IN THE PUBLIC WORKS DEPARTMENT, Tanganyika—The Director of Recruitment, Colonial Office, Great Smith Street, London, S.W.1, quoting CDE.112/8/03.

ASSISTANT LECTURER (Grade B) IN BIOLOGICAL SUBJECTS in the Department of Chemistry and Applied Chemistry—The Principal, Royal Technical College, Salford, 5.

ASSISTANT METEOROLOGIST (with at least three years experience in forecasting for aviation) to the Gold Coast Government—The Crown Agents for the Colonies, 4 Millbank, London, S.W.1, quoting M3B/33547/NF.

BIOCHEMIST (with mature and varied experience in isolation of pure substances from biological materials) to develop and apply biological methods to synthesis of compounds labelled with Carbon 14 and other radioactive isotopes (Ref. F.180/53A); and CHEMISTS (with good all-round laboratory experience in inorganic, organic or analytical chemistry) for duties concerned with synthesis of compounds labelled with radioactive isotopes by chemical and biological methods, extraction of radioactive isotopes from irradiated materials at high levels of activity, production of radioactive appliances for medical and industrial use, associated analytical problems (Ref. F.182/53A); at the Ministry of Supply Radiochemical Centre, Amersham—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting the appropriate Ref. No.

BIOCHEMIST (senior grade) at the County Hospital—The Secretary, York "A" and Tadcaster Hospital Management Committee, Bootham Park, York.

CHEMIST OR PHYSICIST (with good honours degree) for interesting work on problems associated with the hardening of Portland cement—The Controller, Cement and Concrete Association Research Station, Wexham Springs, Stoke Poges, Bucks.

DESIGN ENGINEERS in the Ministry of Supply at Harwell, to assist on design problems of control and instrumentation for new types of reactors—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting D.186/53A.

ENGINEER (Mechanical) in the Ministry of Supply at Harwell to work on mechanical design and specification of new types of reactors—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting C.252/53A.

ENGINEERS (electrical) to assist design, planning, construction, of electrical plant and services for large new project, at Harwell—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting D.187/53A.

ENTOMOLOGIST (with at least second-class honours degree in entomology) in the British Solomon Islands Protectorate—The Director of Recruitment, Colonial Office, Great Smith Street, London, S.W.1, quoting CDE.87/45/01.

EXECUTIVE ENGINEER IN THE PUBLIC WORKS DEPARTMENT, Fiji—The Director of Recruitment, Colonial Office, Great Smith Street, London, S.W.1, quoting CDE.112/49/02

INDUSTRIAL CHEMIST at Harwell to assist in problems associated with treatment of radioactive material, water supplies, and general chemical service—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting F.170/53A.

LECTURER IN PHYSICS, and an ASSISTANT LECTURER IN ZOOLOGY (Grade B or Grade A), at Brighton Technical College—The Director of Education, 54 Old Steine, Brighton 1.

LECTURER IN PHYSIOLOGY AND PHARMACOLOGY—The Registrar, The University, Nottingham.

LECTURER in PURE MATHEMATICS—The Head of Mathematics Department, Imperial College of Science and Technology, South Kensington, London, S.W.7.

METALLURGIST (graduate or A.I.M.) to undertake research on improved tin alloys—The Director, Tin Research Institute, Fraser Road, Perivale, Greenford.

PHYSICIST (of graduate or equivalent standing) for work involving the application of physical methods to dust problems and to metallurgical research, and a METALLURGIST (of graduate or equivalent standing) in connexion with a programme of work relating to the establishment of basic data on the physical and mechanical properties of steel in cast form—The Director, British Steel Castings Research Association, Broomgrove Lodge, Sheffield 10.

SENIOR LECTURER IN PHYSICS—The Secretary, Royal Technical College, Glasgow.

SENIOR MECHANICAL AND ELECTRICAL ENGINEER in the Public Works Department, Sudan—The Sudan Agent in London, Sudan House, Cleveland Row, London, S.W.1, quoting 'M/E Engineer 1813'.

SENIOR SCIENTIFIC OFFICER (Ref. C.237/53A) to be responsible to Head of Fundamental Studies Group for leading team engaged on fundamental engineering design studies for new types of nuclear reactors, and SCIENTIFIC OFFICERS (Ref. C.238/53A) to assist in these studies, at the Atomic Energy Research Establishment, Harwell—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting the appropriate Ref No.

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# REPORTS and other PUBLICATIONS

*(not included in the monthly Books Supplement)*

## Great Britain and Ireland

Philosophical Transactions of the Royal Society of London. Series B: Biological Sciences. No. 644, Vol. 237: A Study of the Branched Cells of the Mammalian Epidermis with Special Reference to the Fate of their Division Products. By R. E. Billingham and P. B. Medawar. Pp. 151–171. (London: Cambridge University Press, 1953.) 9s. [123

Scientific Proceedings of the Royal Dublin Society. Vol. 26 (N.S.), No. 7: Effects of some Single Viruses and of Combinations of the same Viruses on Three Potato Varieties. By Robert McKay and James B. Loughnane. Pp. 133–143+plates 10–11. (Dublin: Royal Dublin Society, 1953.) 4s. [123

Brompton Hospital Reports: a Collection of Papers recently Published from the Hospital. Vol. 21, 1952. Pp. vii+206. (London: Brompton Hospital, 1953.) 15s. net. [123

British Journal of Animal Behaviour: Official Journal of the Association for the Study of Animal Behaviour. (Quarterly.) Vol. 1, No. 1, January. Pp. 40. (London: Baillière, Tindall and Cox, Ltd., 1953.) Annual subscription, 27s. 6d. [173

Bulletin of the British Museum (Natural History). Zoology, Vol. 2, No. 1: The Ostracod Genus *Trachyleberis*. By J. P. Harding and P. C. Sylvester-Bradley. Pp. 16+2 plates. 4s. Zoology, Vol. 2, No. 2: On the Puerulus Stage of some Spiny Lobsters (*Palinuridae*). By Isabella Gordon. Pp. 17–42. 6s. (London: British Museum (Natural History), 1953.) [173

## Other Countries

Gold Coast. Forestry Department Bulletin No. 4: The Vegetation Zones of the Gold Coast. By C. J. Taylor. Pp. vi+12. (Accra: Government Printer, 1952.) 2s. 6d. [53

Publications de l'Institut National pour l'Étude Agronomique du Congo Belge. Série Scientifique No. 55: Cartographie et caractérisation pédologique de la Catena de Yangambi. Par Prof. L. De Leenheer, J. D'Hoore et K. Sys. Pp. 62. 50 francs. Série Scientifique No. 56: Recherches sur la transpiration et le bilan d'eau de quelques plantes tropicale (Palmier à huile, Caféier, Cacaoyer, etc.). Par Dr. A. Ringoet. Pp. 139. 140 francs. (Bruxelles: Institut National pour l'Étude Agronomique du Congo Belge, 1952.) [103

Companhia de Diamantes de Angola. Publicacoes Culturais No. 15: Museu do Dondo; Subsidios para o estudo da biologia na Lunda. Estudos Diversos, 7. Pp. 136. (Lisboa: Companhia de Diamantes de Angola, 1952.) [103

Institut de France. Académie des Sciences Annuaire pour 1953. Pp. 248. (Paris: Libr. Gauthier-Villars, 1953.) [103

Norsk Polarinstitutt. Meddelelser Nr. 69: Norsk Ishavsfangst, en fortegnelse over litteratur. Ved Adolf Hoel. Pp. 22. 2.50 kr. Meddelelser Nr. 70: Plants collected in Vestspitsbergen in the Summer of 1933. By Asbjørn Hagen. Pp. 14. 2 kr. Meddelelser Nr. 71: Conglomerates formed in situ on the Gipshuk Coastal Plain, Vestspitsbergen. By Rolf W. Feyling-Hanssen. Pp. 9. 2.50 kr. Skrifter Nr. 97: The Downtonian and Devonian Vertebrates of Spitsbergen, 9, Morphologic and Systematic Studies of the Spitsbergen Cephalaspids, Results of Th. Vogt's Expedition 1928 and the English-Norwegian-Swedish Expedition 1939. By Gustav Wängsjö. A, Text. Pp. 615. B, Plates. Pp. 42+118 plates. 75 kr. (Oslo: Jacob Dybwad, 1952.) [103

Leybold Polarographische Berichte. Band 1, Heft 1-2, Oktober. Pp. 54. (Koln: Staufen-Verlag, 1952.) Jährlich, 10 D. marks. [103

Articulos cientificos publicados en America Latina. Vol. 3, 1950. Pp. viii+324. (Montevideo: Centro de Cooperacion Cientifica de la Unesco para America Latina, 1952.) [103

Bulletin of the Madras Government Museum. New Series, General Section, Vol. 3, No. 4: Indian Epigraphy and South Indian Scripts. By C. Sivaramamurti. Pp. viii+280+12 plates. (Madras: Government Press, 1952.) 14.8 rupees. [103

Universität Hamburg. Abhandlungen aus dem Gebiet der Auslandskunde, Band 57, Reihe C, Naturwissenschaften, Band 16: Regionale Typen im Jahresgang der Niederschläge in Vorderindien und ihre Beziehung zu Landschaftsgrundlagen. Von Hildegard Ludwig. Pp. ix+144. (Hamburg: Cram, de Gruyter und Co., 1953.) 21 D. marks. [103

Scientific Reports of the Indian Agricultural Research Institute for the Year ended 30th June 1950. Pp. 101. (Delhi: Manager of Publications, 1952.) 3.12 rupees; 6s. [103

Commonwealth Scientific and Industrial Research Organization. Bulletin No. 268: An Australian Phytochemical Survey, 2, Alkaloids in Queensland Flowering Plants. By L. J. Webb. Pp. 99. Bulletin No. 270: Rubber Accumulation in Guayule (*Parthenium argentatum* Gray) in South Australia. By R. E. Shapter. Pp. 31+8 plates. (Melbourne: Commonwealth Scientific and Industrial Research Organization, 1952.) [103

Bernice P. Bishop Museum. Bulletin 208: Report of the Director for 1951. By Charles H. Edmondson. Pp. 48. Bulletin 209: The Flora of Ponape. By Sidney F. Glassman. Pp. 152. Special Publication 42: Charles Montague Cooke, Jr., a Bio-Bibliography. By Yoshio Kondo and William J. Clench. Pp. v+56. (Honolulu: Bernice P. Bishop Museum, 1952.) [103

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# STATE SUPPORT FOR SCIENTIFIC RESEARCH

THE National Science Foundation was established in the United States in 1950, and is, in some of its functions, the counterpart of the Department of Scientific and Industrial Research in Great Britain. Thus it awards a substantial number of scholarships and graduate fellowships in the sciences, promotes the exchange of scientific information, assesses scientific investigations undertaken by Federal establishments and so on. The allocation of Federal monies for research purposes is in the hands of the National Science Board, consisting of twenty-four persons eminent in science, medicine, engineering, agriculture, education or public affairs; these men, and the executive director of the Board, are appointed by the President of the United States and the appointments are confirmed by the Senate. The first chairman of the Board was Dr. J. B. Conant, now U.S. High Commissioner in Western Germany.

The second annual report of the National Science Foundation*, for the fiscal year 1952, has a foreword by Dr. C. I. Barnard, now chairman of the National Science Board, who insists that the present restriction of appropriations to a maximum of 15 million dollars in any year seriously limits the capacity of the Foundation for carrying out effectively its statutory directives; sufficient funds for the full development of the potential scientific man-power resources of the United States have not been available, and Dr. Barnard maintains that man-power is the critical factor. The proportion of the population potentially capable of assimilating the training required of scientists, or possessing the curiosity, interest and ambition to pursue effective scientific careers, is strictly limited compared with the need for such trained individuals in the development of fundamental science. Moreover, social organization and scientific development have now much reduced earlier limitations on the rate at which practical results could be expected to come from the application of science; and this justifies a greater expenditure of man-power, resources and money solely for the extension of knowledge and development of fundamental scientific ideas for their potential, if not immediately apparent, practical significance.

Dr. Barnard's generalization that we have reached the stage when the maintenance of an expanding pool of tested scientific knowledge is good economics, as well as indispensable in the effective utilization of the world's natural resources for the needs of an increasing and under-nourished population, and essential for military or economic security, is as valid in Great Britain as in the United States; though with the reservation that, in Great Britain, finance and economic resources are perhaps of greater significance than, as in the United States, man-power. Nor would it appear that the significance of fundamental science for our national life, indeed for our international interests, is better understood in Britain than in the United States. Dr. Barnard can find greater encouragement in the support of the scientific community during the Foundation's difficult initial period than could the Advisory Council for Scientific and Industrial Research in its recent report. Neither the Department nor the Foundation can hope to be effective without the active support of scientists and of their institutions.

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* Second Annual Report of the National Science Foundation, Fiscal Year 1952. Pp. viii+77. (Washington, D.C.: Government Printing Office, 1953.) 30 cents.

Dr. Barnard refers also to the danger, inherent in any government organization for promoting basic science, which lies in its propensity to exercise the kind and degree of control appropriate to research and development more closely related to immediate practical ends. That danger is known in Great Britain, and here again the chief safeguard, as he remarks, in addition to the integrity and understanding of the director and members of the Board, is the extensive, active co-operation of scientists in general. Like the Department of Scientific and Industrial Research with its advisory boards and assessors, the Foundation depends for wise judgment of the merits of scientific research proposals upon the personal advice of those most competent and respected in their various fields, and the collaboration of scientists is also indispensable to the Foundation in evaluating scientific progress and scientific needs. This is a task of great delicacy, and in seeking, as required by the Act, to evaluate scientific progress and locate fields that need scientific development, the Foundation must rely upon such collaboration if it is to avoid the dangers of indirect control, too strict adherence to scientific orthodoxy or discouragement of independent research in fields of great potential importance.

Apart from its operational responsibilities for the support of basic research in the sciences, the encouragement of young scientific talent by the award of graduate fellowships, the improvement of science teaching and broadening the flow of scientific information, for which the Foundation has had to devise suitable and effective techniques, the report records definite progress by the Foundation in both the fact-gathering and the analytical phases of policy development. During the year, the Foundation started, as the first of a continuing series of fact-gathering studies under a newly established Programme Analysis Office, to compile statistical information on Federal obligations for research and development at non-profit institutions. Other studies will be concerned with the organization of Federal agencies for research administration and with their budgets for research and development, the content of their research programmes and the impact of Federal support of research upon industrial development and upon colleges and universities in the United States. The Foundation is also supporting an investigation by the American Physiological Society on the content and scope of the physiological sciences, the role of physiology in the realm of education, the professional personnel in the field and the scientific contribution which may be expected of physiology over the next few years and present plans to achieve it.

Besides this, the Foundation has undertaken some short-range studies on scientific topics which are urgent from the point of view of national defence, welfare or scientific promise. The aim in such studies is to determine the extent and kind of Federal support and the outline of basic research needed to make the most rapid progress. Examples cited are the studies of the status, need and potentialities of basic research in high-temperature physics, chemistry and metallurgy, and on the utilization of solar energy from the point of view of both the biological and the physical sciences. The Foundation is also making a full inventory of existing scientific and technical knowledge and research on techniques and instruments for exploration for minerals.

Even this brief summary indicates that, in framing both its short-term and its long-term policy, the National Science Foundation is going far beyond the surveys in 1938 and 1940 of the National Resources Committee and the National Resources Planning Board, respectively, and is covering ground that in Great Britain, at least in part, is dealt with by the Advisory Council on Scientific Policy and by the Select Committee on Estimates, for example, in its report during the session 1946–47 on expenditure on research and development. As the President of the United States emphasized in a message to Congress in January 1952, on the basis of these studies the Foundation will formulate a broad national policy designed to assure that the scope and the quality of basic research in the United States are adequate for national security and technological progress. The Foundation is responsible for a continuing analysis of the whole national effort in basic research, including the evaluation of the research programmes of other Federal agencies.

Although this conception follows the recommendations of the Hoover Commission, it does not appear that support for such a policy is any more firmly assured in the United States than in Britain. The preliminary figures from its survey of the national research effort quoted in this report indicate that the national expenditure on scientific research and development in 1952 was about 3,000 million dollars, of which nearly two-thirds came from the Federal Government, one-third from industry and three per cent from universities. The greater part of this expenditure, and, accordingly, of the available research facilities and specialized man-power, is committed to specific programmes, such as the discovery of new products and cheaper or more efficient processes.

This position is regarded by the Foundation as a serious threat to the security and future well-being of the United States. Great advances in science have seldom come from such applied research, and, in the view of the Foundation and its advisory groups, the corner-stone of national scientific policy is to secure adequate support, in terms of scientific workers and facilities, as well as funds, for basic research in the sciences. The Foundation, moreover, is intended to become, ultimately, the principal agency through which the Federal Government gives support to basic research that is not directly related to the statutory functions of other Federal agencies, and specifically it is responsible for stimulating or sponsoring basic research in subjects which might otherwise receive insufficient attention. Adequate general support of basic research and training in the sciences constitute, the Foundation remarks in this report, a defence in depth which is essential for the establishment and maintenance of technological supremacy—or perhaps one might better say, excellence.

By the end of 1952 the Foundation was in a position to take the lead in Federal support of basic research, both by considering support of such research in fields receiving inadequate attention and by stimulating or sponsoring such research in scientific subjects of general importance to other Federal agencies. In doing this, however, the Foundation fully recognizes the extent to which success in framing a national science policy depends upon the full co-operation of scientific men in educational institutions, in industry and in the Federal Government service. It claims no monopoly of constructive thinking on these problems; but it is already clear that the Foundation's assertion that it can accelerate the formulation of policy and buttress scientific progress, particularly to meet the unique requirements of the United States, is fully justified. The Foundation points out that, as a country, the United States do not fully appreciate the importance of basic research to technology, tending to reverse the technological sequence—basic research, applied research, development. When all allowance is made for differing conditions in the United States, the experience of the Foundation cannot fail to provide much that is helpful as well as interesting to those responsible for the formulation of scientific policy in Great Britain. The progress of the National Science Foundation and the success of its efforts to correct the lack of balance, especially in times of crisis, between the support of basic research and applied research and development, will be watched and followed with keen interest.

# THE PROGRESS OF ELECTRONICS

Advances in Electronics

Edited by L. Marton. Vol. 3; pp. xii+357; 7.50 dollars. Vol. 4; pp. x+344; 7.80 dollars.
(New York: Academic Press, Inc.; London: Academic Books, Ltd., 1951–52.)

ALTHOUGH there has been a certain amount of resistance to its introduction on the part of physicists and electrical engineers, the term 'electronics' has now become well established as somewhat loosely defining a portion of the field of electrical science. The developments that have taken place in this subject during the past decade or so have been so rapid and extensive that the description of the results achieved occupies a relatively large portion of the scientific and technical literature of the present time. It was with the object of producing a guide to the research worker anxious to acquaint himself with advances in related fields that publication began a few years ago of a series of volumes entitled "Advances in Electronics" under the editorship of Mr. L. Marton, of the National Bureau of Standards, Washington, D.C. The first volume was published in 1949 (see *Nature*, 163, 893; 1949) and was followed a year later by Vol. 2 (*Nature*, 169, 50; 1952).

In the preface to the first volume, an explanation is given of the difficulty which confronted the board of editors in defining the scope of the subject with which they intended to deal. It was decided to limit the scope of their work to the publication of critical and integrated reviews of specific topics in the field of physical electronics and in selected branches of engineering electronics. In connexion with the latter, it was desired to keep to a reasonable minimum discussion of the instrumental and circuit techniques which are associated with electronic devices and which form the subject of a large part of the current technical periodical literature.

In view of the fact that Vol. 3 in the series was published in the first half of 1951, and Vol. 4 late last year, it would seem that it is the ambition or intention of the editorial board to make this an annual series. Furthermore, it is to be noted that, whereas in the first volume all the contributors were drawn from the United States of America, some of the contributions in the two latest volumes are by eminent men of science and engineers in Britain and France.

The first contribution in Vol. 3 is on field emission microscopy, by F. Ashworth, and this summarizes the experience gained in the investigation of the possibilities of the field-emission microscope, which under suitable conditions may achieve resolving powers of atomic dimensions and magnifications up to a million. The next chapter, on velocity-modulated tubes, brings together the combined experience of four workers in France and California in a review of the theory and mode of operation of the klystron which has proved so useful in the generation and amplification of electrical oscillations at frequencies from a few hundred megacycles per second upwards. There follow two papers on the electronic theory of the plane magnetron, by L. Brillouin, and of the cylindrical magnetron, by L. Brillouin and F. Bloch; these should prove useful to those concerned with the design and development of this type of tube, which seems almost indispensable for the generation of considerable powers at extremely high frequencies. The more practical developments in small electronic components are dealt with in two contributions from the National Bureau of Standards under the titles of tube miniaturization, by J. E. White, and subminiaturization techniques, by G. Shapiro. The last three contributions are more directly related to some of the developments in modern electrical communications, and the ever-present problem of securing an adequate signal as free as possible from any accompanying and disturbing noise. The principles of pulse code modulation are reviewed by H. F. Mayer; modern methods of network synthesis are summarized by E. A. Guillemin; and a timely and useful critical examination of communication theory is presented by M. Leifer and W. F. Schreiber as a conclusion to the volume.

The fourth and most recent volume opens with a theoretical paper on electron scattering in solids, by Prof. H. S. W. Massey, who discusses elastic and inelastic scattering of fast electrons in solids and also multiple scattering and diffusion, and the relative importance of the different processes which determine the electrical resistance of metals, alloys and semiconductors. Next follows a contribution by G. A. Morton on the scintillation counter, one of the most valuable tools in the field of nuclear research for the detection of high-energy radiations. This discussion indicates the general principles of the phosphor crystal radiation-detector, and its uses and limitations for counter purposes. The article should prove a useful starting-point to those concerned with improving the performance and reliability and the range of applications of the scintillation-counter. The random motion of free electrons in a conductor or the emission of electrons by the cathode of a vacuum tube gives rise to those spontaneous fluctuations of electricity now generally known as 'noise'. In an article on fluctuation phenomena, A. van der Ziel reviews the Fourier analysis of the subject and the application of the phenomena to various generators, including vacuum and gas-discharge tubes, and crystal diodes and transistors. The scope of the subject covered is perhaps indicated by the fact that the list of references at the end of the contribution includes ten books, seven review papers and some ninety original papers. The subject of electronic digital computers is next dealt with by C. V. L. Smith, who reviews the recent development of high-speed automatically sequenced computers. This article includes a description of the machines developed in the United States known as 'Whirlwind', with its special electronic storage tube, and 'SEAC', which at present uses mercury line storage but is so constructed as to permit the later incorporation of cathode-ray-tube storage on the principles developed by F. C. Williams in Great Britain. The magnetron valve again receives attention in this series with a very practical paper entitled modulation of continuous-wave magnetrons, by J. S. Donal, jun. The last two papers in Vol. 4 also strike a more practical and novel note in dealing with, respectively, the magnetic airborne detector, by W. E. Fromm, and multi-channel radio telemetering, by M. G. Pawley and W. E. Triest. The development of both these subjects originated during the Second World War; but it is clear that there are civil applications of the instruments and techniques described, and it is most useful to have these reviews of the progress made during the past decade.

In most cases the contributions in both volumes are accompanied by a selected bibliography which will be valuable in guiding the research student to more detailed knowledge where he desires to seek it. The volumes are very well presented in a uniform style, and there is no doubt that the editor and his advisory board are rendering a great service to the scientific community in presenting this series, which will find an important place on our bookshelves.

R. L. Smith-Rose

# ECONOMIC PLANTS OF THE WORLD

## Economic Botany

A Textbook of Useful Plants and Plant Products. By Albert F. Hill. (McGraw-Hill Publications in the Botanical Sciences.) Second edition. Pp. xii+560. (London: McGraw-Hill Publishing Co., Ltd., 1952.) 59*s*. 6*d*.

EVERYTHING that helps towards a fuller realization and better understanding of our dependence on the plant world is of value to-day, and the second edition of Dr. A. F. Hill's well-known book will therefore be welcomed not only for itself but also for its considerable contribution towards this end.

The book may be described, like its predecessor, as an invaluable compendium of useful information about useful plants, presented in a way which, though perhaps a little staccato for some tastes, is both direct and simple. In general form it closely repeats the first edition, but it has been brought generally up to date and particularly so with regard to such matters as rubber, antibiotics, artificial fibres, new drugs and so on. A noteworthy addition is a very clear diagram illustrating the modern chemical utilizations of wood.

It is the easiest thing in the world to reproach a book for not being what its author never intended it to be, and Dr. Hill makes it plain that he does not essay to deal with many of the economic and social problems of his subject; but it must nevertheless be admitted that the first pages of the introductory chapter, which is entitled "The Importance and Nature of Plant Products", do something less than justice to the rest of the book. There is a certain bleakness about them, and a slightly more humanistic approach would not only help to illumine the main body of the book, but would also put into truer perspective some of the author's comments on certain agricultural policies and practices. Similarly, in the new preface the emphasis is on plants as strategic materials rather than on their significance as one of the potential ultimate sources of world prosperity and tranquillity. It is this emphasis again, perhaps, that accounts for the rather unexpected order of treatment in the main text, which, beginning with the industrial plant-products such as fibres, wood, rubber and the rest, goes on then to drugs and leaves food supplies until the last. But as regards this book, these are matters of form rather than substance; and although they may involve some difference of opinion, they do not detract from the achievement in Dr. Hill's valuable work. It is a book which claims a rightful place not only in every botanical library but in many others also.

Ronald Good

# SCIENCE APPLIED TO FOOD

## Food Science

A Symposium on Quality and Preservation of Foods. Edited by Dr. E. C. Bate-Smith and T. N. Morris. Pp. xvii+319+17 plates. (Cambridge: At the University Press, 1952.) 40*s*. net.

TO the scientific worker concerned with the study of food this book is of particular interest and value in that it deals mainly with the chemistry and biology of food materials, with little ordinary technological matter.

The book is, as the editors state, "a collection of lectures by contributors each of whom is an authority in his own field", and is not offered as a comprehensive text-book of food science. It is such study of the fundamentals of food science that is properly the function of the State-owned research stations—and this aspect is a predominant feature in these lectures, which give clearly and concisely a record bringing up to date our scientific knowledge of the subjects discussed. The contributions are written in a simple, logical and direct manner, and the information is given briefly yet with adequate explanation. The style of composition is pleasing and is the same in all chapters, giving a sense of uniformity throughout the book.

The book is incomplete as a text-book on food science; but it does cover a large and a very important part of the subject. This will be realized from its contents, which consist of a well-balanced and thoughtful introduction followed by successive chapters on economics, supply and distribution of foods in the United Kingdom; the principal foodstuffs—meat, fish, eggs, fresh fruit and vegetables, potatoes and cereals; the basic constituents of foods—proteins, mucopolysaccharides and mucoproteins, carbohydrates and fats; some aspects of quality in foods; the micro-organisms; chemical mechanisms of spoilage; and the principles of food preservation. No chapter of the book gives a full account of the subject discussed—indeed, this would necessitate a book on each—but what is done is to give information and explanation which should advance the intelligent application of science to the study and the industry of food.

Though the standard of information and description is in general a high one which can be properly understood and appreciated only by those who have considerable scientific knowledge and some experience of food science, there are included matters such as data and statements on well-known technical procedures which, though perhaps essentials of the course of lectures, are not so valuable in a book of this standard. This is noticeable especially in Chapter 7 on "The Principles of Food Preservation", which consists largely of such matter, and markedly so in the section on sugar preserves, no doubt because sugars are relatively simple and well-understood constituents of food and because, too, new work in this subject is more associated with their analytical separation and measurement—which matters do not come within the purview of this book. One point of criticism is that the reader may feel, as I certainly did, that in some of the sections there are too many references quoted, many of which seem unnecessary.

E. B. HUGHES

# VESALIUS ON THE BRAIN

## Vesalius on the Human Brain

Introduction, Translation of Text, Translation of Descriptions of Figures, Notes to the Translations, Figures. By Charles Singer. (Publications of the Wellcome Historical Medical Museum, New Series, No. 4.) Pp. xxvi+152. (London, New York and Toronto: Oxford University Press, 1952.) 21*s*. net.

THE writer of this review is conscious that its title may be perverted into a *double entendre*, and indeed it does recall the following incident. When Harvey Cushing was staying with Osler at his Oxford house, familiarly known as "The Open Arms", a visitor who called to see them was told by Lady Osler that the two Vesalius lunatics were in the Bodleian Library. To these two romantic disciples of Vesalius may now be added a third, in the formidable person of Dr. Charles Singer.

A detailed annotated translation into English or other modern language of the whole of the "Fabrica" of Vesalius is long overdue, although it could not fail to be a profitable enterprise, and its paramount importance to the historian of science is only too evident. The difficulty of the undertaking, however, amply explains the delay. In fact, it seems as if nothing short of a panel of scholars would suffice for the task. Vesalius's Latin is often bewildering, and his meaning may be so obscure as to call for very free and imaginative translation, nor does he always acknowledge his debts to predecessors. Hence the translators must be able to command a knowledge of the history of anatomy as it came down to Vesalius from the time of the Greeks. A few of the figures are also incomprehensible, and even so learned and experienced an interpreter as Dr. Singer is constrained to give them up. Some translation has already been attempted. We have a beautifully printed French version by Verschaffelt of the first six chapters (Haarlem, 1924), English translations of the last chapter and the preface by Farrington (1931–32), German and three Dutch translations of the Epitome (1543, 1569, 1583–86, 1647), English translation by Saunders and O'Malley of Lib. I, Chap. 39 (1946), English translation of the captions of the figures by Saunders and O'Malley (1950), English translation of the Epitome by Lind and Asling (1949), and minor fragments by Lambert and Hotchkiss (1935, 1942). These, however, touch no more than the fringe of the task, and most of them lack the indispensable commentary.

Dr. Singer's translation is based on the first edition of the "Fabrica"; but the second edition has been drawn upon for corrections and additions. These are the only editions for which Vesalius himself was responsible. If we may assume that the high standard of Dr. Singer's edition will be maintained in the complete work, we shall have a modern version of the "Fabrica" of the utmost value, since it could no longer be excusable to consult the illustrations without studying the text.

The present monograph opens with an introduction, in which the author extols the "Fabrica" as one of the great achievements of the human spirit. Its beautiful figures, he says, are Vesalius's most permanent contribution to science, and they establish exact graphic treatment as an essential adjunct of biological research, and as the *causa causans* of the organic sciences. He, however, emphasizes that Vesalius's anatomy is by no means all human. For example, the vascular system is derived from various animals, and may be roughly described as the venous system of ungulates and the arterial system of monkeys. The Introduction includes a brief analysis of the seven books of the "Fabrica", its 'tiresome' Ciceronian literary style, Vesalius as a physiological Galenist, and Vesalius as a discoverer and his debts to his predecessors, especially in regard to his work on the brain. The excellent diagram of Galen's physiological system on p. xix fails to show, what Dr. Singer, of course, knows full well, that the pulmonary artery and precaval vein are afferent and efferent to the heart according to Galen, and that the anterior projection of the "rete mirabile" is the modern chorioid plexus of the lateral ventricle.

The Introduction is followed by the English translation of Chapters 1–12 and 18 of Book 7, which deal with the brain and its dissection, after which come Dr. Singer's instructive notes and comments. Finally all Vesalius's figures of the brain are reproduced and their captions translated, to which are added some pre-Vesalian brain figures by Laurentius (1518), Berengarius (1523), Dryander (1536) and Stephanus (published 1545).

Dr. Singer is to be warmly congratulated on this highly important addition to the Vesalian corpus.

F. J. COLE

## The Philosophy of the Enlightenment

By Ernst Cassirer. Translated by Fritz C. A. Koelln and James P. Pettegrove. Pp. xiii+366. (Princeton, N.J.: Princeton University Press; London: Oxford University Press, 1951.) 40s. net.

THIS is a translation of Prof. Ernst Cassirer's "Die Philosophie der Aufklärung" (1932). It is very welcome, and the Princeton University Press has produced a result in keeping with a great theme. The first three chapters give the 'feel' of the Enlightenment, whereas the rest offer more specific information. The appropriate headings comprise religion; the conquest of the historical world; law, State and society; fundamental problems of æsthetics. In all this the reader is confronted by the age of reason, an age bubbling with enthusiasm and seemingly indifferent to the existence of any situation incapable of a purely rational solution. Yet historically it was the heir apparent rather than the heir presumptive (for those having eyes to see) of the Renaissance and the Reformation.

To French clarity of thought, the pedigree must have seemed wholly adequate; to British minds, less shaken by the Reformation, its appeal was perhaps more formative than doctrinal. But in any event, philosophy had come back, true to type, as a way of life, self-liberated from the academic prison. It was to swell over everything, conquering and to conquer. The epoch cannot, however, be described as basically irreligious (as Prof. Cassirer says, undiluted scepticism could never have achieved so much); rather was the tendency one towards transcendentalism, especially in Germany. The paradox of the Enlightenment remains—its rejection of much of the past, coupled with the remarkable stability of a subsequent system founded essentially upon the outcome of a series of severe, and often painful, operations.

F. I. G. RAWLINS

## Medieval Logic

An Outline of its Development from 1250 to c. 1400. By Philotheus Boehner. Pp. xvii+130. (Manchester: Manchester University Press, 1952.) 12s. 6d. net.

THE author of this valuable historical study modestly claims that he is pointing to a gap in our common knowledge, not filling it; but, in fact, he does a good deal more. His aim is to show two things: that the traditional logic of the text-books, including those of the neo-scholastics, contains no more than part of the medieval logic; and that twentieth-century symbolic logic is a development on the same lines as the part that has been missed out, and in no sense in opposition to medieval ideas as some of its exponents have imagined. It was Kant, not the medievals, who alleged that logic had sprung perfect and fully armed from the brain of Aristotle, as Athena from the head of Zeus. Their view, Father Boehner claims, was that Aristotle had devised the "Ars Vetus" and that they were devising the "Ars Nova", continuing, developing and completing what he had successfully begun. The difficulty for the student of the present day is that so much of the work of the thirteenth and fourteenth centuries is inaccessible; some of it exists only in the form of a single manuscript.

The medieval thinkers developed a theory of 'supposition', of what terms stand for and what substitutions can be made, and also a theory of 'consequences', of the relation 'if—then'. William of Ockham, it appears, used the notion of 'material implication', commonly believed to be the invention of Lord Russell. Most of their ideas go easily and very conveniently into modern notation. Father Boehner makes a useful comment on this point. "Modern logic has made a decided step forward in assuming only a few constants which serve the purpose of bringing about an extremely simplified language. With these constants, their definitions and the rules governing their use, the scholastic theory of supposition has disappeared. It has vanished, however, at the cost of creating a new terminology foreign to that of any ordinary language. Though the language of logic has gained in clarity and precision, it has not been without a price."

A. D. R.

## Practical Chemistry for Schools and Intermediate Students

By J. W. Davis. Pp. xxiv+815. (London: John Murray (Publishers), Ltd., 1952.) 15s. 6d.

THIS book describes more than a sufficient number of chemistry experiments to meet the requirements of the General Certificate of Education of both the Ordinary and Advanced level. Much of the material is off the beaten track, for the author, Mr. J. W. Davis, is known among teachers for his resourcefulness and his novel ideas. Mr. Davis dispenses with chapters and divides his matter into sections, to which he devotes the following number of pages: general chemistry, 71; qualitative analysis, 29; volumetric analysis, 68; preparations (organic and inorganic), 108; and miscellaneous, 33. The last section should be especially interesting to teachers; it contains notes on such matters as the running of a laboratory, the care of apparatus and the uses of various appliances. The full course of volumetric analysis runs mostly on customary lines but includes a few novelties. The scheme of qualitative analysis, framed for mixtures containing one metal per group, exhibits no unusual features. It is in the preparations and in the many informative experiments illustrative of fundamental principles that one meets the author's skill and originality. Herein Mr. Davis displays a rare aptitude for modifying classical experiments and familiar techniques and devising new ones with economy of time and apparatus. His book can be confidently recommended.

## Joy and Verity, other Poems and a Poetic Drama

By Dr. Marie C. Stopes. Pp. 126. (London: Hogarth Press, 1952.) 6s. net.

THIS is the latest volume of a series of poetical works by Dr. Marie Stopes that began to appear in 1939. They are interesting in that love is treated passionately from a feminine point of view, and that the author does not hesitate to touch the themes of science with emotion and with imagination.

The outstanding poem in the volume is the title poem of forty-one stanzas, "Joy and Verity", which contains the distillation of a whole philosophy of life.

Personally, I enjoyed the poetic drama "Antigone Awakened". The matter is interesting—the theme of Sophocles' play with another ending. The spoken words of the actors and the chorus run easily and leave a feeling of freshness and of music.

Dr. Marie Stopes has always been a crusader. One gets more than a hint that the reforming spirit is now turning its attention to the breaking down of the inhibitions of scientists.

F. K.

# LIVERPOOL MEETING OF THE BRITISH ASSOCIATION

THIS year the British Association will meet in Liverpool for the sixth time. Between the first occasion in 1837 and the last in 1923, the alteration in the character of the meetings has reflected the change in the status and the role of the scientist no less than its proceedings have recorded the progress of a revolutionary age. In 1837, the president was William Cavendish, Earl of Burlington; but the address was read by Prof. Traill. Few records of the meeting survive beyond the girdings of the critics at what was thought to be the excessive degree of feasting and festivity. In 1854 the president was again a man of affairs, the Earl of Harrowby, and his address, carefully composed and resounding in phrase, was in part the conventional record of the Association's work during the year and in part an expression of his own views on the place of science in the community.

The later meetings, in 1870, 1896 and 1923, brought men of quite different outlook and reputation to the presidential chair. The first was T. H. Huxley, who delivered a remarkable address on the history of the rise and progress of a single biological doctrine which he termed biogenesis. In 1896 Lister spoke on Rontgen rays, on Pasteur's work on fermentation and then, for the first time before a public audience, about his own contribution to antisepsis. It is interesting to recall that Rutherford, who was president at the Liverpool meeting of 1923, attended his first meeting of the Association in 1896. It was natural that he should refer to it in the address which he delivered in 1923. "The visit to your city in 1896 was for me a memorable occasion, for it was here that I first attended a meeting of this Association, and here I read my first scientific paper. . . . The year 1896 has always seemed to me a memorable one for other reasons for in looking back with some sense of perspective we cannot fail to recognise that the last Liverpool meeting marked the beginning of what has been aptly termed the heroic age of Physical Science." It was peculiarly appropriate that Rutherford's presidential address should have been the first to be broadcast. It was a bold experiment on the part of the B.B.C., in the cultural no less than in the technical sense, and even in those days when cumbersome headphones had to be used and the crystal detector delicately adjusted, it seems to have been justified by its success. It was appropriate for another reason that the first such broadcast should be made from Liverpool, because the earliest public demonstration of signalling for short distances by electric waves had been given at the Association's meeting at Oxford in 1894 by Oliver Lodge, who was at that time professor of physics at University College, Liverpool.

Sir Edward Appleton will deliver his presidential address this year on "Science for its own Sake". In addition, Sir Edward will deliver a junior presidential address to student members, the title of which will be "Finding Things out with Radio and Rockets". This event will be an innovation, the idea of which came from the president himself. As at the Belfast meeting, special provision will be made for young people. Indeed, it is hoped that the active participation of young people on a larger scale than ever before will be a feature of the meeting. The local education authorities of Merseyside have expressed a lively interest in the project; and, with their co-operation, it is confidently expected that there will be a thousand student members at the meeting.

The handbook, "A Scientific Survey of Merseyside", has been prepared under the editorship of Prof. Wilfred Smith, and the majority of the articles have been written by his colleagues in the University. Those who know the care and time which have been given to the preparation of the handbook are confident that it will be an authoritative presentation which will merit a permanent place on the bookshelf as a work of reference.

The evening discourses will be given by Sir Harold Spencer Jones on "Continuous Creation" and by Mr. Eric Shipton on "Everest". The presidential addresses in the sections range from "The Development of Organic Chemistry since the Time of Liebig" by Prof. G. R. Clemo, to "Open and Repressed Monetary Inflation" by Prof. F. W. Paish. Not the least attractive should be the address in Section L by Mr. Robert Birley, headmaster of Eton College, under the provocative title, "Greek or Chemistry or Both ?".

The programme of general excursions is varied; they will range as far as Lake Vyrnwy in one direction and Lake Windermere in the other. Some of the sectional visits of more technical interest will be to the developing chain of light industries on either side of the Mersey. Further, after the meeting ends, there will be a special visit to the Isle of Man during September 9–12 at the invitation of the trustees of the Manx Museum.

There is no doubt of the welcome that Liverpool will give to the Association. The city values its long connexion with the British Association and the forthcoming meeting is anticipated with eagerness. The Norman Lockyer Lecture which was delivered by Sir Harold Spencer Jones in January was immensely successful. The Philharmonic Hall was filled and could have been filled again.

The University is especially proud to receive the Association in its own jubilee year, the celebration of which has just ended. Since the last meeting in Liverpool the accommodation of the University, for the smaller meetings, has been considerably extended, and the sections will have ample space within the precinct for most of their activities. The inaugural meeting will be held on September 2 in the splendid Philharmonic Hall belonging to the City, and will be preceded by a special congregation of the University for the conferment of honorary degrees.

The local committee for the meeting is confident that, under the presidency of Sir Edward Appleton, it will be an outstanding success; for it will bear the impress of its president's rare qualities of intellect and character.

# STANDARD SAMPLES OF ORGANIC SUBSTANCES FOR PHYSICO-CHEMICAL MEASUREMENTS

By D. AMBROSE

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FORMULATION of the fundamental laws of chemistry depended upon the recognition that properties of pure substances are constants which can be measured, and improvements in technique have required ever higher standards of purity in the samples used for these measurements, since the values obtained are frequently sensitive to the presence of small amounts of impurities; the use of impure samples is, in fact, one of the chief reasons for distrusting many of the older physical data acquired when chemists were building up the vast body of chemical knowledge, and in recent years a start has been made in accumulating a corresponding body of exact physical knowledge about pure chemical substances. To illustrate the need for this, melting and boiling points, the properties most frequently recorded to characterize substances, may be considered. A pioneer in the study of pure compounds has been Prof. J. Timmermans (of the International Bureau of Physico-Chemical Standards, Brussels), who in his books "Chemical Species" (1941) and "Physico-Chemical Constants of Pure Organic Compounds" (1950) has laid down the principles to be followed in a critical appraisal of published data, and collated what is satisfactory. Of the thousands of organic substances known, data for only about fifteen hundred are included in the publication last mentioned, and whereas the author states that boiling points should be known to 0·05° C. and freezing points to 0·1° C., in few cases is the range of values quoted from different investigators as small as this, even for common substances; for example, there is a range of 0·9° C. for the freezing point of methyl alcohol and 0·6° C. for the boiling point of acetic acid.

Precision is of value not only in fundamental science but also in applied science and industry, and a striking characteristic of modern chemical industry is the increasing stringency of specifications even for technical grades of material. Besides the economic reason that unwanted impurities are paid for as the desired material, pure materials tend to give purer products with greater reproducibility of properties and there is a necessity for purity (or at least a constant composition) in pharmaceutical products where traces of impurity may have great physiological effect. Some years ago, benzene of freezing point 5·4° C. was considered a first-grade material and anything with a higher melting point was almost unknown; but the true freezing point has been established as 5·53° C., and there is now a demand for commercial quantities of material approaching this purity for synthetic processes; a similar situation is arising with naphthalene, for which the present standard test is based on a melting point of 80·2° C., whereas the best value is now 80·27° C., corresponding to a change in the purity as determined by melting point of approximately 0·2 per cent.

This rise in the standard of commercial materials is due to the development of improved methods of analysis and process control which enable specifications to be drawn up and material to be produced nearer to the exact requirements of the user; and satisfactory analytical techniques depend upon the availability of pure reference samples. Such standard samples of inorganic materials have been available for many years; for example, the U.S. National Bureau of Standards has supplied standard alloys and pure metals for the past fifty years, and the system of standard analytical reagents is well established; but the use of organic standards is a recent development with which this article will deal.

## Use of Standard Samples

The uses of standard samples may be broadly divided into two categories. In the first (the primary establishment of standards) fall the determination with the highest attainable accuracy of physical properties of substances, and following those determinations, the intercomparison of measurements made in different laboratories and the transfer of measured quantities from one laboratory to another. For such purposes the user has generally had to purify and standardize the substance himself by applying suitable tests; but in the past ten years a remarkable example of co-operative work has been carried out by the American Petroleum Institute in conjunction with the U.S. National Bureau of Standards in preparing more than two hundred hydrocarbons in a state of the highest attainable purity for the systematic measurement of physical properties at various laboratories. To workers engaged in the field of pure organic compounds, this American contribution, which has been under the direction of Prof. F. D. Rossini, overshadows all others; but consideration that, even so, only about twenty compounds a year are being examined, shows what a stupendous task the collection of physico-chemical data is, and only those restricted fields of chemistry can be examined in which they are most needed.

The second category of uses for standard substances includes those in which the values of their properties as determined with the highest grade of instrument are used to calibrate and check the readings obtained with other instruments. Perhaps the most familiar example of this is the calibration of thermometers at the ice- and steam-points, and water is probably the most widely used standard substance, its triple point, latent heat of fusion, specific heat, and density being used as standards; other examples of the use of standard substances are provided by mercury for measurement of pressure, benzoic acid for calibrating bomb calorimeters and the whole series of secondary fixed points in thermometry. Besides direct calibration, it is useful to be able to check the results of a given method (and the operator) by applying it to a pure material the value for which is known accurately. A typical example occurred in the Chemical Research Laboratory, Teddington, when measurements of the refractive indices of a number of pyridine bases were unaccountably discordant. It was not until samples of pure *n*-pentane were also examined that the cell of the Pulfrich-type refractometer was found to be unsuitable for use with volatile liquids; when the cell had been modified, no further difficulties were experienced. The necessity for this would have been much harder to demonstrate had samples of materials known to be pure not been available.

Fresh interest in the use of standard substances, especially hydrocarbons, has been aroused by the widespread adoption of instrumental methods of analysis; in particular, the infra-red, ultra-violet and mass-spectrometers, the last of which has become a standard method of analysis for hydrocarbon gases in the still rapidly expanding petroleum and petrochemical industries. In general, analysis with these instruments is carried out by consideration of the pattern produced over a wide range of wave-length or mass number, and to this end a large number of spectrograms and cracking patterns of pure materials have been published, chiefly by the U.S. National Bureau of Standards, which do, in fact, enable analyses to be made. It is, however, more satisfactory to check the instrument-reading on a standard sample as well, since different instruments have their own characteristics, causing slight variations in the pattern produced. So marked is this with the mass-spectrometer that frequent recalibration with both pure materials and blends of known composition is needed, since the cracking pattern changes according to the condition of the electrodes. For these purposes it is impracticable for the user to make all the standards he needs, and in any event the use of standards of one origin eliminates a possible source of error when results obtained in different laboratories are to be compared. Requirements for standard samples are therefore still increasing, and in view of their importance the Commission for Physico-chemical Constants of the International Union of Chemistry has decided that one of its aims shall be the encouragement of their use.

## Purification

Generally, the preliminary stages in the preparation of material suitable for use as a standard must be carried out on a relatively large scale to permit the discard later of considerable portions containing impurities; and where possible it is often preferable to start with a commercial grade of the substance, or one closely related, which may be intensively purified to yield a small proportion of high-grade material, rather than to attempt a complete laboratory synthesis. This is the method used for the simpler coal tar and petroleum products such as benzene, toluene and the lower aliphatic hydrocarbons; but suitable raw material is often not available for more complicated substances. Laboratory methods of synthesis have then to be applied, often on an unusually large scale since it is desirable to make batches of about 1 kgm. and, for example, methods have now been developed for carrying out the Grignard reactions necessary in hydrocarbon syntheses on a 50-mole scale. In synthesis it is important that all materials used should be purified to avoid unnecessary impurities arising in the reaction, and further purification should be carried out at each of the intermediate stages even if the yield is thereby much reduced. The methods of purification are the usual ones of the organic chemist—distillation, crystallization, sublimation, adsorption, besides any suitable chemical reactions—but carried to the limit with consequent reduction of yield. In ordinary synthesis a balance has to be struck between the requirements for purity and for high yield; the second cannot be considered in producing material of the highest purity and, for example, in the production of 99·99 per cent benzene the material was crystallized about twenty-five times, while in distillation processes to produce the API-Research samples, often a middle cut of only 200–300 ml. was taken from 1 or 2 litres of already highly purified material.

## Purity: Its Definition and Determination

A pure substance may be considered as one all the molecules of which are identical, and it is customary to express purity in moles per cent, or the fraction of identical molecules in a given sample; but a difficulty arises over the definition of identical molecules because of the existence of isotopes. These cause definite variations in properties, but so minute that separation is rendered exceedingly difficult; not so minute, however, but that the exhaustive fractionation applied in purifying a sample may change the isotopic abundance ratios sufficiently to cause a measurable change in properties. Not only do the isotopic ratios change in the laboratory, but also their slight differences in thermodynamic and kinetic properties have led to natural fractionation so that the natural isotopic ratios are seldom constants. The Pure Metals Commission of the International Union of Pure and Applied Chemistry has resolved this difficulty by adopting two definitions of a pure metal, an 'ideal', and a 'practical'. A practical definition can only be considered in terms of the use to which the purified material is to be put, and the measurement by which the purity is determined. Any absolute definition which might specify the isotopic abundance ratios given by the International Commission of Atomic Weights would be ideal because they are not controllable in highly purified materials, and this applies throughout chemistry.

In setting up a chemical standard, the effect of the residual impurities must be considered; if negligible on the property to be measured, then those impurities may be ignored even though purity determined by other measurements is low. Of course, it will usually happen that a highly purified material will be suitable as a standard for many properties; but this is not always so, and sometimes the requirements for different properties are considerably different or even mutually exclusive. Hence the practical definition of a pure material as one the properties of which are unchanged by further purification must be qualified by a list of those properties, and each material considered separately before the statement of purity is generalized as indicating a standard for all properties. For example, the term 'spectroscopically pure' is used for solvents suitable for spectroscopy, but this merely means that the *cyclo*hexane or *iso*octane frequently used in ultra-violet work is free from impurities which absorb in that region, that is, olefines and aromatics, and they almost certainly contain other naphthenes and paraffins which do not affect their properties in the ultra-violet. Again, the lower pyridine bases all have refractive indices between 1·50 and 1·51, so in a sample of one of the picolines the effect on refractive index of a small proportion of another isomer is negligible compared with the similar proportion of water ($n = 1\cdot33$) which is absorbed on manipulation in air. On the other hand, in standardizing an instrument for the infra-red analysis of mixtures of these substances, it is the isomeric impurity which is of importance since the effect of water is easily allowed for.

Thanks to its special properties at low temperatures, the production of helium containing only $10^{-10}$ impurity has been claimed; but this is unique, and the present limit of impurity removal from organic compounds is usually about $10^{-4}$, a figure which is outside the sensitivity of most chemical methods of analysis applicable to organic materials, for the impurities present are often either homologues or isomers with almost identical chemical properties. Purity determination of organic compounds then depends upon physical measurements, and these should remain unvarying through whatever further process of purification the material is put, or from whatever source it is obtained, whether natural or synthetic. Any suitable physical property may be used, such as density, refractive index, boiling point or vapour pressure, that one being chosen for which so far as possible the substance has a value clearly distinct from its possible contaminants. Spectrometry is usually only a subsidiary method of checking pure compounds, since although sharply defined characteristics of the spectrograms sometimes enable certain impurities to be detected in trace quantities, there are often others present in considerable concentration which cannot be detected. Thus it is usually desirable to combine the results of several methods of testing. During the past ten years, however, methods of freezing-point determination have been developed which enable a quantitative estimate of purity to be made, and this precision and the relative simplicity of the determination have led to their widespread adoption in place of other methods; in fact, it is through this development that the supply of standardized materials has been put on a satisfactory basis. Melting-point determinations have long been used by the organic chemist as a check on purity, the assumption that all impurities lower the melting point being generally valid; but as customarily carried out, they are not precise, and freezing points are now much more accurately determined by plotting cooling curves. A sample of the liquid material is allowed to cool at a controlled rate in a suitable apparatus and its temperature measured precisely, in early methods with a platinum resistance thermometer but now more generally by some kind of automatic recording device, since it is not the absolute temperature but the change in temperature which is of importance. Most liquids must supercool before crystallization will occur, and skill is required to reduce the extent of supercooling to the minimum, by seeding at the right time, so as to produce as smooth a curve as possible. The rate of cooling is made very slow (perhaps 1° in 10 min. before crystallization begins), so that the complete cooling curve may take up to 1½ hr. to plot, and thermal equilibrium between solid and liquid is attained by stirring. In these conditions, when changes in temperature are measured to 0·001° C., a gradual depression is normally found as solidification takes place, from which the purity of the sample can be calculated, the limit of detectable impurity being about 0·01 mol. per cent. It may sometimes be preferable to work in reverse and plot a melting curve, for example, with substances which form glasses under conditions of slow cooling; the validity of the method depends upon the assumption that the pure material crystallizes from the melt, and where this is in doubt more complicated measurements of the specific heat in the melting region are required. These provide an even more sensitive test for impurities, but fortunately there is a large range of substances for which melting- or freezing-point determinations are adequate.

The value of freezing-point determinations is leading to their gradual adoption for routine testing besides the establishment of standards; but in ordinary practice purity is often established by comparing the properties of samples with a standard or the equivalent, the published values. This is actually a way of establishing impurity, but if a number of properties are of the correct value the purity may be considered as satisfactorily established.

## Supply of Standard Samples

The scale and type of work required for the preparation of pure compounds and measurement of their properties has resulted in a small number of laboratories specializing in it, of which the leading one has been the U.S. National Bureau of Standards in Washington. In conjunction with the American Petroleum Institute, about two hundred compounds, mostly hydrocarbons, are supplied in certified purity for use in calibrating spectrometers, and in addition the best samples are available on loan as the API-Research samples to investigators who wish to measure needed physical properties. Purities of these last normally lie between 99·7 and 99·95 mol. per cent, and those of the spectroscopic standard samples only a little lower. (This work has now been transferred to the Carnegie Institute of Technology, American Petroleum Institute Research Laboratory, Pittsburgh 13, Pennsylvania, U.S.A.) Certain hydrocarbons of slightly lower but still high and certified purity are also sold commercially in the United States, and when in 1949, in Great Britain, the Chemical Research Laboratory was asked by the Spectroscopic Panel of the Institute of Petroleum to start a scheme for the supply of standard samples of hydrocarbons, stocks of some of these were obtained for division into small samples, and some from the National Bureau of Standards. This scheme accorded well with the existing programme of the Purification and Measurements Section of the Organic Group of the Laboratory, which was already engaged on the purification of coal tar constituents with the view of measuring the following properties: vapour pressures, melting points, densities, refractive indices, ultraviolet and infra-red spectra, and, in conjunction with the National Physical Laboratory, heats of combustion and specific heats over a wide range of temperature; and the Laboratory now has a list of more than three dozen standard substances available for distribution, of which nearly one-half, including four coal-tar bases and five aromatic hydrocarbons, have been made in Britain. Various industrial firms have co-operated in the preparation of standards by providing suitable stock for purification, and one industrial research laboratory has given material of a purity sufficiently high for use as a standard; such gifts are welcome to augment the restricted resources available to the scheme, and acknowledgment of the source of the materials is made when samples are distributed. In selecting further compounds for inclusion in the standard samples programme, due regard is paid to the direction of the research programme approved by the Chemistry Research Board, and the needs, so far as we can ascertain them, of our customers; for the scheme to be of the greatest service it is essential that the Laboratory should aim at making those standards for which there is the widest demand. In the three years during which the scheme has been in existence, approximately eight hundred samples have been supplied to nearly forty different laboratories in industry and the universities.

This article, describing the background to one aspect of the work of the Chemical Research Laboratory, Department of Scientific and Industrial Research, Teddington, is published by permission of the Director.

# SOME CHEMICAL ASPECTS OF NORMAL GROWTH*

By Prof. F. BERGEL

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In his book "On Growth and Form"[1], where he describes the application of mathematical–physical methods to these two facets of biology, D'Arcy Thompson said that growth was a somewhat vague word for a very complex matter. Stimulated by this remark, a definition of growth and related phenomena was sought. After enumerating examples of mechanical and non-biological growth[2], including that of crystals[3] (illustrated by ciné films[4]), certain basic characteristics emerged, such as dependency on time, interdependency of growth, development and form, and irreversibility of increase in mass or volume. Then attention was turned to the cell as the unit of living matter. There biological growth consists of two kinds: by enlargement—auxetic growth; and by division—multiplicative growth. Further events may take place which are so closely connected with biological growth that they were by necessity included: fertilization, induction and differentiation, maintenance, regeneration and repair. Considering them in the light of elementary cytological knowledge, the following definition of biological growth phenomena was established: they are processes consisting of continuous synthesis of complex cellular constituents from assimilated material, leading through cell enlargement and multiplication to the mature organism, the size of which is determined by certain limiting factors and which often, by production of egg-cells undergoing fertilization by sperms, can perpetuate itself.

The next step was to seek out those problems which have yielded or would yield to a chemical or physicochemical treatment. Obviously energy is required to enable the cell not only to grow and to synthesize its constituents but also to maintain its high degree of orderliness. This energy is provided by light quanta in plants and by oxidation – reduction metabolism in animals. As randomness or disorder from a thermodynamic point of view corresponds to high entropy, and the opposite to low entropy, the carbohydrate and phosphate cycles, coupled to protein and fat metabolism and assisted by innumerable enzymes, generate energy in such form and manner that the remarkable stability of cells and their specific and identical processes—that is, a low state of entropy—are maintained.

Apart from oxygen and water, nutrients reach the cell and penetrate through the lipoproteinous membrane; on the whole, small molecules are taken up with greater ease and are then caught inside the cell by microsomes, mitochondria and the nuclei with their pre-existing large molecules, to be transformed into compounds required by the cell. It is assumed that the identity of specific sequential and steric properties of macromolecules so produced may be due to moulding processes on template molecules.

In contrast to some bacteria and fungi, the growth of which on synthetic media has been studied profitably, amoebæ do not grow on such media, and the development of tissue culture towards the use of synthetic nutrients, as investigated by Dr. C. Waymouth at the Chester Beatty Research Institute, is only slowly progressing. Although one knows at present relatively much about the metabolic events of energy production and the constitution of small molecular cell-constituents, it has taken a long time to sort out these low-molecular essentials with regard to their effect on growth, and it may take very much longer to recognize the possible existence and role of larger particles. The biochemical problems of cell division are not solved yet in detail. Whether the attainment of a critical ratio of size between cytoplasm and nucleus or between surface and volume, or whether with the enlargement of the cell the critical concentration of substances possibly of nucleic acid nature[5] will trigger off mitosis, or whether a number of factors have to come together to this end, the last and true physical or chemical cause of cell cleavage is still largely unknown. Even greater complexities meet the student of the biochemical phenomena of fertilization, induction and cyto- and histo-differentiation. Shifting of nucleic acid gradients[6], mutual influences of the first cells derived from the fertilized egg[7], polarities in the cells and defined evocator substances[8] have been suggested, defended and sometimes abandoned. Particularly, the story of the evocators is in some respects reminiscent of that of the carcinogenic substances, because in both groups a great number of dissimilar substances, maybe by different modes of action, produce the same terminal effects—morphogenesis and malignancy, respectively. Claims have been put forward in favour of embryonic growth factors being replaceable by proteose–polynucleotide combinations[9]. It is not impossible that the disappearance of such specific factors, together with the cessation of sensitivity of most tissues to the action of growth regulators of low molecular weight, may contribute to the slowing-down and final arrest of growth in the adult organism. In addition, mechanical and thermodynamic conditions could lead as well to this phenomenon of limitation of growth, especially if energy required for maintenance and repair reaches equality with that produced by metabolic processes and thus, roughly speaking, loss of heat can be just balanced by intake of food.

## Building Units

It is recognized that, apart from medium-sized and smaller units such as co-enzymes, some hormones, energy carriers and other functional substances, mostly large molecules, are present in cells and participate in their structure, growth and development. On the other hand, still larger particles such as microsomes, mitochondria, chromosomes, nuclei and plasmagenes form the subject of recent investigations which will not be included in this review. Among the macromolecules, proteins and nucleotides seem to play a major part in cellular events. Dr. T. S. Work[10] has, in some recent lectures, described the biosynthesis of proteins. It remains, therefore, to consider the nucleic acid problem and to give some attention to configurational questions with regard to proteins and to the relationship between the synthesis of these two macro-structures so that some of the points touched upon above may become clearer. In Table I the connexions between pyrimidines, purines, nucleosides, nucleotides, and finally ribo- (RNA) and deoxyribo- (DNA) nucleic acids are presented. The biosynthesis of the bases and the sugars have been progressively studied during recent years[11]. The work of the Cambridge school has largely contributed to the final elucidation of nucleosides[12] and, together with the results obtained by American workers, to that of the nucleic acids themselves as poly-3′ : 5′-phosphates.

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* Synopsis of three lectures given at the Pharmacology Department, University College, London, during January–February 1953.

The most stimulating analysis by Brown and Todd[13] of accumulated evidence with the important hypothesis of 2′ : 3′-*cyclo*phosphates as intermediates of breakdown of ribonucleic acid has led to the isolation by Markham and Smith[14] of such compounds from controlled hydrolysis of ribonucleic acid. Table 1 also traces the interconnexions of nucleic catabolism which, so it is believed, following work by Haddow and Timmis[15] on substances producing kidney hypertrophy, is as important for normal growth as their anabolism or synthesis. A study of the enzyme systems responsible for the last stage of the degradation, particularly of xanthine oxidase and its inhibitors, has been commenced in this connexion[16].

From the configurational and physico-chemical point of view, especially according to recent work by Butler *et al.*, Ambrose, and Alexander *et al.*[17], one is more inclined to favour the Furberg variation of Astbury's closely packed column of deoxyribonucleic acid with its bases alternating on both sides of a zig-zag phosphate-sugar chain. This arrangement produces a practical distance of about 7 A. between the acid groups of the polyelectrolyte if the macromolecule is moderately stretched. How this fits in with the newest rope idea of Pauling and Corey[18] for nucleic acid will have to be seen, particularly as nucleic acids *in vitro* and *in vivo* may show differences in steric properties. However, the recent views on structure and physico-chemical properties of proteins[19,20] would fit in well with nucleic acids having, apart from branching, only a statistical but not a factual distance of 3·4 A. between neighbouring acidic groups like the proteins in β-*trans*-configuration between proximate side-chains. There are some steric questions in the protein field to which there exist more than one answer. Proteins can also occur in a contracted α-form, and Pauling and Corey[19] have suggested for this an α-helix arrangement with side-chains at right angles to the axis of the spiral and hydrogen bonding across turns. More recently these American authors[21] expressed themselves in favour of a polypeptide chain helix itself pursuing a helical course ; several of these would form rope-like strands similar to those mentioned above for nucleic acids. As nearly all functional proteins belong to the group of globular proteins, it is important to know something about their history of formation. According to Ambrose[22], they originate in a kind of β-α-pathway (to which reference will be made below) to coil up either as a result of interaction of reactive side-chains or, following Pauling's antigen–antibody hypothesis, around or below another protein molecule of a certain shape. As far as their primary synthesis in β or α form is concerned, this brings one face to face with the problem of identical reproduction of configurational and sequential features of proteins in the cell. Gale's recent work[23] on *Staphylococcus aureus* and the selective inhibitory action of certain antibiotics on the protein and nucleic acid synthesis of these bacteria supports the views expressed before in various quarters that nucleic acid and protein syntheses are interconnected. So far it has not been established in what manner. *In vivo* polynucleotides are always combined with proteinous substances such as histones, protamines or proteins. If one takes into consideration what was said above, namely, that *in vitro* observations may not apply to the conditions in the cell, the speculation that nucleic acids act as templates, or at least as part of templates for their own synthesis and that of proteins, is an attractive one ; but no final proof is as yet available. Recently, Dounce[24] has published some ideas on this subject, the first step of the biosynthesis consisting of an

Table 1

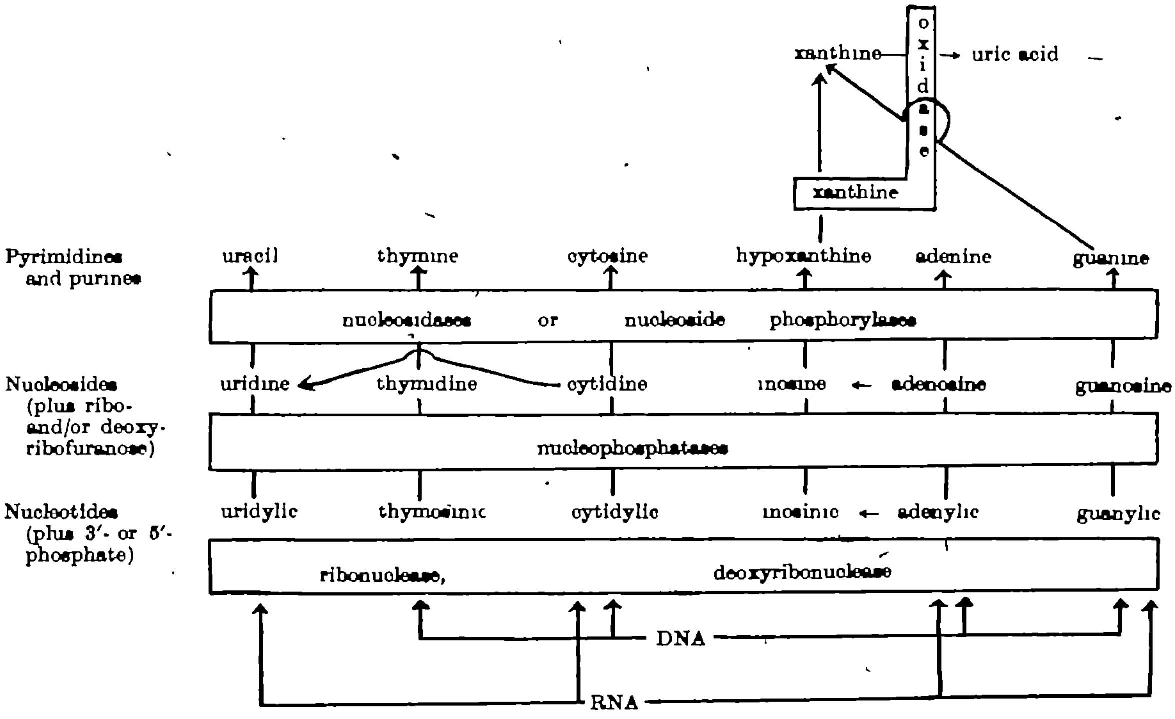
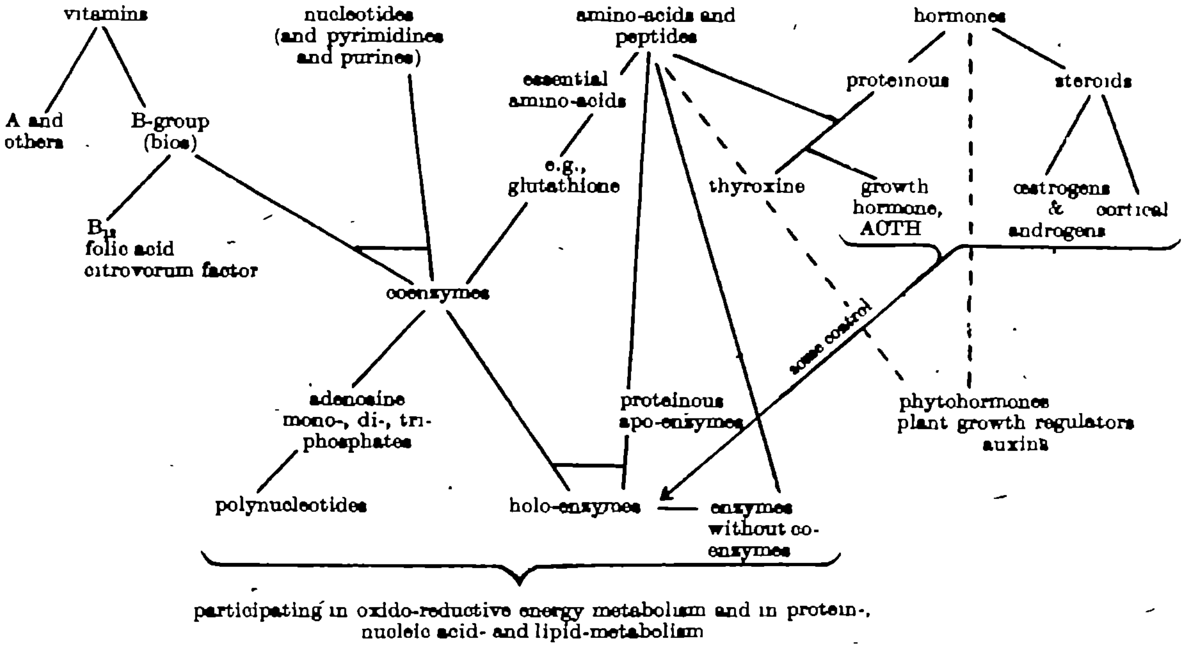


Table 2


vitamins
A and others
B-group (bios)
$B_{12}$ folic acid citrovorum factor
nucleotides (and pyrimidines and purines)
amino-acids and peptides
essential amino-acids
e.g., glutathione
hormones
proteinous
steroids
thyroxine
growth hormone, ACTH
oestrogens & cortical androgens
some control
coenzymes
adenosine mono-, di-, tri-phosphates
polynucleotides
proteinous apo-enzymes
holo-enzymes
enzymes without co-enzymes
phytohormones plant growth regulators auxins
participating in oxido-reductive energy metabolism and in protein-, nucleic acid- and lipid-metabolism

action of adenosine triphosphate on nucleic acid, producing a hypothetical diphosphonucleic acid from which, with amino-acids, polypeptide-chains and with mono-nucleotides, polynucleotides are supposed to emerge. If one pays more attention to experimental evidence and takes into consideration the following points—the 7 A. distance of the side-chains in the β-*trans* form of the initial peptide chain and of the P—OH-groups in the Furberg nucleic acid model, the relative lack of specificity of nucleic acids in directing the sequence of amino-acids, and a hypothesis put forward by Haurowitz[24]—one can arrive at another speculation. It amounts to this: that a pre-existing protein is held in position by the nucleic acid which is acting mainly as a 'backbone', and that the protein functions as the actual template on to which amino-acids 'crystallize' out each on identical spots in a crystal growth fashion. Possibly under the influence of further enzymatically acting proteins, a peptide chain is formed. This new peptide chain will leave the surface of the template and overcome its attracting forces if, after Ambrose[25], one assumes that the intramolecular attraction of N—H and C=O groups to form hydrogen bonds could pull the amino-acid side-chain away from the template. Now, the new protein folds up into a globular form as indicated above. There are, of course, other views, such as that expressed by Work[19] on transpeptidation. It is clear that all this needs more solid experimental evidence in the future.

## Regulators

It was mentioned before that smaller molecules play their part in cellular events, and some exert considerable influence on growth phenomena. These can be loosely grouped together under the name of growth regulators, a term which, even when restricted to those substances occurring in living organisms, still comprises substances of great chemical diversity. From Table 2 it can be seen that a variety of sub-groups is involved.

Some of these substances are synthesized by the organism; others are ingested with food. Some are involved in energy-producing metabolism; others have specific anabolic or catabolic functions or form the right building-units for the synthetic processes of the cells. A considerable number have similar or identical functions in lower and higher organisms due to the same biochemical arrangements. However, the auxins or plant growth regulators seem to exercise their promoting and controlling effects solely in higher plants—for example, the group derived metabolically from tryptophane, indolylacetic acid and indolyl acetonitrile[26]. The mode of action of these and a great number of synthetic analogues has not so far been established with certainty, although attempts at solving the mystery of their stimulatory and inhibitory effects have been made[27]. Such attempts have promoted work in the field of abnormal growth, for example, that on urethane by Haddow and Sexton[28]. It is especially the B-group of vitamins which have proved to be of equal value to micro-organisms and animals, a matter which has been recently discussed, among other things, on the occasion of a meeting of the Nutrition Society[29].

Apart from those identified with bios factors, and with essential co-enzymes, a super-growth factor *T* was claimed by Goetsch[30] to have been isolated from torula yeast. Later[31], it was shown that it consisted of a mixture of folic acid, folinic acid, *Lactobacillus bulgaricus* factor, deoxyribosides and a small amount of vitamin $B_{12}$. The last-named and folic acid and its derivatives have aroused particular interest, as they may be involved in nucleic acid synthesis and thus in cell division[32]. While it is not clear whether they participate in these events in the form of co-enzymes, the situation with pantothenic acid is now clarified. The formula of co-enzyme A has recently been published[33], and its role in biosyntheses, such as those of citrate, fatty acids, sterols and phospholipids, established. Even a peptide, glutathione, has now been recognized as a co-enzyme by Racker and

Krimsky[34]; it is involved in the oxidative phosphorylation of phosphoglyceraldehyde. Whether strepogenine, another peptide-growth factor, and certain amino-acids which in tadpoles, according to Gudernatsch and Hoffmann[35], either support growth or just maintenance or morphogenesis, act as regulators or are used as building units, is unknown. Of course, all functional proteins, whether as apoenzymes or as proteinous enzymes, operate directly or indirectly in processes of growth and development. The same applies to pituitary hormones such as growth, adrenocorticotropic (ACTH) and gonadotropic hormones, the first having an immediate effect on overall growth, and the last two by controlling other endocrine substances. It is not unlikely that some of the effects are achieved by influencing the level of protein synthesis, as put forward by F. G. Young[36] and more recently by Cornforth and Long[37], and as confirmed with regard to the growth-retarding effects of corticosteroids in this manner by Clark[38]. The action of androgens and œstrogens on sex organs, apart from their luteinizing and follicle-stimulating activity, turns out to be more and more that of balancing regulators[39], which links the field of normal with that of abnormal growth. There are many chemical problems still unsolved with regard to normal growth and development, and a long list could be prepared which should clearly emerge from this very condensed summary.

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# METAL PHYSICS WORK OF THE DIVISION OF TRIBOPHYSICS, C.S.I.R.O.

By Dr. W. BOAS

Chief, Division of Tribophysics, Commonwealth Scientific and Industrial Research Organization, University of Melbourne

THE Division of Tribophysics of the Commonwealth Scientific and Industrial Research Organization, which began life thirteen years ago as a group studying war-time problems of friction and lubrication, has just moved into its new home in the grounds of the University of Melbourne. The laboratory, a brick building of three stories and a basement, occupies a position in the heart of the University. That a university, already hard-pressed for space, should be willing to give up such an excellent site to a laboratory of the Organization is a tribute to the friendly spirit of co-operation that has developed between the Organization and the universities in Australia.

The work of the Division has broadened from its strictly utilitarian beginnings and now includes a general study of the physics and physical chemistry of solids, particularly metals, and of solid surfaces. The metal physics work of the Division is mainly concerned with the study of the mechanisms of plastic deformation and phase changes, the two main phenomena involved in changing the properties of metals. This work is aimed at a better understanding of the properties and behaviour of metals and alloys, so that the optimum conditions of a material for its various applications can be stated, or alloys developed for new applications.

## Thermal Fatigue

One of the first investigations originated from the observation that lead-base bearings withstood repeated heating and cooling as an engine was started and stopped, whereas tin-base bearings showed cracking and surface damage. This difference in behaviour was traced back to the crystal structures of the pure metals lead and tin. The thermal expansion of the cubic metal lead is the same in all crystallographic directions, whereas the tetragonal tin has a coefficient of thermal expansion in the direction of the tetragonal axis twice that in any direction at right angles to this axis. In tin, at the boundaries between crystals of different orientations, free thermal expansion is hindered, and therefore, when the temperature changes, stresses are set up which are large enough to cause plastic deformation and even cracking. In consequence of this effect, polycrystalline specimens of those non-cubic metals which have a large degree of anisotropy of thermal expansion cannot be obtained in a completely strain-free condition.

As the stresses originate at the grain boundaries, they are not uniform in the crystals, and hence the deformation of the crystals is inhomogeneous. Such inhomogeneous stresses have an important effect on the plastic behaviour and failure of metals, and they may arise from various sources.

## Inhomogeneity of Plastic Deformation

An obvious cause of macroscopic inhomogeneity is the friction between forming-tool and metal in industrial methods of deformation, such as drawing and rolling. The inhomogeneity of deformation on a microscopic scale must affect the mechanical properties of polycrystalline metals. If the crystals in an aggregate were independent of each other, the properties of the aggregate would be fully determined by the properties of the crystals and could be calculated by averaging the values of the properties of crystals of all orientations occurring in the aggregate. However, if the aggregate is subjected to stresses, the interaction between the crystals becomes important, as the boundary between any two crystals cannot at the same time suffer two independent deformations.

It has been shown experimentally that, in an aggregate, there are wide differences in the amounts of deformation and work-hardening from crystal to crystal. Moreover, the deformation is not uniform even within any one crystal since it is influenced by that of its neighbours. As a boundary is approached, the deformation becomes larger than at the centre if the average deformation of the neighbour is larger, and in the neighbour the deformation is less near this boundary than at its centre. Thus, a strong crystal supports its neighbours whereas a crystal with a low elastic limit has a weakening effect.

Most of these results were obtained from observations on the surface of the specimen. Special etching techniques, however, made it possible to investigate the behaviour of crystals which, during deformation, were in the interior—that is, surrounded on all sides by other crystals. These crystals behaved in the same way as those in the surface. This was confirmed by a study of duplex alloys, in which the inhomogeneity is due to the different compositions and structures of the crystals of the two phases rather than to their anisotropy.

As it is thus clear that the inhomogeneity of deformation is not a surface effect but occurs throughout the volume of the specimen and is inherent in all crystal aggregates, it has to be taken into account in any theory in which the properties of polycrystalline aggregates are calculated from those of the single crystals.

## Recrystallization

One of the methods used in arriving at these results was to observe the recrystallization behaviour of metals and alloys. For this a knowledge of the mode of growth of the new crystals during recrystallization is desirable.

In order to observe the progress of recrystallization continuously, a method was developed using polarized light reflected from the surface of non-cubic metals where the plane of polarization is rotated by an amount depending on the orientation of the crystal. Observations made on zinc show that the growth of a nucleus during recrystallization is very irregular; its extent varies with direction and from point to point in a crystal, and it can stop altogether for relatively long periods.

The observation of irregularity of growth throws doubt on conclusions drawn previously from measurements of the rate of nucleation during the recrystallization of fine-grained specimens. By counting the number of new grains which appeared after various periods of annealing, the apparent nucleation-rate was found to increase with the duration of annealing, and, assuming a constant rate of growth during the period from nucleation to observation, the true rate of nucleation was said to increase too. This conclusion presents a puzzle from the theoretical point of view and cannot be sustained in view of the observed erratic growth of the nuclei. The period during which a growing nucleus remains too small to be observable will be extremely variable, and, for a constant and even slowly decreasing nucleation-rate, the number of unobserved nuclei will increase with time. A certain fraction of these will grow to an observable size in successive units of time, and hence the apparent rate of nucleation will increase though the true nucleation-rate may not.

## Mechanism of Plastic Deformation

The plastic deformation of metals occurs mainly by slip within the crystals, and it is now generally assumed that slip takes place through the motion of dislocations. Although the basic idea of the theory —that is, that slip is a localized process—is well founded on experimental results, several rather artificial assumptions have to be made to explain some of the experimental observations. Further, much of the earlier published work used unsuitable materials and methods. Hence, an experimental attack on the problems of slip and work-hardening of metals is being made by measuring the changes produced by deformation in internal energy, X-ray interferences and electrical resistivity.

Previous investigations had shown that about 10 per cent of the work done on a specimen during plastic deformation is stored, whereas the major part is dissipated as heat. The stored energy is liberated on annealing and can be determined as the (small) difference in specific heats of undeformed and deformed specimens with an accuracy of about 20–30 per cent.

Using a differential method, in which deformed and annealed specimens of equal weight are heated simultaneously in the one enclosure, an accuracy of ± 5 per cent is obtained. The difference in power supplied to the specimens, in order to maintain their temperature difference within 1/20 deg. C., is measured continuously with a specially designed differential wattmeter. The curve showing the release of the stored energy as a function of temperature is thus obtained directly.

Results obtained for specimens of electrolytic copper deformed in torsion show that the stored energy increases with deformation in a similar way to the torque required to produce the deformation. Small amounts of some impurities appear to be responsible for large differences both in the recrystallization temperatures and in the shapes of the curve of released energy against temperature, and may also change markedly the total stored energy. With nickel, about 40 per cent of the stored energy is released in a temperature-range in which the electrical resistivity reverts almost to the lower value of the undeformed metal, whereas removal of both work-hardening and broadening of X-ray diffraction lines occurs at a temperature about 300 deg. C. higher. These results support the suggestion that vacancies generated during plastic deformation are the main cause of the accompanying increase in electrical resistivity.

The electrical resistivity of several metals and alloys was measured at temperatures in the range from − 183 to + 100° C. after various degrees of deformation by wire-drawing which was carried out in the same temperature-range. The results showed that the behaviour of some metals, notably of tungsten and molybdenum, which formerly had been considered anomalous because of a large relative increase in resistivity, can be explained if the high recrystallization temperatures of these metals are taken into account. Another observation was that, on wire-drawing and rolling, the electrical resistivity of some cubic metals becomes anisotropic. An analysis of the results indicated that the increase in electrical resistivity with deformation may not be caused entirely by dislocations and lattice vacancies, but that stacking faults in face-centred cubic crystals may also play an important part.

## Mechanism of Phase Changes

There are two ways in which a transformation in the solid state may occur. First, the atoms may be rearranged to form a crystal of the new structure which has the same external shape as the original crystal. Such transformations involve nucleation and growth of nuclei, and depend on thermally activated diffusion. Secondly, the rearrangement of the atoms may occur in such a way that each atom has the same neighbours in the new structure as it had in the old. This leads to a change in external shape which produces relief effects on polished surfaces. These phase changes occur extremely rapidly, even at temperatures where the rate of diffusion is very small, and proceed only during cooling and not isothermally to any appreciable extent.

As for the mechanism of thermally activated diffusion, it appears that the movement of atoms is connected with that of lattice holes. The development of the theory may be assisted by investigating the effect of atomic packing on the rate of diffusion, and for this reason the rate of self-diffusion was measured in various directions in tin crystals, as these show anisotropy of the diffusion-rate and no chemical complications occur, since only one type of atom is involved. It was found that the activation energy for diffusion along the tetragonal axis was about one and a half times that for diffusion in any direction at right angles to it, and the geometrical factor was about forty times larger for the tetragonal axis. However, it has not been possible to correlate the activation energy with such other physical properties as are mainly determined by the energy with which the atom is bound to its equilibrium position in the structure.

The investigation of 'diffusionless' transformations is particularly attractive, as it is hoped that from their features the movement of the atoms during the transformation may be deduced. An attempt is now being made to determine the atomic movements in transformations which produce changes in external shape, although they occur by thermal diffusion. The fact that the orientation of the new crystals is related to that of the matrix suggests that the mechanisms by which nucleation-growth and diffusionless transformations occur may not be as fundamentally different as was previously thought.

The work described in this paper is the result of close collaboration of a number of workers, and it is difficult to disentangle the individual contributions. For this reason no reference has been made to particular publications.

# OBITUARIES

## Dr. R. W. Gurney

Dr. Ronald Gurney, who died at his home in New York on April 15 at the age of fifty-four, was born in Cheltenham and was educated at Cheltenham College. After service in the Gloucestershire Regiment in the First World War, he went to Cambridge, where he was an undergraduate at Trinity Hall. He began his career as a scientist at the Cavendish Laboratory under Rutherford, where he carried out experiments on the ionization by fast particles and published a number of papers on this subject. It was during a visit to the United States, however, that he made in 1929 the first of those striking incursions into theoretical physics by which he will be mainly remembered; in collaboration with E. U. Condon, he gave the first correct explanation of α-decay in terms of wave mechanics, anticipating by several months the similar but more detailed treatment of Gamow. From this time onwards he became a theorist; after some years at Manchester with W. L. Bragg, he came to Bristol in 1935 and worked with me. We produced jointly the book "Electronic Processes in Ionic Crystals", and also a theory of the nature of the photographic latent image, much—if not all—of which has stood the test of time. In addition, he worked on the theory of liquids, and in Manchester and Bristol he laid the foundation of his future work on ions in solution.

In 1941 Gurney went to the United States and worked first at the Ballistic Research Laboratories of the Aberdeen Proving Ground, then at the Argonne Atomic Laboratory, at the Johns Hopkins University, and finally at the University of Maryland.

Gurney's publications include the books "Elementary Quantum Mechanics" (1934), "Ions in Solution" (1936), "Introduction to Statistical Mechanics" (1949) and "Ionic Processes in Solution", recently published by the McGraw-Hill Book Co. It was typical of him that, though he could use mathematics as well as another, he never trusted it; no theory was a theory to him until he could grasp it intuitively and, above all, draw diagrams of it. In this he was among theorists perhaps the truest representative of Rutherford's school, and of the British tradition. Wherever Gurney went—and not least at Bristol—he contributed to the work of the place a capacity to see things clearly, graphically, and in their essentials. He was a man with whom it was a privilege to work, and from whose unique qualities of mind and character his collaborators could learn much.

In 1950 Gurney had a stroke, and although he recovered well he was advised not to incur the strain of regular lecturing. During his last three years he was able, with the constant help of his wife Mrs. Natalie Gurney, to devote himself to his last book, which has appeared since his death. His many friends and colleagues will look forward to another example of his unique ability to make the complex simple and to get to the heart of things.

N. F. Mott

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## Dr. C. E. M. Joad

Dr. C. E. M. Joad was reader in philosophy in the University of London and head of the Department of Philosophy, Birkbeck College. By his recent death, philosophy has lost one of its most lucid expositors and teachers. A list of his writings shows how wide were his interests. He was not satisfied until he had studied the philosophical bearings of modern developments in science, in the theory and practice of politics and in changes in manners and morals. When his thinking led to a major change in his personal beliefs, he explained his reasons and his readers had the full benefit of his experience. He thought aloud and on paper, and he dealt with no problem which he did not illuminate. His favourite saying was that if anything could be said, it could be said clearly, and certainly he never said or wrote anything vague or obscure. This may sometimes have led him to over-simplify some problems and to do less than justice to the more subtle points, but his readers have nothing to unlearn; they are beguiled into a deeper study of the problems set out in such a clear and stimulating way in Dr. Joad's various guides to philosophy. These books are models of what an introduction to a difficult subject should be.

In his own philosophical thinking, Dr. Joad was in the unfortunate position of having outgrown the Idealistic teaching of his Oxford days, and of being out of sympathy with the modern school, though he never ceased to admire the brilliance of its leading thinkers. He thought he had found the key to much that is unsatisfactory in modern thinking and conduct in the 'dropping of the object' in our judgments of value, a view that is presented brilliantly and provocatively in his study of decadence. He was happiest in the writings of the ancients, and he had the faculty of presenting their problems as though they were fresh and contemporary. To hear him lecture on the Nicomachean ethics of Aristotle was an unforgettable experience.

Dr. Joad esteemed it a privilege, and the source of his greatest satisfaction, to have been able to guide the thinking of so many young people. Thousands of students, inside and outside university walls, owe to him the discovery that it is exciting to think and a duty to think clearly. He will be missed far more than he would have expected, for he was essentially a humble man.

## Mr. W. Birtwistle

Mr. W. Birtwistle died at Skibbereen, Co. Cork, on March 4, within two days of his sixty-third birthday. Educated at Blackburn Grammar School, he served in the First World War, and in 1920–24 studied oceanography and fisheries under the late Prof. James Johnstone in the University of Liverpool. In 1925 he took up duty as fisheries economist, in charge of the Fisheries Department, Straits Settlements, and Federated Malay States, later assuming the title of director of fisheries. He retired in 1945.

Mr. Birtwistle was a pioneer of fishery development in the Far East, with especial attention to the introduction of power-driven fishing craft, and the cultivation of fish in rice fields. These and many other developments he sponsored were published in the annual reports of the Malayan Fisheries Department. He could foresee future developments in Asia, and made provision for the advanced training of Asian staff in the late 1930's. The wisdom of this has already been shown in the good work done by these men. He was highly respected by the fishermen, and on his death tributes were paid by men of all nationalities in Malaya.

# NEWS and VIEWS

## Sedleian Chair of Natural Philosophy at Oxford: Prof. Sydney Chapman, F.R.S.

The retirement of Prof. Sydney Chapman from the Sedleian chair of natural philosophy at Oxford has just been announced. Prof. Chapman reaches the age limit after occupying this chair since 1946. Before going to Oxford (see *Nature*, 157, 155; 1946) Prof. Chapman had been at the Imperial College of Science and Technology, London, for no less than twenty-two years. Fortunately, his departure from Oxford is not going to hinder his interests in geomagnetism and the upper atmosphere, for he is to continue as professor of geophysics at the University of Alaska, an appointment which he has held since 1951 in addition to his work at Oxford. His many friends all over the world will be glad to think that in this way he will be able to increase the very considerable debt that is already owed to him by workers in those fields which are peculiarly his own, and where his influence will remain for many years to come.

## Prof. George Temple, F.R.S.

The appointment has been announced of Prof. George Temple to succeed Prof. Chapman. Like his predecessor, Prof. Temple has wide interests. Educated at Birkbeck College, London, and Trinity College, Cambridge, he held teaching posts at Birkbeck College (1922–24), at the City and Guilds College (1924–28) and at the Royal College of Science (1928–30) before being appointed to the chair of applied mathematics at King's College, London, a position which he has held with great success for the past twenty-one years. Prof. Temple was elected a Fellow of the Royal Society in 1943. His earlier researches were in mathematical physics and relativity, to be followed by a vigorous and highly productive application to the quantum theory when this was developed in the late 1920's. A text-book on Rayleigh's principle and another on the general principles of the quantum theory bear evidence of these interests. More recently he has been occupied with problems in aerodynamics, and has become one of the leading theoretical experts in the subject in Britain. He will be most welcome at Oxford, where his wide knowledge of mathematics will help to supplement that of his colleagues, and where his considerable administrative experience and easy charm of manner will prove most valuable.

## Letters to Sir William Siemens

A collection of more than two hundred and fifty letters written by men of science, statesmen, artists and other notable personalities to Sir William Siemens, the distinguished scientist and engineer of the nineteenth century, has recently been acquired from a relative of Lady Siemens by Sir George Nelson, chairman and managing director of the English Electric Co., Ltd. These letters, arranged chronologically, have been mounted in two special volumes with the printed text on facing pages, together with a short biography of Siemens written by W. H. Kennett, short notes on the authors of the letters and an index. A third volume, made up of the printed copies of the letters, the biography, etc., and facsimile copies of twenty-two of the letters (which to the inexpert eye are scarcely distinguishable from the originals), was presented by Sir George on May 14 to the Institution of Electrical Engineers. In addition, a thousand copies of a general edition of the letters have been printed and will be presented to universities, libraries and engineering societies. The letters are very mixed in content and personality of author, but they serve a useful purpose in revealing the wide interests of Siemens and in reflecting the manners of the times in which he lived. The letters written by men of science form a minority, but they are a notable array; his correspondents included Airy, Bessemer, Crookes, Darwin, Dawson, Faraday, Fowler, Hooker, Helmholtz, Huxley, Kelvin, Lockyer, Maxwell, Rankine, Rayleigh, Roscoe, Tyndall, Wheatstone and Whitworth. That by Sir Norman Lockyer, the astronomer and founder-editor of *Nature*, deals with a previous statement made by him that there is no oxygen to be detected spectroscopically in the sun's chromosphere. The letters range in date from one of a number by Faraday in 1862 to one by Lady Kelvin in 1902 deploring the death of Queen Victoria and looking forward, with very mixed feelings, to the Coronation of Edward VII.

## Committee on the Effects of Synthetic Detergents

The Minister of Housing and Local Government, Mr. Harold Macmillan, has stated that, after consulting the Secretary of State for Scotland and the Minister of Health, he has appointed a committee with the following terms of reference: "to examine and report on the effects of the increasing use of synthetic detergents and to make any recommendations that seem desirable with particular reference to the functioning of the public health services". The committee is constituted as follows: Sir Harry Jephcott, chairman and managing director of Glaxo Laboratories, Ltd. (chairman); Dr. N. R. Beattie, principal medical officer, Ministry of Health; C. E. Boast, borough engineer and surveyor, County Borough of Croydon; Prof. J. C. Cruickshank, professor of bacteriology as applied to hygiene, London School of Hygiene and Tropical Medicine; G. H. W. Cullinan, general manager, Shell Chemicals, Ltd.; Lt.-Col. E. F. W. Mackenzie, director of water examination, Metropolitan Water Board; G. MacRobbie, assistant secretary, Department of Health for Scotland; F. D. Morrell, director, Unilever, Ltd., London; Dr. J. R. Nicholls, deputy government chemist; F. T. K. Pentelow, chief inspector of salmon and freshwater fisheries, Ministry of Agriculture and Fisheries; Dr. B. A. Southgate, director, Water Pollution Research Laboratory, Department of Scientific and Industrial Research; H. Symon, under-secretary, Ministry of Housing and Local Government; W. L. Thomas, chief chemist and technical director, Woolcombers, Ltd., Bradford; C. B. Townend, chief engineer, main drainage, Middlesex County Council; R. Craig Wood, managing director, Thomas Hedley and Co., Ltd., Newcastle upon Tyne. *Technical Officers:* Dr. E. A. B. Birse, chief inspector of alkali works and rivers pollution, Department of Health for Scotland; Lt.-Col. F. G. Hill, adviser on sewerage and sewage disposal, Ministry of Housing and Local Government; Dr. A. Key, senior chemical inspector, Ministry of Housing and Local Government. The secretary to the committee is Mr. A. R. Isserlis, Ministry of Housing and Local Government.

## Geological Society of Australia

The recently constituted Geological Society of Australia grew from groups of geologists who have met more or less informally during the past few years at various centres in the Commonwealth. The Society has been organized on a Federal basis with State divisions, local branches at appropriate centres, and a Federal Council governing the whole. While membership is being established in the several States (including the Federal Territories), the Society is functioning under a Provisional Council with Prof. E. S. Hills as chairman. Formal elections are to be held in June. The first publication of the Society, No. 1 of the *News Bulletin*, has appeared (March 1953) and plans for the issue of a *Journal* are well advanced. No papers will appear in the *News Bulletin*, the function of which is intended to be the welding of closer personal bonds between Australian geologists. The first issue is of lively interest and contains many items of personal news besides summaries of work in progress. The New South Wales Division, for example, has reports from the University of Sydney, New England University College, the Geological Survey, a number of museums and public authorities, and various mining companies in the Broken Hill district.

Noteworthy news items include the following. A late Pre-Cambrian tillite has been discovered in the north of Western Australia. The heat-flow in Tasmania is being measured by the Geophysics Department of the National University. Prof. S. W. Carey is spending a sabbatical year developing his views on continental drift. Prof. E. S. Hills is completing a study of Upper Devonian cauldron subsidences in Victoria including one fifteen miles across. Some of the members of Prof. C. E. Marshall's staff at Sydney are engaged in investigating the geology of the Solomon Islands and parts of Papua; a recent graduate has been "well-sitting" (*sic*) with an oil company; and a teaching fellow "has resigned to enter the church". Altogether the *Bulletin* should add considerably to the gaiety of Australian—and not only Australian—geologists. But it closes on a more sombre note with an obituary notice of the late Prof. E. W. Skeats, who died in January at the age of seventy-eight. Judging by the response of Australian geologists to the demands and privileges of their new Society, success would seem to be well assured. The first issue of the forthcoming *Journal* will be eagerly awaited.

## The Spirit of Applied Mathematics

Under the title of "The Spirit of Applied Mathematics", Prof. C. A. Coulson gave his inaugural lecture on October 28, 1952, as Rouse Ball professor of applied mathematics in the University of Oxford, and the text of the lecture has now been published (pp. 24. Oxford: Clarendon Press; London: Oxford University Press, 1953. 2*s*. 6*d*. net). After tributes to the founder of the chair, to his own predecessor, Prof. E. A. Milne, and to the mathematician – physicist – biologist, D. E. Lea, Prof. Coulson said that applied mathematics is, more frequently than not, misunderstood. Even its name is against it, as it suggests that it is a mental rag-bag in which one can rummage to find a bit of unused mathematics applicable to the latest discovery in experimental physics. But really the glory of applied mathematics, he continued, is not in such applications but in the creation of concepts, an intellectual adventure which combines creative imagination and canons of beauty to give insight into the nature of the world. Lying between pure mathematics and the experimental sciences of physics and chemistry, the results of which remain substantially unaltered, applied mathematics has the surprising difference that it is liable to rapid changes, and its progress consists of the creative process of finding a new set of concepts to transcend the old. The value of such concepts does not depend on their permanence, and some of the best, for example, Bohr's theory of the atom, did not survive unchanged for more than a generation. The essentials, said Prof. Coulson, are the joy, passion and creative impulse, the search for beauty, simplicity and integrity in structure and form, set in an environment partly dependent on, and yet in its deepest sense independent of, experiment and pure mathematics.

## Sea Foam

SOMETIMES, after heavy and prolonged onshore storms, great masses of foam are drifted in from the sea on to local rocks and beaches. A curious feature of these lather-like masses is the way in which they persist for relatively long periods even when blown about by the wind. Ordinary lathers soon revert to their former unlathered state; but sea foams may persist for a day or more when the weather continues moist and stormy and no sun shines. It is possible that the foam is 'held' by the presence of some protein material, and Miss E. M. Moore suggests that this protein material might be found in the alginate products of sea-weeds. This, however, does not explain how the surface tension of sea-water could be so lowered that the whipping action of storm waves could create a frothy mass (*Aust. Mus. Mag.*, 10, 11; 1952). A likely explanation of the phenomenon is that, during storms, large numbers of planktonic organisms are destroyed and broken up because of the battering they receive in choppy seas. The surface tension-lowering chemicals which are thus released into the sea-water would allow the waves to whip up a froth and, if there is also present enough protein matter released from the alginate, a foam with lasting qualities might result.

## Surface Photometry of Southern Elliptical Nebulæ

A PAPER by Dr. David S. Evans on "Surface Photometry of Southern Elliptical Nebulæ", which has been published as No. 19 in the series of "Communications from the Radcliffe Observatory, Pretoria" (reprinted from *Mon. Not. Roy. Astro. Soc.*, 111, 6; 1952), discusses the surface brightness of a group of seven elliptical nebulæ in the region R.A. 3h. to 4h. 30m. Of these nebulæ, four are in pairs and each pair can be photographed on one plate. There is a description of the various details pertaining to the photography, etc., connected with the work, followed by a discussion of the results, which are shown in seven diagrams, these isophotes being drawn with an interval of 0·5 magnitude. In these the dotted lines represent Hubble's distributions in accordance with his law $m = m_0 + 5 \log (r/a + 1)$, where $r$ is the distance measured along a radius and $a$ is a constant. While the maps do little more than confirm Hubble's results, there are certain differences of detail which can best be seen in the plot of *NGC* 1291, the latter showing re-drawings of the central isophotes. There is an obvious rotation of the line of the major axes of successive isophotes, and the natural interpretation of this would be a shear due to rotation. It is asserted that this phenomenon is very probably real in the case of *NGC* 1291, and Evans thinks that this also applies to *NGC* 1549, although the effect is not so well marked. *NGC* 1553 presents some anomalies and resembles two elliptical nebulæ, one seen behind the other, though there is no suggestion that this is so. While it scarcely seems correctly classified as a spiral, as an elliptical nebula it is atypical. Observational material on the remaining bright southern elliptical nebulæ is being accumulated, and it is hoped that a detailed discussion will follow in due course.

## Papain

DERIVED by tapping the mature but unripe green fruits of the papaw (*Carica papaya*), the proteolytic enzyme papain has for a number of years received considerable attention from planters although its market is at present confined largely to the United States. The papaw is indigenous to tropical America, but its cultivation has spread to most tropical countries and its commercial production has hitherto been confined principally to Ceylon and British East Africa (*Col. Plant and Animal Prod.*, 3, No. 1; 1952–53). In the United States papain has five main uses. In the brewing industry it is used for 'chill proofing' beer, while other important applications are in medicine and pharmaceutical preparations; in the food industry, in pre-cooked foods and in the manufacture of meat-tenderizing preparations; and, in the textile industry, particularly in shrinkage resistance and other treatment of wool, wool and silk mixtures, and perhaps in silk processing. Papain is used to a much more limited extent in the United Kingdom, and the chief applications may not extend far beyond pharmacy and textiles. In other countries there would appear to be use for papain in the brewing industry.

## Canadian Association of Physicists: Annual Congress in London, Ontario

THE ninth annual congress of the Canadian Association of Physicists will be held during May 28–30 in the University of Western Ontario, London. Prof. J. T. Wilson, professor of geophysics in the University of Toronto and formerly war-time director of operational research in the Canadian Army, will be the after-dinner speaker at the Association's dinner on May 28, and the presidential address on the structure of physical theories will be delivered on May 29 by G. C. Laurence, of Atomic Energy, Ltd. A reception by the board of governors of the University of Western Ontario will follow. The remainder of the programme of the congress will consist of contributed papers, a symposium on the physics of metals, and two invited papers by Prof. M. S. Vallarta, of the El Collegio Nacional de Mexico, on cosmic-ray physics, and by Dr. H. L. Anderson, of the University of Chicago, on the nature of the $\pi$-meson.

## Eighth Pacific Science Congress: Meeting in the Philippines

THE Eighth Pacific Science Congress will be held in the Philippines (in Quezon City, Manila, Los Banos and Baguio) during November 16–28, with headquarters in the Liberal Arts Building, University of the Philippines, Quezon City; concurrently with this, the Fourth Far Eastern Prehistoric Congress will take place. The programme for the Pacific Science Congress will be organized under the following twelve headings: geology and geophysics, meteorology, oceanography, zoology, botany, soil resources, forestry, agriculture, anthropology, public health, nutrition and social sciences. General symposia will be held as follows : rice enrichment ; Pacific oceanography ; management and utilization of natural resources ; geology and mining industry ; plant geography ; typhoons ; anthropological subjects (with special emphasis on recent archæological finds, outstanding ethnographical studies and problems, and recent work in linguistics) ; historic and prehistoric population movements into the Pacific and major lines of migration ; crop improvement ; animal improvement in the Pacific ; reforestation ; Pacific conservation ; museums ; international organizations of the United Nations, etc. In addition, there will be two special symposia. Besides those who will be at the Congress as official members or members (the latter being appointed by representative institutions or accredited by scientific societies), interested persons may attend the Congress as 'participants' ; British scientific workers who wish to attend should write in the first place to the Assistant Secretary of the Royal Society, Burlington House, London, W.1. Papers will be limited to ten minutes for reading and five minutes for discussion ; all papers (and abstracts of not more than four hundred words) must be sent in by September 1. Further information can be obtained from the Secretary-General, Eighth Pacific Science Congress, National Research Council of the Philippines, Quezon City, Philippines.

## Royal Society of South Africa : Council for 1953

At the anniversary meeting of the Royal Society of South Africa, held on March 18, the following members of Council were elected for 1953 : *President*, S. H. Skaife ; *Honorary General Secretary*, W. J. Talbot ; *Honorary Treasurer*, N. Sapeika ; *Acting Honorary Editor of Transactions*, A. M. Talbot ; *Honorary Librarian*, E. Newbery ; *Other Members of Council*, R. S. Adamson, D. Burnett, W. J. Copenhagen, A. J. H. Goodwin, S. H. Haughton, W. E. Isaac, W. J. Lutjeharms, R. H. Stoy and C. van Riet Lowe.

## Society for Endocrinology: Officers and Committee

Officers and committee for 1953 of the Society for Endocrinology have been elected as follows : *Chairman*, Dr. S. J. Folley ; *Honorary Secretaries*, Prof. C. H. Gray and Prof. N. F. Maclagan ; *Honorary Treasurer*, Dr. G. W. Harris ; *Editor of the Society's Proceedings*, Prof. S. Zuckerman ; *Ordinary Members of the Committee*, Dr. T. Mann, Dr. C. J. O. R. Morris, Dr. I. W. Rowlands and Dr. S. L. Simpson. Communications should be sent to Prof. C. H. Gray, secretary of the Society, at the Department of Chemical Pathology, King's College Hospital, Denmark Hill, London, S.E.5.

## Announcements

A meeting arranged jointly by the Acoustics Group of the Physical Society and the Royal Aeronautical Society on the subject of aeronautical acoustics, and jet noise in particular, will be held at the Institution of Mechanical Engineers on May 21. There will be three sessions on engine, aircraft and ground noise, respectively, and a general discussion will follow. Further information can be obtained from the General Secretary, Royal Aeronautical Society, 4 Hamilton Place, London, W.1.

An exhibition of the Flinders Petrie collection of Egyptian antiquities will be held in the Museum of Egyptology, University College, Malet Street, London, W.C.1, during June 18–August 31 (admission free ; Monday-Friday, 10 a.m.–5 p.m. ; Saturday, 10 a.m.–noon). The Flinders Petrie centenary lecture will be given by Prof. S. R. K. Glanville, Herbert Thompson professor of Egyptology in the University of Cambridge ; the lecture will be open to the public and will be given in the Anatomy Theatre, University College, Gower Street, London, W.C.1, at 5.30 p.m., on June 17.

The summer conference of the Society for Applied Bacteriology will be held in Oxford during July 6–9. On July 7 a symposium will be held on "Antibiotics, their Production and Uses in Industry", at which papers will be read on antibiotic-producing organisms, antibiotic fermentations and their biological control, the chemistry of some antibiotics and their uses in the control of plant diseases and animal feeding. The remainder of the conference will consist of original contributions. Further details may be obtained from the Honorary Secretary, G. Sykes, Boots Pure Drug Co., Ltd., Microbiology Division, West Bridgford, Nottingham.

The annual meeting of the Société de Chimie Physique will this year take the form of a discussion on "Recent Advances in the Study of Molecular Structure", to be held in Paris during July 6–10. The various topics will each be introduced by a general summary given as follows : Sir John Lennard-Jones, principal of the University College of North Staffordshire, recent advances in our knowledge of the chemical bond ; Prof. R. Mecke (Freiburg im Breisgau), recent advances in the field of spectroscopy ; Prof. Roubine (Lille), microwave spectroscopy ; Mr. Grison (Bergerac), localization of hydrogen atoms by X-ray diffraction ; Dr. L. E. Sutton (Oxford), electron diffraction ; Prof. Cauchois (Paris), X-ray spectra ; Dr. G. E. Bacon (Harwell), neutron diffraction ; Dr. M. Lederer (Paris), determination of the molecular structures of natural organic substances. Further information can be obtained from the general secretary of the Société de Chimie Physique, Prof. G. Emschwiller, 10 rue Vauquelin, Paris 5e.

At the combined invitation of the Amsterdams Chemisch Dispuut, the Utrechtse Chemische Club and the Chemisch Dispuut Leiden, Prof. John Read, of the University of St. Andrews, has recently given a series of lectures in the three Dutch universities concerned, beginning at Amsterdam on April 27. In meeting the special request of these three student societies, Prof. Read dealt with the subject of alchemy and its connexions with art and music, and in particular with the art of the Netherlands. The lectures were accompanied by artistic and musical illustrations, and it is a tribute to the linguistic abilities of Dutch students that at each centre the whole of the proceedings, including questions and discussions, were conducted in English. At Amsterdam, in the laboratory of Prof. J. P. Wibaut, Prof. Read also gave an account to advanced and research students, and members of the teaching staff, of some of his own collaborative researches on the chemistry and stereochemistry of plant products, originating in the University of Sydney and continued at St. Andrews.

Erratum. In the communication "Kramer and Russell Effects with Single Crystals of Zinc" in *Nature* of May 16, p. 890, by Dr. L. Grunberg and Dr. K. H. R. Wright, the descriptions (*a*) and (*b*) below the illustration should be interchanged.

# CHEMISTRY AND PHYSICS IN SPAIN

DURING the period April 15–21 the Real Sociedad Española de Fisica y Quimica celebrated its fiftieth anniversary. The proceedings opened with an official reception at which representatives of various foreign chemical and physical societies presented congratulatory addresses, followed by an address on the Society itself by the president, Prof. M. Lora Tamayo. Witness was given to the importance with which science is regarded in modern Spain by the fact that on the dais no less than four ministers of State were present, namely, the Ministers for External Affairs, for National Education, for Industry, and a Minister representing the Sub-Secretariat of the Chief of State. In attendance were the majority of the ambassadors of the foreign delegates. The Minister for National Education welcomed the foreign delegates to Spain.

The actual work of the conference was preceded by a Requiem Mass in the Church of Consejo Superior de Investigaciones Cientificas. Four days were devoted to colloquia and to the communication of papers on original work carried out by Spanish men of science. In addition, a number of open lectures were given on special themes. These included the following: the physical limits of vision, by Prof. J. M. Otero; lignin and its formation, by Prof. K. Freudenberg; the total synthesis of nucleic co-enzymes, by Prof. A. R. Todd; the determination of geological age by isotopic methods, by Prof. Otto Hahn; diene synthesis in natural products, by Prof. Kurt Alder; the role of chromatography, by Prof. A. Tiselius; and electrochemical polarization, by Prof. A. Rius. These alone indicate the truly international character of the meeting.

The meeting also gave opportunity for a reunion of the International Commission on Optics and for the officers of the International Union of Chemistry to discuss the forthcoming meeting at Stockholm.

The Minister for Industry welcomed the delegates and showed them around the permanent exhibit of the activities of the Instituto Nacional de Industria. This is a truly impressive display of the industrial activities which are being developed in Spain. Research work on the lines of that in Britain by the Department of Scientific and Industrial Research is being carried out to the large pilot-plant scale in Madrid on various topics. These include the treatment of shale for the production of lubricants and the utilization of waste raw materials of vegetable origin such as grape stones, sprouts, vine shoots and straw by the process of fermentation followed by briquetting of the non-hydrolysable residue. It is contemplated that 30,000 metric tons a year of yeast for animal consumption, 24,000 tons of petrol and higher ketones for motor fuel, 35,000 tons of wood preservatives and 145,000 tons of charcoal will be produced, together with acetone, methanol and other by-products. The pilot plant has operated successfully, and engineering drawings for the larger plant are now almost completed.

The Instituto Nacional de Industria participates with private firms in a great number of industrial operations which are required for the reconstruction of the national economy in Spain. The outcome of this welding together of national effort and private enterprise will certainly be a matter which the rest of the world cannot ignore.

As will be seen from this brief account of the proceedings of the anniversary meeting of the Society, attendance at and participation in the scientific meetings were tasks of no mean order. In addition, the proverbial Spanish hospitality was on a truly lavish scale, including opera, dinners and tours. Spanish men of science can, at least so far as the foreign delegates are concerned, rest assured that the anniversary celebrations of their Society was an event of outstanding interest. ERIC K. RIDEAL

# RUMFORD BICENTENNIAL SYMPOSIA AND AWARDS

MARCH 26 was the two-hundredth anniversary of the birth of Benjamin Thompson, Count Rumford, who although an American by birth, has left his mark on European science and technology. Apart from his purely scientific achievements, he is best remembered in Britain as the founder of the Royal Institution; he also established the Rumford Medals, one series of which is awarded by the Royal Society and another by the American Academy of Arts and Sciences, the latter for work carried out in America only.

To celebrate the anniversary, the American Academy of Arts and Sciences organized a conference in Boston to which were invited all former Rumford medallists, but which was also open to the scientific public. A great number of the American medallists were present, as well as four medallists of the Royal Society—Sir Alfred Egerton and Prof. F. E. Simon from Britain, Prof. M. Siegbahn from Sweden and Prof. P. Debye from the United States. The celebrations started with a banquet given by the American Academy in the Harvard Club at Boston; the president of the Academy, Dr. Edwin H. Land, of 'Polaroid' fame, presided, and Sir Alfred Egerton transmitted the greetings of the Royal Society and of the Royal Institution. The menu included Rumford's famous soup which he devised for feeding the poor; fortunately, as part of an opulent dinner it produced none of the bad effects it had when for a time, about a hundred years ago, it became the sole diet of the inmates of a British prison! The main speaker was Prof. Sanborn Brown, who gave a very informative and amusing talk on Rumford as a physicist and technologist, and also presented a picture of his personality which made it clear why Rumford was not too popular with many of his contemporaries.

The first symposium was held on the morning of March 27 in the rooms of the Academy and dealt with recent developments in thermodynamics. Prof. P. W. Bridgman spoke on "Reflections on Thermodynamics", Sir Alfred Egerton on "Management of Flame", Prof. L. Onsager on "Reciprocal Relations in Irreversible Processes" and Prof. F. E. Simon on "Helium and the Range of Stability of the Solid State". In the afternoon another symposium took place on recent developments in atomic spectroscopy; Prof. M. Deutsch discussed "Positronium", Prof. W. E. Lamb, jun., "Excited Hydrogen Atoms", Prof. E. M. Purcell "Line Spectra in Radio Astronomy" and Prof. I. I. Rabi "Molecular Beam Radiofrequency Methods for the Study of Excited States of Atoms".

In the evening, Rumford Medals were presented by Dr. Land to Profs. E. Fermi, W. E. Lamb and L. Onsager, who were introduced by Profs. P. Debye, N. F. Ramsey and J. G. Kirkwood, respectively. After the ceremony a reception for the Rumford Medallists was held in the very pleasant rooms of the American Academy of Arts and Sciences. There was also an opportunity of visiting an exhibition of Rumford's scientific works.

On March 28 there was a final symposium on recent developments in nuclear physics. The speakers were Prof. E. Fermi on "Meson Physics", Prof. J. R. Oppenheimer on "Recent Progress in the Understanding of Nuclear Forces", Prof. M. Siegbahn on "Nuclear Spectroscopy" and Prof. V. F. Weisskopf on "Problems of Nuclear Structure". All the symposia were followed by lively discussions, and as there were not more than about a hundred people present the intimate atmosphere contributed very much to the outstanding success of the meetings.

The symposia were organized in a quietly efficient way, and the guests were sincerely grateful for the gracious and generous hospitality accorded to them. Their thanks are due to the officers and staff of the American Academy, in particular to Prof. Harlow Shapley, the chairman of the Rumford Bicentenary Committee, and to Mr. R. W. Burhoe, the executive officer of the Academy.

F. E. SIMON

## THE BRITISH DYESTUFFS INDUSTRY

THE address, "Our Changing Chemical Industries: an Appraisement", which Dr. Herbert Levinstein delivered to the British Association of Chemists on February 27 on the occasion of the award to him of the Hinchley Medal, further expounds a disturbing passage in Sir Henry Tizard's Messel Memorial Lecture last July. Sir Henry Tizard had expressed disquiet at Britain's apparent lack of success in competing in the world's markets for chemicals, and quoted figures to show that our share of world trade in chemicals had gone down steadily from 22 per cent in 1913 to 18 per cent in 1950. Germany had been out of the world's markets twice in this period and her share fell from 37 per cent in 1913 and 36 per cent in 1937 to 11·5 per cent in 1950. Dr. Levinstein recognized that the chemical industry in Britain is changing in character as, in accordance with the general tendency to expansion across industrial frontiers rather than within them, firms like the Distillers' Co. and the petroleum firms have extended their manufacturing activities far beyond their original field. There are now in Britain half a dozen firms, with large capital, making chemicals, whereas formerly there was only one; however, we have not yet begun to reap full advantage of the operations of these big companies.

These changes should substantially strengthen the chemical industry of Britain, diminish dollar imports and help exports; but nevertheless, Dr. Levinstein urged that there is much to justify Sir Henry Tizard's misgivings. Arguing that in Britain, as in Germany and in Switzerland, the dyestuffs industry is the foundation of organic chemical industry, he suggested that consideration of the beginnings of this industry, the reasons for its leaving its birthplace in Britain, and its growth to really gigantic proportions in Germany would explain much that has disturbed Sir Henry Tizard. Reviewing the beginnings of the industry and its decline in Britain by the 'seventies, Dr. Levinstein said that the absence of a patent law in Germany until 1877 and, until much later, in Switzerland, and of any provision in British patent law for working in Britain, allowed German and Swiss inventors to take out British patents without obligation to manufacture here, while during this period they could infringe British or other patents in their own countries. The weakness of the British patent system was also exploited by the Germans during 1877–1914, after the Imperial patent law of 1877 embodied Caro's definition of a chemical invention, namely, the obtaining of a new and unexpected technical effect.

The imposition in Britain of the same duty on pure alcohol for industrial purposes as on potable spirits also gave a great advantage to the Germans, and this was not modified until nearly thirty years later when the Government wished to make cordite. A further factor was the difficulty in obtaining capital for new and risky developments, a position which persisted until the comparatively recent formation of the Finance Corporation for Industry. Dr. Levinstein dismissed as irrelevant the view that the superior education of the German chemist or the neglect of research by the British manufacturer had played any real part in the transfer of the dyestuffs industry to Germany. It is true, he said, that training in organic chemistry was better in Germany and in Switzerland than in Britain in the early years of the period. The first large and distinguished school of organic chemistry in Britain was under W. H. Perkin, jun., at the Victoria University, Manchester; but there was never any difficulty in obtaining good German, Swiss, or British chemists from abroad. As regards research, Dr. Levinstein claimed that more research was carried out by his firm at Blackley than was justified by the sales, and that, although on a modest scale compared with that of the Germans, far more research was done there than by any other firm in Britain.

Reviewing the achievements in restoring the British industry on the outbreak of war in 1914, and which, in fact, prevented the Germans from using their stocks of dyestuffs for bargaining at the Peace Conference, Dr. Levinstein pointed out that in 1919 imports into Great Britain had fallen to 3,232 tons from 18,900 tons in 1913, and that we were already exporting 5,446 tons. Although the British range of dyes was incomplete and the plants employed were not necessarily the best for peace conditions, the back of the task was broken and a large research organization had been established. Delays in implementing the promise to introduce the Dyestuffs (Import Regulation) Act and other political and economic factors led to the partial dispersal of the research and technical staff; but Dr. Levinstein expressed his concern that a recent book, "Twenty-five Years Ago, the Story of the I.C.I. Merger", issued by Imperial Chemical Industries, Ltd., had not given a fair account of what had been done to re-establish the British dyestuffs industry before that combine was formed. He also contested the claim that the Dyestuffs Act was only intended to protect the home market and not, by securing the home market, to build up exports. The object of the Act was to secure for the home market a wide, substantially complete range of dyestuffs ; but if exports were neglected, overheads would be extravagantly high. The highest export of British dyestuffs before the Second World War was in 1929, and only in that year and in 1937 (5,728 tons) were the figures for 1919 (5,446 tons) and 1920 (6,157 tons) exceeded. In nineteen years under the Dyestuffs Act, nothing was done to increase British exports of dyestuffs.

This, Dr. Levinstein suggested, had some bearing on the figures which caused Sir Henry Tizard concern. Moreover, there had been no further reduction in imports, which averaged 2,325 tons during 1919–26 (including the abnormally high figures for 1920, following the Sankey judgment) and also for 1927–38. The post-war period figures showed improvement. Exports increased to 12,148 tons in 1950 and 12,486 in 1951, and thus do not substantiate the claim that the German firms have recovered their lost ground. On the other hand, imports increased from 786 tons in 1950 to 1,657 tons in 1951, and of these last Dr. Levinstein noted that 676 tons came from Switzerland and 220 tons from the United States, as much being paid to these 'hard currency' countries as we paid to Germany in 1913. Dr. Levinstein also noted that there are now thirty-seven dyestuffs makers in Britain, and he concluded his survey by referring to the potentialities of the small firm and the possibility of formidable competition later from the U.S.S.R. in dyestuffs and in other chemicals.

# FOOD PRODUCTS FROM PLANTS

THE Nutrition Panel of the Society of Chemical Industry, at the third of its series of meetings on "Food and the Future", held in the rooms of the Chemical Society, London, W.1, on March 25, discussed the subject of "Newer Sources of Foodstuffs". Two papers were under discussion : one by Dr. A. C. Thaysen, of the Colonial Microbiological Research Institute, Trinidad, on food and fodder yeast, and the other by Mr. N. W. Pirie, of the Rothamsted Experimental Station, on the efficient use of sunlight for food production.

Dr. Thaysen's paper pointed out that the process of making use of waste material as a medium for the growth of yeast is a measure of our shortage of food. The original idea for the use of yeast as a human food was for children in countries experiencing undernutrition where the need for supplementary protein is most acute. The value of yeast lies in its ability to convert about 80 per cent of the inorganic nitrogen supplied into protein. The rate of conversion, compared with more orthodox methods, is enormous : for example, a fully grown bullock, weighing half a ton, produces protein at the rate of 0·9 lb. per day ; half a ton of soya beans at the rate of 82 lb. per day ; and half a ton of *Torulopsis* could produce protein at the rate of 51 tons in 24 hr.

Food yeast is at present being produced both in Jamaica and in South Africa. The cost, at 1*s*. 2*d*. per lb., corresponds to 0·069*d*. per lb. of protein, compared with 0·8*d*. per lb. of protein from beef. However, very little yeast is at present consumed by man. In Germany and Finland it is used solely as animal feed, and, if the comparison is then made between yeast and other sources of animal feed, the economic aspect, at the present time, is unfavourable ; thus food yeast sells at £130 per long ton, compared with soya bean meal at £30. It is necessary to take into account the presence of an appreciable concentration of vitamins in the yeast. As a supplement to human dietaries, apart from its protein content, yeast would supply much-needed members of the vitamin B-complex and, used in this way, is certainly economical.

In the absence abroad of Dr. Thaysen, his paper was introduced by Mr. H. J. Bunker, who emphasized the future possibilities of food yeast, when present economics could be considered irrelevant. He pointed out that dried brewers' yeast sells at £90 per ton, and when debittered, but not extracted, at £130.

The value of *Torulopsis* as a food converter, compared with *Saccharomyces*, lies in its ability to ferment pentoses as well as hexoses. This is valid only when waste sulphite liquor is used as a medium ; when grown on molasses, both these organisms are equally valuable. Vast quantities of raw material are available : for example, as much as a quarter of a million tons of waste sulphite liquor, which really is a waste material, is available annually in the United States and Canada, as well as hydrolysed wood, banana skins, bracken and peat.

*Rhodotorula gracilis* could provide a valuable addition to fat resources, as the organism contains 42 per cent fat and 23 per cent protein. Earlier reports of the unpalatability of yeast, when it was said that only about 15 gm. per day could be consumed without causing digestive disorders, were probably due to contamination with defrothing agents. Well-prepared yeast is quite palatable.

Mr. Pirie said in his paper that at present we are entirely dependent upon sunlight for our food supplies ; but photosynthesis is extremely inefficient. Much of the light is reflected, absorbed by inactive surfaces or by surfaces which are rendered inactive because of unsuitable conditions. The advocates of unicellular photosynthetic organisms, such as *Chlorella*, dispute that farming is the best way to produce food. Algæ have, however, no greater efficiency in trapping sunlight, but can be more readily made to work at maximum efficiency by provision of optimum temperature, carbon dioxide and nutrients. These conditions would render *Chlorella* culture as costly as glasshouse cultivation. It was pointed out later in the discussion, however, that efficiencies up to 20 per cent have been achieved by growing *Chlorella* in the open, as compared with 2–3 per cent for ordinary crops. In addition, the plasticity of metabolism of the organism permits production of food material of any desired composition : for example, 60 per cent protein : 5 per cent fat or 10 per cent protein : 80 per cent fat.

As the green plant will be our main source of food for a long time to come, the best use must be made of it. Only a small part of the crop is eaten directly by man ; most is fed to animals or used as a fertilizer, or even wasted. Crops grown primarily as animal food are wasteful, despite the high esteem in which their products are held, because the overall conversion is usually only 5–10 per cent. Economies in the use of soil can be made both here and by replacing textile fibres by synthetic fibres.

The direct consumption of crops by man is desirable. Plants are, however, relatively poor sources of protein, with the exception of legume seeds and most young leaves. Young, vigorously growing leaves contain up to 30–40 per cent protein and little fibre ; but only a few plant species will stand up to continuous cropping of very young leaves. The alternative is to separate the fibre from the proteins, fats and carbohydrates of lower-quality leaves. The advantage of fractionating leafy crops lies in the fact that the products are more valuable when separated than when combined. The proteins are suitable for non-ruminants and perhaps man, the fluid extract could be used for feed or as a medium for micro-organisms, and the fibrous residue, still containing some proteins and starches, is suitable for ruminants or even for fuel.

In many parts of the world there are abundant leafy wastes, such as potato haulms, sugar-beet leaves and sweet potato leaves. When, however, satisfactory techniques have been developed, our choice of domesticated plants might well be reconsidered. Plants that use sunlight most efficiently might be chosen rather than those grown merely because a use has been found for them. On the question of economics, leaf protein, even extracted from crops grown specially for the purpose, would cost less than existing protein foods and about the same as estimates for yeast and *Chlorella*.

The discussion revealed two trends of thought on these new natural sources of foodstuffs. One was that orthodox agriculture would see us through this century and that these novel methods should await the development of new techniques. The other was that present drawbacks to these new foods are largely due to lack of information and that further investigation is most desirable. As Mr. Pirie said, all methods of increasing the world's food supply must be pushed ahead, for they are complementary rather than conflicting.

A. E. Bender

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# BRITISH GELATINE AND GLUE RESEARCH ASSOCIATION

## ANNUAL REPORTS FOR 1951 AND 1952

THE recently received third annual report of the council of the British Gelatine and Glue Research Association (pp. 13; 1951) covers the year October 1950–September 1951, and the fourth (pp. 19; 1952) for that ending in September 1952. The former report records an increase of two in the full membership but no change in the staff. Two meetings of the Research Panel were well attended, the second, a symposium on the uses of gelatine and glue, providing a valuable opportunity for interchange of views between manufacturers and users. It was decided that at future meetings, in addition to papers of the type previously presented, accounts would be given of the research work of the Association; and the visit to the laboratories, which is a regular feature of Panel meetings, has proved a valuable link between the Association's staff and that of member firms. The fourth annual report records two additions to associate membership and one to full membership, as well as the appointment of an additional research officer for work on the physical and mechanical properties of gelatine and glue. The laboratories were officially opened on November 29, 1951, by Sir Robert Duncalfe, and two further meetings of the Research Panel are reported (see *Nature*, 169, 24 (1952); 170, 24 (1952); and 171, 250 (1953)).

The reports of the Director of Research, included with each of these annual reports, indicate that during the next two or three years a substantial body of new knowledge concerning gelatine and glue will have been built up. Work on the purification of gelatin by ion exchange resins, for example, has shown that the ash content of gelatin is reduced from 2–3 per cent to 0·005 per cent by passing a 5 per cent solution through a mixed bed of the 'Amberlite' resins *IR*120 and *IRA*400. Even very high arsenic contents can thus be reduced below the limit prescribed for edible gelatine, and the method provides a ready means of determining isoelectric points. Detailed studies of the viscosity of very dilute solutions of gelatin have shown that the gelatin molecule is in a partly folded configuration at its isoelectric point, the equal and opposite charges along the molecule contributing to the folding. The technique developed by F. Sanger, in which fluorodinitrobenzene reacts with free amino groups of proteins, has been applied to the determination of end-groups in gelatin, and studies have also been made of the organic constituents of bone, while new methods have been developed for estimating the colour and clarity of gelatine and glue solutions and gels and for the accurate determination of arsenic in gelatine. A device has been constructed to facilitate accurate testing of jelly 'strength', and a detailed investigation of sampling errors in bacterial counts on powdered gelatine indicates that the variation is related to irregular distribution of bacteria in the gelatine, probably originating from the drying operation.

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# WORLD-WIDE CHANGES IN THE PHASE OF THE COSMIC-RAY SOLAR DAILY VARIATION

By T. THAMBYAHPILLAI and Dr. H. ELLIOT
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MEASUREMENTS of the cosmic-ray diurnal variation at sea-level using directional counter arrays[1] have shown that the variation is at least in part due to an anisotropic distribution of the primary radiation entering the atmosphere. Since the variation is dependent on solar rather than sidereal time,

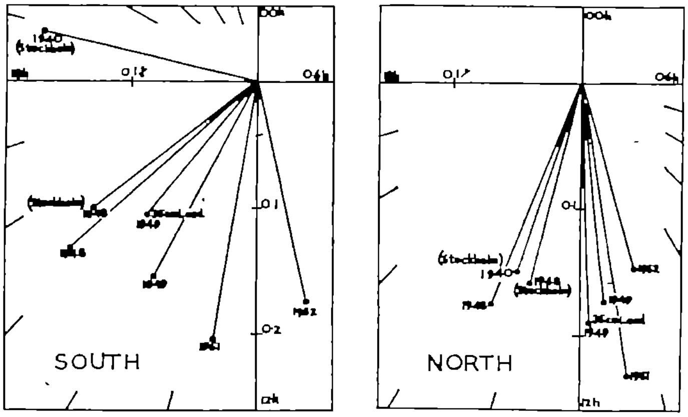

Fig. 1 Harmonic dials showing the first harmonics of the daily variation measured in Manchester and Stockholm using counter telescopes pointing south and north. All the measurements have been made using unshielded telescopes with the exception of one set of data for Manchester in 1949, when 35 cm. lead absorber was used

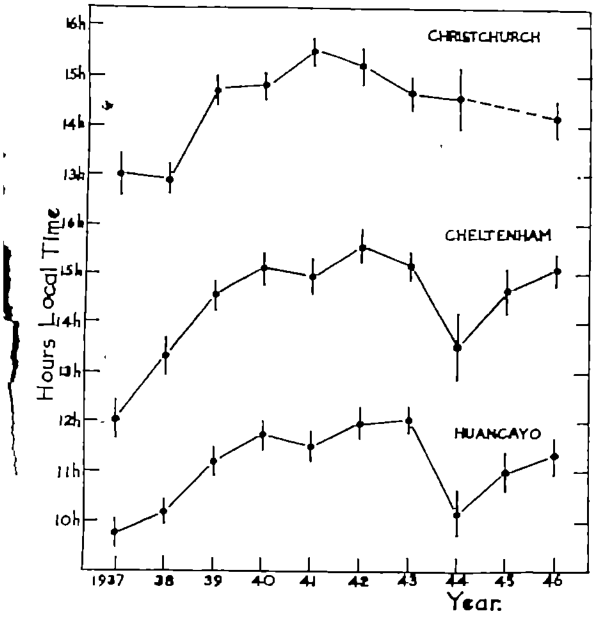

Fig. 2. Times of maximum for the first harmonics of the daily variation as measured by ionization chambers at Christchurch (lat. 43° S.), Cheltenham (39° N.) and Huancayo (12° S., 3,350 m. altitude)

the anisotropy is evidently caused in some way by the sun, and it is therefore important to ascertain whether there is any relation between the variation and the sunspot cycle. Earlier measurements in Manchester have therefore been repeated during the past two years, using the same apparatus as was used in 1948 and which consists of two counter telescopes with rather wide angles of acceptance, one pointing south and the other to the north and inclined at 45° to the vertical.

Fig. 1 shows the first harmonics of the annual mean daily variations plotted on a harmonic dial for 1951 and 1952, together with the earlier measurements in Stockholm and Manchester. It will be seen that there appears to have been a significant change in the daily variations between 1940 and the present time. The time of maximum for the south-pointing telescopes has fallen progressively earlier in the day from 1940 to 1952. There is a similar but much less marked trend for the north direction. The changes in amplitude over this period are not significant.

In view of these results, the ionization chamber data published by the Carnegie Institution of Washington[2], for Cheltenham (U.S.A.), Christchurch (N.Z.) and Huancayo (Peru), covering the period 1937–46 have also been examined. The first two stations are close to sea-level and at very nearly the same latitude (~ 40°) in the northern and southern hemispheres, respectively, whereas Huancayo is close to the equator and at an altitude of 3,350 m. The average diurnal variations at Christchurch and Cheltenham over the whole period 1937–46 have very nearly the same amplitude and phase, whereas that for Huancayo has the same amplitude but the time for maximum is 3·3 hr. earlier than at the other two stations. The phases of the annual mean daily variation at the three stations are shown plotted in Fig. 2 for each year. It will be seen that phase-changes have occurred during this period, and that the changes are roughly parallel at the three stations, indicating that they are not local in origin.

In Fig. 3 we have plotted all the data on the phase of the diurnal variation which are readily available. In all cases except the Hafelekar observations, a correction for barometric pressure only has been made. The Hafelekar observations, as published, had in addition been corrected for atmospheric temperature, and to this extent there is an uncertainty as to whether they are directly comparable with the observations from the other stations. Where directional counter measurements have been used, the mean variation for the two directions has been plotted. The Huancayo points have been displaced by a constant amount corresponding to 3·3 hr. to bring them into line with the other stations.

It will be seen that, although the points show a certain amount of scatter, there appears to have been a systematic change in phase over the years. The time of maximum fell progressively later from 1933 to 1942, and then the time of maximum has become gradually earlier from 1942 up to the present. It has been shown by Sekido and Kodama[3] that there is a relation between the phase of the diurnal variation and geomagnetic activity, the time of maximum falling earlier on days of high activity than on days which are undisturbed magnetically. It appears, however, that the changes in phase shown in Fig. 3 can at best be only partially accounted for in this way, since geomagnetic activity shows a predominantly 11-year cycle and the points in the

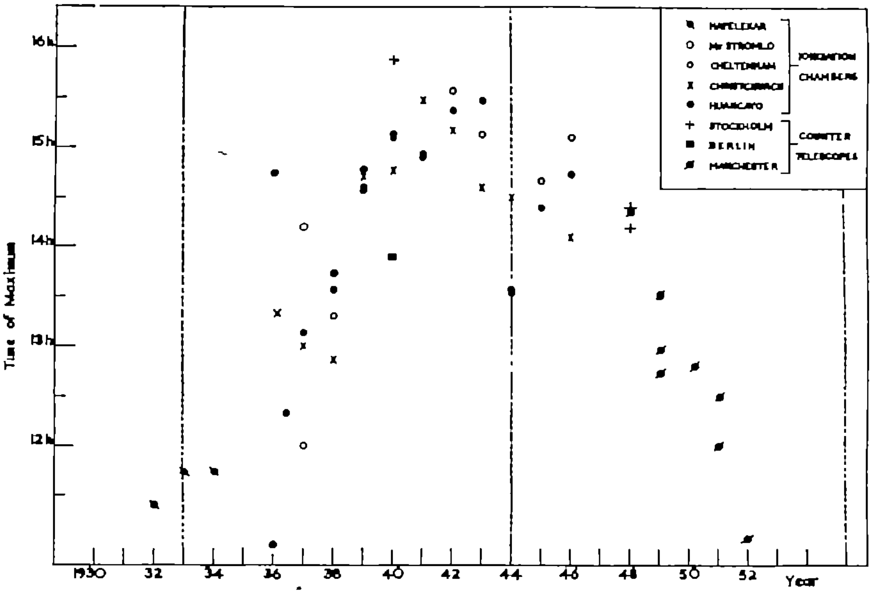

Fig. 3. Time of maximum of the first harmonics of the diurnal variation. The years of sunspot minimum are indicated by the broken lines

diagram do not show such a periodicity to any marked degree. The years of sunspot minimum are indicated by the broken lines in Fig. 3, where it will be seen that the minimum of 1933 corresponds to an early time of maximum for the daily variation and it appears likely that a similar state of affairs will hold for the next minimum (1955). The intervening minimum of 1944, however, corresponds to a late time of maximum. It is worthy of note that if the phase change is a periodic effect, the data in Fig. 3 could be fitted to a 22-year wave, which is, of course, the true period of the sunspot cycle. It is impossible at this stage to say with certainty whether or not the cosmic-ray data do show such a cycle, and many more years of systematic observation will be required to produce a conclusive result. There can be little doubt, however, that systematic changes in the phase of the diurnal variation do occur on a world-wide scale.

We are indebted to Dr. A. R. Hogg and Dr. D. I. Dawton for providing us with the results of their measurements on the daily variation. [April 23.

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# FORMATION OF LABILE PHOSPHATE ESTERS BY IRRADIATION OF NUCLEIC ACIDS WITH X-RAYS IN AQUEOUS SYSTEMS

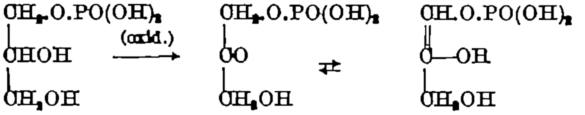
By Dr. GEORGE SCHOLES and Dr. JOSEPH WEISS

University of Durham, King's College, Newcastle upon Tyne

WHEREAS previously the action of X-rays on aqueous solutions of nucleic acids was considered to be essentially of a physical nature, studies carried out in this laboratory have established that definite chemical processes take place during the irradiation[1-4]. At lower doses of radiation, these chemical effects include the formation of ammonia and of inorganic phosphate; by using higher doses the formation of certain free bases and of titratable acid groups in addition could be shown. On the basis of these and other experimental findings, a tentative mechanism for the overall attack of the radicals produced by the radiation has been proposed[3,4]. The experiments seemed to suggest that hydrolysis of certain labile substances plays a part and that these substances include labile phosphate esters. However, the evidence then available was largely of an indirect nature.

We have now obtained some direct experimental evidence on this point, this being based on the fact that labile phosphate esters are more or less easily hydrolysed with the formation of inorganic phosphate. Blank and irradiated nucleate solutions were hydrolysed by dilute acid (under standard conditions) and the amount of liberated inorganic phosphate determined by the method of Berenblum and Chain[5]. In this way we have been able to show that, for example, with doses of the order of $9 \times 10^4$ r-units, in the presence of oxygen, the additional amounts of inorganic phosphate liberated from irradiated ribonucleic acid and deoxyribonucleic acid solutions are about fifteen times the amounts of free phosphate formed during the irradiation.

A study of the effects of X-rays on some relatively simple organic phosphate esters has shown that these can serve to some extent as model compounds. Among the substances investigated from this point of view were α- and β-glycerophosphate and 3-phosphoglyceric acid. Here again, further appreciable amounts of inorganic phosphate were released on subsequent hydrolysis of the irradiated solutions, although the acid-lability of these intermediate esters was rather lower than the lability of the esters formed from the nucleic acids. The interest in these three-carbon systems arises from the fact that the point of attack by the oxidative radicals can be predicted on chemical grounds with some degree of certainty. Such considerations would suggest that the formation of labile phosphate esters, for example, by irradiation of α-glycerophosphate solutions, results from an oxidative attack on the secondary alcohol group (β-position) according to the following reaction:

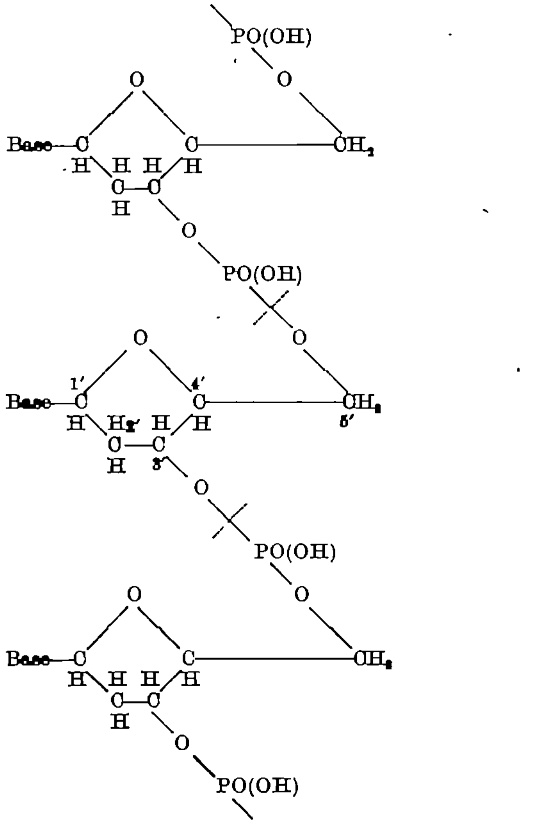


$$\begin{array}{l} CH_2.O.PO(OH)_2 \\ | \\ CHOH \\ | \\ CH_2OH \end{array} \xrightarrow{(oxid.)} \begin{array}{l} CH_2.O.PO(OH)_2 \\ | \\ CO \\ | \\ CH_2OH \end{array} \rightleftarrows \begin{array}{l} CH.O.PO(OH)_2 \\ \| \\ C-OH \\ | \\ CH_2OH \end{array}$$

(I)

It is apparent that the acid lability of the irradiated solutions can be due here to the formation of compounds similar to (I).

In the case of the nucleic acids, we have already presented evidence that both the basic and pentose

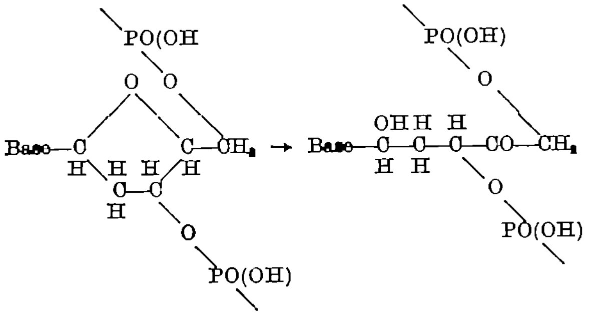


constituents are attacked by the radicals produced during irradiation, and it is possible that chemical changes in either of these components may increase the acid-lability of the resulting product.

The following discussion is limited to the labile esters which can arise by oxidation of the sugar part.

A small section of, for example, deoxyribonucleic acid can be represented as shown on p. 920. From this scheme it is obvious that the pentose —C(4′) atom occupies a unique position in this structure in that it is adjacent to two phosphate groups; oxidation at this centre, therefore, should have a pronounced labilizing effect. Furthermore, electrostatic interaction between the two phosphate groups may be an additional factor in their mutual labilization[6]. Subsequent hydrolysis of the labile phosphate bonds produced in this way will lead to a transverse fission of the polynucleotide chain with the production of both (3′)– and (5′)– (end) phosphate groups. When the (5′)– phosphate is already an end group, this should lead directly to the formation of inorganic phosphate.

If, on the other hand, there is an oxidative attack at C(3′) or C(5′), this will lead to an immediate scission of the corresponding phosphate bond without the intermediate formation of a labile ester. In deoxyribonucleic acid, neither oxidation at C(1′) nor at C(2′) should have any labilizing effect on the phosphate linkages. In ribonucleic acid, oxidation at C(2′), which here is a secondary alcohol group, could labilize the phosphate in the (3′)– position. On chemical grounds, however, it appears that C(4′) in both nucleic acids is rather vulnerable and a likely point of attack. Further, it is to be expected that oxidation at this position should also lead to an opening of the furanose ring:



Therefore, in addition to labilization of the adjacent phosphate bonds, the glycosidic linkage may also be considerably weakened, leading to the liberation of the base; the presence of free bases in irradiated nucleate solutions has already been observed previously[1].

These considerations may also be of some importance for the understanding of the mechanism of the 'after-effect' in deoxyribonucleic acid solutions[7,8], namely, the decrease in viscosity which continues for some time after cessation of irradiation. We have already stated[2,3] that some of the immediate loss of viscosity may be closely associated with a loss of 'hydrogen bonding', particularly through elimination of polar groups by the action of the radicals upon the constituent bases and possibly to some extent by elimination of phosphate end groups. Furthermore, an immediate scission of the polynucleotide chain should be brought about by oxidative attacks at the pentose C(3′) and C(5′), as pointed out above.

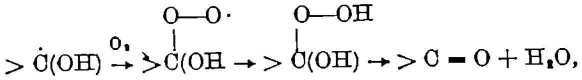
On the other hand, with regard to the post-irradiation effect, our results suggest that this may be due to the following reactions: (a) Transverse fission of the polynucleotide chain by hydrolysis of 'labile' phosphate esters as outlined above. This may be accompanied by loss of the corresponding base, and thus loss of some hydrogen bonds. (b) Attack at the double (ethylenic) bonds of the pyrimidines by the free radicals and (hydrolytic) liberation of the chemically changed base from the main polynucleotide chain.

It has been stated that the 'after-effect' in irradiated deoxyribonucleic acid solutions depends entirely upon the presence of oxygen[8,9]. However, this appears to be somewhat unlikely in view of the fact that there are also oxidizing (OH) radicals present under vacuum conditions. The effect of molecular oxygen has been studied in a number of other systems; for example, in the formation of acetaldehyde from alcohol[10], or of pyruvic acid from lactic acid[10] and from alanine[10], the ratios of the yields in the presence and absence of oxygen were found to be between 3 and 6, depending on the substance and on the experimental conditions. Therefore, the presence of oxygen during irradiation of the nucleic acids should only enhance the extent of oxidative attack upon the basic and pentose components.

In evacuated solutions, for example, the oxidation of a secondary alcohol group of the sugar would require a process similar to:

$$>CH(OH) \xrightarrow{OH} >\dot{C}(OH) \xrightarrow{OH} >C = O.$$

In the presence of oxygen, on the other hand, because of the process $H + O_2 \rightarrow HO_2$, the effective number of OH radicals may be increased by inhibiting the recombination of the primarily formed H and OH. Probably more important still, the yield may also be increased by reaction of the initially formed organic radicals with oxygen:



$$> \dot{C}(OH) \xrightarrow{O_2} >\overset{O-O\cdot}{\overset{|}{C}}(OH \rightarrow > \overset{O-OH}{\overset{|}{C}}(OH) \rightarrow > C = O + H_2O,$$

that is, via a peroxide radical, which can eventually lead to the corresponding carbonyl compound.

All these experiments refer to *in vitro* conditions, and therefore any conclusions drawn from them with regard to the biological action of X-rays on nucleic acids are bound to be highly speculative. However, it is perhaps worth pointing out that there may be a connexion between the labile phosphate esters produced by the action of, for example, X-rays on nucleic acids and 'high-energy phosphate bonds'.

In general, observations on the lability of phosphate esters may also be of use in the elucidation of the point of attack of the free radicals.

Full details of this work will be published elsewhere.

[Jan. 6.

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# POSITION OF HÆMS IN THE HÆMOGLOBIN MOLECULE

By PROF. D. KEILIN, F.R.S.
Molteno Institute, University of Cambridge

ONE of the problems which arises from the study of the mechanisms of oxygenation and oxidation reactions of hæmoglobin is the position occupied by the hæms in relation to the globin. The solution of this problem is of paramount importance for the proper understanding of the structure of hæmoglobin and of the interactions between the hæm and the protein in hæmoglobin, as well as in other natural hæmoprotein compounds.

The nomenclature of hæmoglobin and its derivatives which will be used in the present study comprises the classical terms which have previously been discussed and defined[1,2]. Although the term 'hæmoglobin' will be applied here in its widest sense, covering all hæmoprotein oxygen carriers, irrespective of their origin, but having protohæm as their prosthetic group[3], the position of hæms will be examined mainly in mammalian hæmoglobins (molecular weight 68,000) which have four hæms per molecule.

## Imidazole Theory of Hæm-linked Groups in Hæmoglobin

It was undoubtedly the high histidine content of hæmoglobin that was primarily responsible for the view that the imidazole ring of this amino-acid forms the link between the hæm–iron and the globin. This view received some support from Langenbeck's[4] observation that hæmatin easily combines with different imidazoles, forming, especially with 4-methyl imidazole, very stable parahæmatin compounds. A more definite formulation of this view was made by Conant[5], who, in his Harvey Lectures, suggested that globin is linked to each hæm–iron through two imidazole rings of histidine residues of which one, being more easily displaced by oxygen than the other, forms the oxylabile group responsible for the well-known Bohr effect. However, it was Wyman and his co-workers[6,7,8] who made the first attempt to obtain more direct experimental evidence in support of this theory. The main results of this work were recently summarized by Wyman[9] in a masterly review of different aspects of hæmoprotein compounds. In the course of these investigations[6,7] they found that the heat of ionization of titratable groups between $pH$ 5·5 and 8·5, calculated from the effect of temperature upon titration curves of hæmoglobin, was about 6,500 cal., which is very close to that of the imidazole group of histidine. Moreover, by comparing the effect of temperature on titration curves of hæmoglobin and oxyhæmoglobin, they were able to find that the heat of ionization of the oxylabile acid groups lies very close to that of the imidazole group of histidine. They concluded that the hæm–iron in hæmoglobin is linked with two imidazole groups of histidine residues, being, however, closer to one group than to the other. It is somewhat difficult to reconcile the result of this work, which indicates that the hæm–iron lies between two histidine residues, with one of the conclusions of Wyman's review[9], namely, that hæms in hæmoglobin lie attached to the surface of globin.

The imidazole theory also received support from magnetic susceptibility measurements carried out by Pauling and his co-workers, who were able to determine the nature of the bonds uniting the hæm–iron with the surrounding atoms and to offer the first structural interpretation of the hæm-linked groups in hæmoglobin and its derivatives[10].

## Critical Examination of the Theory of the Embedded Position of Hæms

One of the important deductions which can be drawn from the imidazole theory of the hæm-linked groups, as formulated by Conant, Wyman and Pauling, is that the disk-like hæms lie within a fold or crevice of the globin. The concept of the embedded position of hæms was recently used by Pauling[11,12] and by St. George and Pauling[13] as a basis for an ingenious steric hindrance theory to account for the *S*-shaped oxygen equilibrium curve of hæmoglobin and for the hæm–hæm interaction. According to this theory, the enfolded positions of the four hæms between the layers of globin will limit the accessibility of oxygen to the hæm–iron. However, when an oxygen molecule reaches the first hæm–iron to form the oxygenated complex, the protein structure becomes somewhat loosened and thus makes the second hæm–iron more easily accessible to oxygen. With the formation of successive oxygenated complexes, the degree of hindrance to the penetration of oxygen progressively decreases, and this is reflected in the sigmoid curve of the reversible reaction between hæmoglobin and oxygen.

Since the steric hindrance theory is based upon the assumption that the four hæm groups of hæmoglobin are buried within the globin, St. George and Pauling (1951)[13] made an attempt to obtain more direct evidence in support of their view. For this purpose they investigated the reactions of free hæm and hæmoglobin with different alkyl isocyanides, such as the ethyl, isopropyl and tertiary butyl derivatives. They found that, whereas the nature and size of these isocyanides had no influence upon their affinities for free hæm, they had a marked effect upon their affinities for hæmoglobin. Thus, the affinity of hæmoglobin for isopropyl and tertiary butyl isocyanides was about 3 and 200 times lower respectively than its affinity for ethyl isocyanide. They ascribed this fall in the affinity to the increasing molecular sizes, and therefore to increasing difficulties of penetration of these isocyanides between the protein layers enfolding the four hæms.

However plausible and attractive may appear the theory of the embedded position of hæms in hæmoglobin and of the steric hindrance theory of hæm–hæm interaction, several important experimental results militate against them. Neither of these theories can therefore be accepted without a careful examination of these results, which can be summarized as follows.

(1) *Reactions of hæmoglobin with oxidising and reducing agents.* It is well known that the divalent iron of hæmoglobin is oxidized by potassium ferricyanide ($K_3Fe(CN)_6$) and by methylene blue to the trivalent iron of methæmoglobin, and that the latter is reduced back by sodium dithionite ($Na_2S_2O_4$) to hæmoglobin. All these substances are much larger in size than a molecule of oxygen or of carbon monoxide. In fact, the reactions of hæmoglobin with ferricyanide and methylene blue have already been considered as an indication that the hæms lie attached to the surface of the globin[14]. Moreover, these reactions are of special interest considering that

neither ferricyanide nor dithionite ions can penetrate the cell membrane of the red blood corpuscles, facts which make possible the spectroscopic study of the mechanism and the kinetics of lysis, by different agents, of erythrocytes containing either hæmoglobin or methæmoglobin[15].

(2) *Formation of compounds with nitrosobenzene and imidazoles.* It has been shown that the divalent iron of free hæm and of hæmoglobin combines reversibly with nitrosobenzene forming spectroscopically well-defined complexes[16,17]. The same complexes are obtained when hæmatin and methæmoglobin are treated with phenyl hydroxylamine ($C_6H_5NHOH$). In this reaction phenyl hydroxylamine reduces free hæmatin and methæmoglobin to hæm and hæmoglobin respectively, while it is itself oxidized to nitrosobenzene ($C_6H_5NO$), which then combines with hæm and hæmoglobin[17].

It has also been shown that the trivalent iron of methæmoglobin combines reversibly with 4-methyl imidazole[18], forming a compound with an absorption spectrum of the parahæmatin type. Since the reactions of hæmoglobin and methæmoglobin with oxidizing and reducing substances consist in electron transfer between these substances and the hæm–iron, one cannot dismiss the possibility that such reactions take place indirectly through some groups belonging to the protein. Thus, the oxido-reduction reactions by themselves do not necessarily rule out the possibility of embedded hæms. However, the position is very different in the cases of nitrosobenzene and imidazole, which form co-ordination complexes with the iron of hæmoglobin and methæmoglobin respectively. To form such complexes the hæm–iron must be directly accessible to these substances.

Thus the view that hæms in hæmoglobin are embedded within a fold of globin which may hinder the penetration of oxygen molecules to the hæm–iron is difficult to reconcile with the facts that large polyvalent ions such as ferricyanide and dithionite or comparatively large molecules such as methylene blue, nitrosobenzene, phenyl hydroxylamine and imidazole can easily reach the iron of hæmoglobin or methæmoglobin and react or combine with it.

(3) *Reactivities of free hæmatin and of hæmatin bound to native protein.* The difference in the ability of a free hæmatin and of a hæmatin forming part of a native hæmoprotein to combine with certain substances cannot always be ascribed to the possible greater accessibility of the iron in the free hæmatin. In fact, the hæmatin of methæmoglobin may show a much greater reactivity towards certain substances of small molecular size than does free hæmatin. Thus, whereas methæmoglobin easily combines with azide[19], fluoride[20] and hydrosulphide[21] ions, to form well-defined compounds, free hæmatin forms no spectroscopically recognizable compounds with these substances. Moreover, the easily observed reactions of methæmoglobin, catalase and peroxidase with peroxides are in striking contrast to the great difficulties in demonstrating any of these reactions with free protohæmatin. Indeed, only urohæmatin has been found to form well-defined compounds with hydrogen peroxide and ethyl hydroperoxide[22]. On the other hand, of a variety of substances which combine with free hæmatin, only cyanide, nitric oxide and certain imidazoles combine with methæmoglobin, and of a still larger variety of substances which combine with free hæm[23], only cyanide, alkyl isocyanides, nitric oxide, carbon monoxide and nitrosobenzene combine with hæmoglobin.

(4) *Absorption spectra and nature of hæm complexes with different substances.* Free hæm and hæmatin combine with imidazoles to form compounds which are very similar in their structure and absorption spectra to the hæmochromogens and parahæmatins formed when hæm or hæmatin are combined with a great variety of nitrogenous substances such as pyridine, nicotine, piperidine, ammonia, glycine or denatured proteins. In all these compounds, the fifth and sixth co-ordination valencies of the hæm–iron are occupied by molecules of the corresponding nitrogenous substances[23]. Were the fifth and sixth valencies of iron in hæmoglobin and methæmoglobin occupied by the imidazole rings of histidine residues, their absorption spectra would be expected to resemble those of a hæmochromogen or a parahæmatin, which is not the case.

(5) *Magnetic properties of hæmoglobin and its derivatives.* The magnetic properties of hæmoglobin studied by Pauling and his co-workers enabled them to determine for the first time the nature of the bonds uniting the iron with the surrounding atoms in hæmoglobin and its derivatives. One of the interesting results obtained by Pauling and Coryell[24] is that oxygen which is paramagnetic with two unpaired electrons per molecule, on combining with hæmoglobin which is also paramagnetic with four unpaired electrons per hæm, forms diamagnetic oxyhæmoglobin which has zero magnetic moment. This implies that both oxygen and hæmoglobin on combining to form oxyhæmoglobin or on dissociating from the latter undergo profound changes in their electronic structure. Such behaviour of oxygen during its reaction with hæmoglobin closely resembles its behaviour when submitted to pressure[25,26]. It was shown a long time ago, although the facts have not since become widely known, that when molecular oxygen is compressed, two molecules of oxygen combine reversibly according to the equation: $2O_2 \rightleftharpoons O_4$; the amount of $O_4$ being proportional to the square of the pressure. The formation of $O_4$ can be followed by magnetic measurement, since $O_2$ is paramagnetic and has two unpaired electrons, whereas $O_4$ is diamagnetic and has no unpaired electrons. Here again the formation of $O_4$ and its dissociation to $O_2$ are accompanied by a very marked rearrangement in the electronic structure of the molecule. It is interesting to note that the formation of $O_4$ can also be followed spectroscopically, since $O_4$ shows sharp absorption bands not only in the ultra-violet but also in the visible region of the spectrum, and these can easily be observed in a steel tube fitted with glass windows designed to withstand high pressures. With an optical depth between the windows of about 60 cm. and a pressure of 120 atmospheres (the usual pressure of an oxygen gas cylinder) the four absorption bands in the visible region can easily be seen with a hand spectroscope. Moreover, it is $O_4$ that is responsible for the blue colour and the very sharp absorption bands at 631, 577, 532 and 478 mμ of liquid oxygen when it is examined in a non-silvered Dewar flask by means of a hand spectroscope[25,26]. In fact, the diamagnetic $O_4$ represents about 50 per cent by weight of liquid oxygen.

Magnetic measurements, like other methods applied to the study of hæmoglobin, have great merits as well as limitations. There is no doubt that it is the only method which can reveal the character of the bonding of the iron with the surrounding atoms in hæmoglobin as well as in its reversible and irreversible derivatives. On the other hand, all this knowledge has not so far helped much towards an understanding of the fundamental properties of hæmoglobin, such as the very slow autoxidizability of its iron, its remarkable property of oxygenation, the peculiarities of the oxygen equilibrium curves, the Bohr effect, the nature of the hæm-binding protein groups, the position of the hæm in hæmoglobin, and many other properties, depending upon the integrity of the hæmoprotein molecule. Thus, for example, the Bohr effect cannot be ascribed[9,14], as was previously suggested[16], to changes in the nature of the bonds uniting the iron with the surrounding atoms from ionic of hæmoglobin to covalent of oxyhæmoglobin. In fact, the same changes in the nature of bonds take place in every hæmoprotein which can undergo oxygenation, yet myoglobin and certain hæmoglobins show no Bohr effect. On the other hand, the oxidation of hæmoglobin to methæmoglobin, which like oxygenation to oxyhæmoglobin shows a distinct Bohr effect, is not accompanied by changes in the nature of the iron bonding, which remains ionic.

Moreover, magnetic measurements do not differentiate between free hæm and hæmoglobin, each having four unpaired electrons, which indicates that the iron in both compounds is linked by ionic bonds. Neither do these measurements differentiate between oxyhæmoglobin and hæmochromogen which have no unpaired electrons, thus showing that the iron in both compounds is linked by covalent bonds. In other words, magnetic measurements do not reflect the remarkable differences between native hæmoglobin and those of its derivatives which have irreversibly lost their fundamental biological properties. The same limitation arises when the magnetic technique is applied to the study of other biologically active hæmoprotein compounds[27]. In this respect the study of magnetic properties of hæmoproteins fails to provide some of the information which is easily obtained from the biological and spectroscopic study of these compounds. In fact, by their absorption spectra, especially in the visible region of the spectrum, not only can all the derivatives of hæmoproteins be differentiated and identified but, in addition, any loss in specific biological activity can easily be recognized and estimated.

It appears that the results obtained from magnetic susceptibility measurements, which made possible the identification of the nature of the bonds uniting the iron with surrounding atoms, will not be made full use of until the structure of native globin, especially in relation to its biological specificity, is better understood.

(6) *Reconstruction of hæmoglobin from hæm and native globin.* The concept of the embedded hæms in hæmoglobin is difficult to reconcile with the comparative ease of its splitting into native globin and hæm and the reconstruction from these constituents of hæmoglobin which is capable of combining reversibly with molecular oxygen[28,29].

It is true that, under certain conditions such as those required for removal of hæms[30,31], treatment with strong urea solution[32-34], or high dilution[36,37], the hæmoglobin molecule or the liberated globin[36,31] may undergo a reversible dissociation into two equal parts. This phenomenon suggests that were the hæms embedded between layers of globin, their most likely position would be between the two halves of globin. However, the reversible dissociation of hæmoglobin into two halves is by no means a general phenomenon. It was recorded for hæmoglobins of horse, ox, cat and fœtal sheep, but so far has not been demonstrated for hæmoglobins of man, dog or adult sheep. Moreover, hæmoglobin reconstructed from free native globin and hæm differs from the original material in showing no Bohr effect and in having its oxygen equilibrium represented by a rectangular hyperbola[8]. The concept of steric hindrance cannot therefore be applied to the reaction of this hæmoglobin with oxygen even if the hæms in the reconstructed hæmoglobin are enfolded between the two halves of globin. On the other hand, hæmoglobins dissociated on dilution[36] or on treatment with urea[8] have an increased affinity for oxygen and retain the *S*-shaped oxygen equilibrium curve, although each half of the hæmoglobin molecule must be linked with two hæms now lying on the surface of the globin and therefore freely accessible to oxygen.

(7) *Hæmoglobin and myoglobin.* The view of the embedded position of hæms in hæmoglobin has not so far been extended to myoglobin. This is not surprising considering (*a*) that the size of the myoglobin molecule is only one-fourth that of mammalian blood hæmoglobin, (*b*) that the molecule does not undergo reversible dissociation into smaller units, and (*c*) that in the absence of a Bohr effect it is unnecessary to postulate the co-ordination of its iron with two imidazole groups of histidine one on each side of the disk-like hæm. On the other hand, if it is assumed that the four hæms of hæmoglobin are embedded between the layers of globin while the single hæm of myoglobin lies on the surface of the globin, the differences in the properties of these two pigments, especially the accessibilities of their iron to different reagents, would be greater than they really are. Myoglobin would also offer a more appropriate control than free hæm in the experiments with alkyl isocyanides carried out by St. George and Pauling[18]. That this is not the case is indicated by the reactions of methæmoglobin and metmyoglobin with different substances containing an imidazole group. Whereas both methæmoglobin and metmyoglobin combine reversibly with imidazole and 4(5)methyl imidazole, neither of these two pigments will react with histidine, histamine, carnosine, N-methyl benzimidazole or pilocarpine, which combine with the free hæm and hæmatin to form the corresponding hæmochromogen and parahæmatin compounds[38,39].

So far, all substances which are known to react with myoglobin and its reversible derivatives have been found also to react in the same way with hæmoglobin and its corresponding derivatives.

(8) *Evidence that the sixth co-ordination position around the iron in hæmoglobin and methæmoglobin is occupied by a molecule of water.* On drying hæmoglobin or methæmoglobin, their absorption spectra are replaced by those of hæmochromogen or parahæmatin respectively. On the reintroduction of water, these absorption spectra revert to their original states. Since in typical hæmochromogen and parahæmatin compounds both the fifth and the sixth covalent bonds of iron unite it to nitrogenous groups, the above experiments indicate that the sixth position around the iron in hæmoglobin and methæmoglobin is occupied by a molecule of water which, on drying, is replaced by a nitrogenous group of the protein[40-43].

This view is also supported by study of the absorption spectra of acid and alkaline methæmoglobin at low temperatures[44]. Thus, when a brown solution of acid methæmoglobin at *p*H 6 is cooled in liquid air, its absorption band in the red is intensified and slightly shifted towards the blue end of the spectrum.

On the other hand, when the red solution of alkaline methæmoglobin at pH 9, with absorption bands in the green, is cooled, it turns brown and its absorption spectrum changes to that of the acid form. Since cooling suppresses ionization[44], the above experiments indicate that the iron in acid methæmoglobin is linked to a molecule of water and that the formation of alkaline methæmoglobin involves the loss of a proton, as was originally suggested by Coryell, Stitt and Pauling[45], instead of the addition of a hydroxyl ion.

## Position of the Four Hæms in Relation to Globin

As is shown above, study of the structure and properties of hæmoglobin and its derivatives supports neither the theory of the embedded position of hæms within the fold of the globin nor the steric hindrance theory of hæm–hæm interaction. On the contrary, much of the evidence suggests that the hæms are attached to the surface of the globin through linkages with both the iron and the porphyrin. Of the six co-ordination bonds of the iron atom, four lie in one plane and link it with the nitrogen atoms of the pyrrol nuclei, whereas the fifth and the sixth bonds, one on each side of the disk-like hæm, unite it to a nitrogenous group of the globin and to a molecule of water respectively. This molecule of water can be replaced (1) in hæmoglobin by a molecule of oxygen, carbon monoxide, nitric oxide, hydrogen cyanide, an alkyl isocyanide or nitrosobenzene, and (2) in methæmoglobin by a hydroxyl, cyanide, hydrosulphide, azide or fluoride ion, nitric oxide, hydrogen peroxide, an alkyl peroxide or an imidazole, to give rise to the well-defined derivatives of hæmoglobin and methæmoglobin.

## Interaction between Hæms and Proteins in Hæmoproteins

Although the general weight of evidence invalidates the view that hæms in hæmoglobin are embedded between the layers of globin and that the hæm–iron is linked to the imidazole groups of two histidine residues lying one on either side of the flat hæm molecule, it does not dismiss the possibility that the imidazole rings may form the oxylabile groups responsible for the Bohr effect. Whatever may be the nature of these groups or their position, even if they are not directly linked with the hæm–iron, they may nevertheless be sufficiently influenced by the state of the hæm–iron to acquire the properties ascribed to the oxylabile groups. This is in general agreement with the view put forward by Wyman[46], namely, that the reactions of hæmoglobin with oxygen and carbon monoxide, as well as the Bohr effect, are intimately connected with marked changes in the structural configuration of the hæmoglobin molecule as a whole. In fact, the valency of the iron or its combination with different substances has a very profound effect upon the general protein properties of hæmoglobin such as solubility, crystalline structure, ease of crystallization and susceptibility to denaturation by different agents.

The converse is also true, namely, that the protein has a profound effect upon the properties of hæms linked to it. This is strikingly exemplified by many varieties of hæmoglobins which show marked differences in terms of affinities for oxygen and carbon monoxide, the shapes of the oxygen dissociation curves, the autoxidizability of the hæm–iron and the absorption spectra, especially in the visible region. That certain protein groups of globin which are not linked with, or are not even in close proximity to, the hæm may nevertheless affect its properties is clearly shown by the presence of the protein absorption band in the photodissociation spectrum of the carbon monoxide compound of myoglobin as demonstrated by Bücher and Kaspers[47]. Here the light energy absorbed at about 280 mμ by the two tyrosine and two tryptophane residues of globin is transmitted to, and used for, the photodissociation of the carbon monoxide–iron linkage.

That the protein portion of a molecule of a hæmoprotein cannot be considered as a colloidal carrier of hæmatin which merely enhances the activity of this prosthetic group is clearly illustrated by the fact that the same protohæmatin nucleus in combination with different native proteins may form highly specific hæmoprotein compounds such as hæmoglobin, catalase, peroxidase or a component of cytochrome which have several properties in common, but which show very striking differences both in the nature and in the magnitude of their biological activities.

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# LETTERS TO THE EDITORS

*The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications*

## Effect of Magnet Inhomogeneities in the Strong-Focusing Synchrotron

The amplitude of transverse oscillations in a synchrotron due to gas scattering and spread at injection can be much reduced by using the strong-focusing principle[1]. In such a machine the oscillation amplitude is reduced in comparison with a conventional machine by a factor of order $0{\cdot}4\sqrt{n}$, where $n$ is the field index $(-r_0/H_0 . dH/dr)$. Oscillations induced by magnet misalignments are, however, larger in the strong-focusing machine by a factor of order $2\sqrt{n}$. This suggests that very accurate magnet assembly will be required.

As an example of the tolerances required, we first consider the effects of small random displacements of the sectors. The machine parameters used will be those of ref. 1, namely, $n \approx 3{,}600$; $N$, 240 sectors; orbit radius, $10^4$ cm.; $W$, half-width of vacuum chamber, 1 in. Suppose now that one of the sectors is displaced radially or vertically by $\delta$, then a simple calculation shows that an oscillation of order $5\delta$ will be set up. If all the sectors are displaced by an amount the root mean square value of which around the orbit is $\Delta$, the oscillation amplitude after one revolution will be of order $5\sqrt{240}\Delta \approx 75\Delta$. To ensure that the particle completes one revolution, therefore, we must have $75\Delta < 1$ in., that is, $\Delta < 0{\cdot}013$ in. This represents a fraction of $3{\cdot}6 \times 10^{-6}$ of the machine radius.

If this condition is met, it is important to inquire what happens on subsequent revolutions. A linear system will first be considered. This implies that $n$ is independent of radius, and the various small centrifugal terms in the equations of motion are neglected. We continue to assume for the moment that alternate sectors are identical in form. The behaviour on subsequent revolutions depends essentially on the change of phase of the oscillation after one revolution. Subtracting integral multiples of $2\pi$ from this phase change, so that the remainder $\varphi$ lies between $-\pi$ and $+\pi$, the oscillation amplitude fluctuates sinusoidally with an amplitude of about $2A/\varphi$ and a period of $\pi/\varphi$, where $A$ is the oscillation amplitude after one revolution. If $\varphi = 0$ the system is resonant, and the oscillation amplitude builds up linearly by an amount $A$ per revolution. In the general linear case where $n$ varies slightly from one sector to the next, a further type of resonance can occur. We consider first the special case of a correctly aligned machine. Particles displaced from the equilibrium orbit will oscillate with an amplitude which increases in a roughly exponential manner if $\varphi$ lies in a small region near 0, as in the resonances already considered, or near $\pi$ (cf. Mathieu's equation). In the general case of a misaligned machine with $n$-variation, or other perturbations proportional to displacement or velocity, both linear and exponential types of resonance will occur. For the machine under consideration a change of $n$ by 1·4 per cent varies $\varphi$ by $\pi$, so that it must be controlled throughout the accelerating cycle to less than this if disaster is to be avoided.

The resonant build-up of oscillation can be limited by making the system non-linear, so that $\varphi(A)$ is now a function of amplitude. To study this amplitude limitation, two series of computations are being made on the Automatic Computing Engine at the National Physical Laboratory. The first of these is a study of the pendulum equation $\ddot{y} + (n/4) \sin y = 0$, with a constant impulse forcing term at fixed intervals corresponding to one revolution in the machine. The oscillation has been computed for various values of $n$, $\varphi(0)$ and impulse strength. For the second more realistic calculations, the equation $\ddot{y} \pm n \sin y = 0$ is used, the sign alternating between focusing and defocusing sectors. At the amplitudes considered, only the $y$ and $y^3$ terms in the expansion of $\sin y$ are significant. The sectors are assumed to lie not on a perfect circle, but with their ends randomly distributed a certain distance from that circle, so that the computational problem is one of changing the $y = 0$ axis at each sector boundary. Particle orbits were calculated for one revolution through twenty-five randomly chosen arrangements of sectors to find the magnitude and variation in the amplitude due to misalignments, and for one typical arrangement the particle orbit was computed for up to sixty revolutions for various values of alignment accuracy.

The first calculation showed that $A'$, where $\varphi(A') = \pi + \varphi(0)$, is an important parameter. For small impulses the system behaves like a linear system when $\varphi$ is not near zero, and when $\varphi$ is near zero the amplitude of oscillation varies periodically and is limited to about $A'$. For impulses such that after one revolution $A$ is greater than about $A'/5$, the amplitude builds up erratically but indefinitely.

In the second series of computations the oscillation amplitude after one revolution was consistent with the simple statistical calculation given earlier. After many revolutions the behaviour was similar to that in the first series of computations, except that in the bounded solutions the repeating nature of the pattern of amplitude was not so clearly marked. Indeed, it is not certain that some of the apparently bounded solutions would not have diverged had the computation been carried over a larger number of revolutions. However, the limit of stability appeared to correspond to holding the sector tolerances to about $\pm 0{\cdot}007$ in. when the amount of non-linearity was adjusted so that $A' = W$.

We may conclude from these considerations that very great care must be paid to the magnet design in a strong focusing synchrotron. Elaborate methods of assembly will be necessary to get the particles once round the machine, and a very careful control of the field is essential to ensure that they do not hit the walls on later revolutions. Calculations so far suggest that, in principle, either a linear or non-linear system could be used, provided that the technological problems of constructing a sufficiently accurate magnet can be overcome. It must be emphasized, however, that there are many possible effects which we have not yet considered; notable among them are the coupling between vertical and horizontal oscillations, and the effect of non-linear inhomogeneities due to magnet profile inaccuracies and fringing fields.

We wish to thank Messrs. Bell, Goward and Walkinshaw for helpful discussions on the subject of this letter, and the Director of the National Physical Laboratory and members of the Mathematical Division for carrying out the computing programme. This work has been done in collaboration with the Proton Synchrotron Group of the European Council for Nuclear Research, and is published by permission of the Director of the Atomic Energy Research Establishment.

*Note added in proof.* An extension of the first series of computations to the case where *n* varies slowly from one resonant value to the next while an orbit is being computed shows that the oscillation amplitude can become very large, even though for *fixed n* values in the same range it remains quite limited. Such a variation of *n* is likely to occur during saturation of the magnet iron.

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## Beta-Spectrum of Arsenic-71

For the past few months, the 225-cm. cyclotron[1] and the electromagnetic isotope separator[2] of this Institute have been used as the basic tools for a series of investigations on radioactive isotopes. Radioactive samples produced by cyclotron bombardment have been separated in the isotope separator both for obtaining mass assignments and for providing sources for beta-spectroscopic work. Due to the high intensity and high energy of the beam available in this cyclotron (200–300 μamp. internal beam of 25-MeV. deuterons), very intense beta-sources of separated isotopes can be obtained. The present communication reports the preliminary results of such an investigation on arsenic-71. The work is still in progress and a more detailed paper will be published later.

Arsenic-71 of half-life 60 hr. is obtained among several other arsenic activities by bombarding germanium with deuterons. The isotope is reported to decay by positron emission (energy 0·8 MeV., absorption measurements) and *K*-capture[3]. Mei *et al.*[4] reported an electron line of energy 162 keV., which was ascribed to arsenic-71.

In the present investigation, arsenic-71 has been studied in the intermediate image beta-spectrometer[5]. Germanium metal (fused on to a copper plate by using a special soldering flux) was bombarded in the cyclotron with 25-MeV. deuterons (180 μamp.hr.). The active arsenic, together with some arsenic carrier, was then converted into arsenic hydride. The hydride gas was introduced into the ion source of the isotope separator and the ions of mass number 71 were collected on a thin aluminium foil (0·15 mgm./cm.$^2$). This foil was used as a beta-source in the spectrometer (resolution about 4·5 per cent; the Geiger–Müller counter window had a 'cut-off' of about 6 keV.).

The Kurie plot of the positron spectrum obtained gives an upper limit of 815 ± 20 keV. There is also an indication of the presence of a weak component having the end point at about 300 keV. In addition to Auger lines, we have found three conversion electron lines at 12·2, 22·0 and 164 keV. The former two are interpreted as the *K* and *L* lines of a gamma-ray of energy 23·3 ± 0·3 keV. The 164-keV. line is interpreted as arising from the *K* and *L* conversion of a gamma-ray of energy 175 keV. This line is probably identical with the 162-keV. line reported by Mei *et al.*[4].

The positron continuum and the 164-keV. electron line appeared to decay with a period which was in accord with the half-life found for arsenic-71 (see below).

In another separation of arsenic from germanium bombarded with deuterons, we collected ions of all mass numbers from 69 to 77 on an aluminium foil, which was then cut into narrow strips. In order to check the half-lives, the decay of the activity corresponding to each mass number was followed for several days. The strip corresponding to mass number 69 showed a comparatively weak activity with a half-life of about 35 hr., indicating the presence of some germanium-69 in the arsenic hydride gas. The half-life of arsenic-71 was found to be 65 ± 5 hr.

We wish to thank Messrs. W. Forsling and L. Holm for their help and advice regarding the chemical work.

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## Creep of Copper under Stress Pulses

A general treatment of the problem of creep under intermittent, as distinct from alternating, stress has already been given[1] and applied to the creep of lead. The behaviour of copper conductors is of particular interest[2] because of the stress conditions to which they are subjected in alternators, and because of the important consequences of their failure. Experiments on high-conductivity copper have now been completed with the view of testing in more detail certain deductions which followed from the original analysis.

The character of the creep of the copper wires when tested under 730 kgm.cm.$^{-2}$ at 258° C. depended strongly on the previous anneal time. The instantaneous extension increases, and the creep-rate at any chosen time decreases, with increase in the time of anneal. Detailed discussion of this is outside the scope of this communication: it must suffice to say that all the specimens were annealed in the furnace for 17 hr. prior to the creep test, a time sufficient for the effect to attain equilibrium.

The original analysis indicated that the recovery effect could be formulated in terms of one parameter, *n*. This was the fraction of the material which recovered in full, during the off-load period, its original transient flow properties. It was shown that for lead the flow exactly fitted the Andrade β, or cubic, function[3] $\beta t^{1/3}$, where $t$ is time.

The fraction *n* satisfied the relation

$$1/n = 1 + A(\tau/R)^{1/3}, \qquad (1)$$

where $\tau$ is time of load, $R$ the recovery time (restricted to values less than some critical value $R_c$) and $A$ a constant characteristic of the material. On this basis, approximations involving *n* can be developed for the case of regular repetitive stressing. In the case of copper under the test conditions quoted above, accurate cubic creep parabolas were again exhibited, with an instantaneous strain recovery on unloading

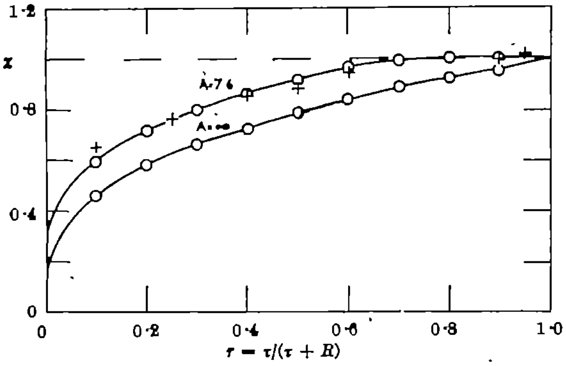

Fig. 1. Wave-form effect, showing the calculated values of χ (circles) for the two cases $A = \infty$ ('no effect') and $A = 7·6$. The crosses are the experimental observations

of ∼0·35 mm. followed by a negligible creep recovery. No modification to the previous treatment was found to be necessary to take account of this property.

It can be shown that the ratio of the creep strain under a regular intermittent stress system to that achieved under an equal continuous stress, and for the same total test time, is given by:

$$\chi = [2{\cdot}845n(1 - 1/m^{1/3}) + 1]\, r^{1/3} \qquad (2)$$

if the transient creep function is a cubic one, $m$ being the number of stress cycles and $r$ the ratio $\tau/(\tau + R)$. Two effects are of importance.

(*a*) *Wave-form effect*. The results of experiments made with $m = 8$, over a total test time of 80 min., are summarized in Fig. 1. The lower curve shows the χ-ratio for a material which exhibits no recovery ($A = \infty$), and the upper curve shows the ratio for the case where $A = 7·6$, the value deduced by fitting any section of one of the composite experimental curves. This calculated curve agrees very well with the experimental values obtained. It is worthy of note that χ can just exceed unity for this case ($m = 8$), and if a similar curve is calculated for $m = \infty$, then χ is found to exceed 1 over the large range of $r$-values, 0·3–1·0.

(*b*) *Frequency effect*. If $R < R_0$, equation (1) applies and $n$ is dependent on the $\tau/(\tau + R)$ ratio only and not on the absolute values of these quantities. In this sense, then, there is no frequency effect, so long as the wave-form is unchanged. However, because of the occurrence of the term $(1 - 1/m^{1/3})$ in equation (2), an effect arises when $m^{1/3}$ is small. As $m^{1/3}$ increases to values much greater than unity, χ levels out sharply to an asymptote at $\chi = (2{\cdot}845n + 1)r^{1/3}$. This is demonstrated by the calculated curve in Fig. 2 for the case where $A = 7·6$ and $r = 0·5$. The experimental points, taken from results after 80 min. of test at different frequencies, are again in very good agreement and confirm the validity of the general treatment and the physical concepts on which this is based.

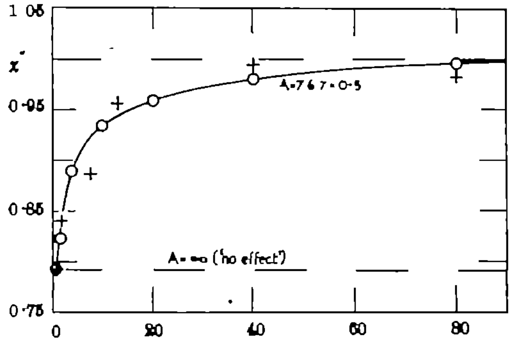

Fig. 2. Frequency effect, showing the calculated values of χ (circles) for the case where $A = 7·6$ and $r = 0·5$. The crosses are the experimental observations. If $A$ equalled ∞ ('no effect'), the points would lie on the horizontal line $\chi = 0·792$

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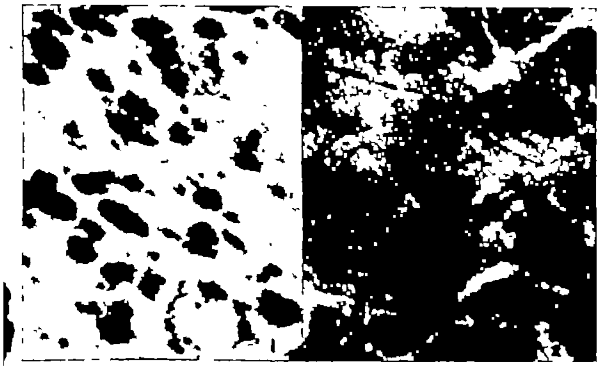
## Microscopical Identification of the Constituents of Coal Dust

In connexion with the work of the Pneumoconiosis Research Unit into the cause of pneumoconiosis, attention has been devoted to the problem of identifying and estimating the quantity of respirable constituents of the dusts found dispersed in the air in collieries. It was considered that a technique based on the plastic behaviour of fine particles as observed by me[1] and later confirmed by Bangham and Berkowitz[2] might be evolved.

A number of different types of crushing lenses have been made, and with them it is possible to crush suitably prepared samples of colliery dusts while watching them under the microscope. Coal substance under the conditions used becomes plastic and spreads. Minerals either spread, or shatter to smaller fragments, of micron size or less. They are colourless and thus easily distinguishable from the coal. Most coals in thin sections are highly coloured and the various ingredients readily recognized, the exceptions being those of high-rank, such as anthracites, which are practically opaque even in the thinnest sections.

The crushing technique for the estimation of some of the ingredients forming coal has now been improved so as to include the high-rank anthracites. The accompanying photographs (× 150) show two high-rank anthracites during crushing. Fig. 1 depicts particulate coal. The oval dark patches of the photograph are translucent and appear reddish-brown under the microscope; they are vitrinite. The lighter grey oval patches are exinite and are bright yellow under the microscope. (The correspondence between colour and constituent has been established in lower-rank coals and it seems reasonable to apply it to higher-rank coals.) The large rather irregular oval white patch is mineral matter. Fig. 2 is an almost continuous sheet of another anthracite formed by the coalescence of a deposit of fine particles in which irregular light-grey flecks (arrowed) represent the yellow exinite. Most of the photograph shows shades of darker grey which represent the vitrinite ingredients and is reddish-brown under the microscope. The clear patches in both photographs are uninterrupted light.

There is a striking difference in the amount of exinite portion of these two anthracites. It is interesting to see that the 'flash' of the yellow exinite as a contrast to the reddish-brown of the vitrinite is as apparent in the anthracite as in the lower-rank coals, although the carbon content is so much higher. It is hoped to investigate whether this phenomenon occurs in anthracites formed by the influence of heat.



Because of the persistence of different colours of the coal ingredients in the anthracites when treated this way, a quantitative estimation of the vitrinite, fusinite, exinite fraction of the coal of all colliery dusts should now be possible. The mineral fraction is readily estimated by the areas of translucency, and it is hoped, at least, to separate the minerals into several groups by a further development of the method based on interference phenomena.

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## Alleged Optical Activity in Crystal Class *m*

Optical activity is theoretically possible in crystals belonging to the non-enantiomorphous classes *m*, *mm*2, $\bar{4}$ and $\bar{4}2m$; but only one substance has ever been cited as an example[1]. This is the dimer of the β-form of methyl mesityl oxide oxalate $(C_9H_{12}O_4)_2$, which was assigned by Sommerfeldt[2] to class *m* on the basis of morphological measurements.

Crystals corresponding exactly with those described by Sommerfeldt have been examined with X-rays and found to have the uniquely identifiable space group $P2_1/c$ with $a = 9{\cdot}15 \pm 3$ A., $b = 11{\cdot}56 \pm 5$ A., $c = 18{\cdot}02 \pm 5$ A., $\beta = 96° 12' \pm 20'$; $d_{\text{obs.}} = 1{\cdot}290$ gm.cm.$^{-3}$, $d_{\text{calc.}} = 1{\cdot}289 \pm 10$ gm.cm.$^{-3}$ for four molecules per unit cell. Sommerfeldt's axes are related to these by the transformation $102/010/\bar{1}02$. Polysynthetic twinning is prevalent, though the polarizing microscope gives no hint of this: the twins have $(10\bar{2})$ and [010] in common and the twinned reciprocal lattice approximates closely to Laue symmetry *mmm*. The habit of the single crystals resembles that of the crystals of the corresponding ethyl ester, which Sommerfeldt assigned to class 2/*m*. (The lattice of the ethyl ester apparently does not so easily permit analogous polysynthetic twinning.) The assignment of the methyl ester to class *m* is therefore erroneous though perhaps understandable.

Sommerfeldt's evidence for optical activity, which was only qualitative, may now be rejected for two reasons: (*a*) the centrosymmetry of the space group; and (*b*) his observations could, as Voigt[3] pointed out, be the result of twinning, or merely a consequence of increasing the illumination and so forcing a perceptible amount of light through the crossed nicols. This example may therefore be rejected, as it neither exhibits optical activity nor is in class *m*.

The absence of any example of optical activity in classes *m*, *mm*2, $\bar{4}$ and $\bar{4}2m$ may suggest some development of the existing theory or, more probably, reflects the considerable experimental difficulties of measuring optical activity in the presence of birefringence, and the decline of interest in this subject during recent years. A large number of substances have by now been reliably assigned to these classes, so that an intensive search among suitable representatives seems desirable.

A full account of the crystallography of the monomeric and dimeric forms, and a detailed discussion of Sommerfeldt's interpretation of the optical observations, will be published elsewhere.

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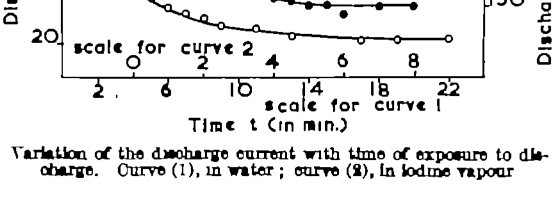
## Langmuir Adsorption as a Determinant of Conductivity in a Low-frequency Electric Discharge

The marked influence of sorption of electronegative gases on photo- and thermo-electric currents in a number of systems is well known[1]. We have now investigated the significance of Langmuir adsorption or chemi-sorption, chiefly occurring under discharge[2], in determining the conductivity of a gas excited at reduced pressures by low-frequency potentials.

Siemens-type ozonizers made of soft soda glass and degassed for the removal of pre-adsorbed gases by heating for 15 hr. at 200° C.[3] were employed; they were filled with iodine or water vapour at a desired pressure and excited by a 50-cycle potential. The root-mean-square value of the current *i* was measured by a microammeter or a galvanometer actuated by a crystal detector, vacuo-junction, etc.; and the nature of the current was studied by a cathode-ray oscillograph. The accompanying graph gives a typical series of results.

With the time of exposure to discharge due to a fixed applied potential sufficient to cause a self-



Variation of the discharge current with time of exposure to discharge. Curve (1), in water; curve (2), in iodine vapour maintained discharge, $i$ (and the associated high-frequency pulses observed on the cathode-ray tube) decreased rapidly and attained saturation within an appreciably short time interval (curves 1 and 2). It is suggested that sorption under discharge was exceedingly rapid[3], and it was attributed to the increased proportion, and accessibility to the surface containing free Langmuir sites[4], of gas particles with enhanced 'activation' energy[5]. Bangham[6] suggested that the amount ($x$) of gas adsorbed up to time $t$ follows a power–time law, $x = kt^{1/m}$. Our results also showed that the decrease ($\delta i$) in the conductivity up to time $t$ obeys a similar relationship (cf. curves 1 and 2 of inset graph: log $\delta i$ is sensibly a linear function of log $t$ as required by an equation $\delta i = k't^{1/m}$ analogous to Bangham's equation.

Calculations showed that the decrease of pressure due to uptake of gas particles by the known available surface area was inappreciable (for example, less than 0·01 mm. mercury when the initial pressure employed was 32·1 mm. of water vapour); in fact, theoretical considerations on the electrical discharge in gases[7] indicate that, for a fixed applied field, a reduction in gas pressure increases $i$, as actually observed[8]. The decrease of the conductivity (see graph) and its high-frequency pulses, with sorption on glass of iodine or water, are in agreement with the general decrease of photo- and thermo-electric currents by adsorbed electro-negative gases[1]; this suggests that atoms adsorbed on Langmuir sites increase the work function of the surface or inhibit the release from the (instantaneous) cathode of secondary electrons, the number of which controls the current $i$. If $S$ stands for a Langmuir site on clean glass surface, sorption of an electronegative atom such as iodine and its influence on electron liberation can be represented as:

$$S + I^{*} \rightarrow S - I;\ S - I + e \rightarrow S - I^{-}.$$

This indicates that atoms when adsorbed on glass retain their electronegativity; a view which is contrary to the current view that in Langmuir adsorption atoms adhere by sharing an electron with an alkali atom in the glass.

The work reported here was carried out in the Chemical Laboratories, Banaras Hindu University, Banaras.

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## Determination of the Relative Electrode Potential of an Uncharged Metal in Solution

A RECTANGULAR frame pendulum (Herbert type), oscillating on a spherical glass bearing in contact with a metal surface and surrounded by an electrolytic solution, is known to exhibit a rate of damping which is roughly a parabolic function of the potential of the metal surface[1] (cf. the classical electrocapillary curve). Rehbinder[1] (see also Rozhanski[2]) envisaged the formation of "reversible micro-fissures" in the metal surface under deformation: the electrical double layer penetrated the orifice of the micro-fissure, reducing cohesion, and hence the hardness, of the metal.

Using a Herbert-type pendulum, a relation between $\frac{1}{a}\frac{da}{dt}$ (where $a$ is initial amplitude of oscillation of pendulum and $t$ is time) and potential was obtained on a zinc surface in $N$ hydrochloric acid with a maximum coinciding with that previously reported. The pendulum was then replaced by a 136° Diamond Pyramid (Vickers) hardness tester, employing a load of 1 kgm. (the same weight as the pendulum), and the same solution and potential variation conditions. No variation of hardness with potential was observed: Rehbinder's explanation hence appears invalid.

The maxima of the $\frac{1}{a}\frac{da}{dt}\Big/$potential relations were determined in $N/10$ and $N/100$ aqueous solutions of hydrochloric acid for zinc, lead, cadmium, copper and nickel. These 'decay maxima' lie upon the linear relation which exists between the potentials of the electrocapillary maxima[3–5] of mercury, gallium and platinum, and the work functions of these metals. Further, determination of the potential of the decay maxima on an amalgamated copper surface in (not highly purified) $M/10$ hydrochloric acid showed this to be $-0·19 \pm 0·03$ V. on the hydrogen scale, whereas in the absence of specific adsorption the potential of the electrocapillary maximum at a mercury-solution interface is about $-0·22$ V. (That the potential of the electrocapillary maximum on amalgamated copper can be taken as closely approximating to that on mercury under the same solution conditions follows, for example, from the equivalence of the overpotential[6] results on mercury and amalgamated copper at the same current densities.) These facts strongly suggest that the potential of the decay maximum can be identified with that of the electrocapillary maximum (charge-free surface). An experimentally easy method of determining the potential of a charge-free surface at a solid metal-solution interface is therefore available. Previous indication of this was by a comparison of pendulum maxima with electrocapillary maxima obtained by measurements on molten zinc in a eutectic of potassium and lithium chlorides[7]; but the invalidity of the conversion of potential scales from that used in the molten, to that of the aqueous, system makes this comparison useless.

It can be shown that $\frac{1}{a}\frac{da}{dt} \simeq K\mu$, where $K$ is a constant and $\mu$ is the coefficient of friction of glass or metal. An explanation of the phenomenon reported therefore rests upon understanding the dependence of friction on interfacial potential. An appreciable layer (continuous or broken by 'welds' between metal and bearing) of electrolytic solution must exist between the metal and the pendulum bearing. Except at the point of zero charge, excess ions of one sign exist in the double layer and mutually repel each other, thus resisting compression increasingly with increasing departure from the potential of zero charge. As the charge on the metal increases, the mean distance from the bearing surface to metal surface increases, thus reducing the attractive force between the surfaces (or, effectively, the load of one surface on the other), and so diminishing the friction. Hence, $\mu$ is greatest when zero charge exists on the metal surface, and the potential at this point thus coincides with the $\frac{1}{a}\frac{da}{dt}$-potential maximum.

It was suggested by Barker[8] that the chief features of the friction-potential relations of platinum are due to the adsorption of oxygen and hydrogen. Bowden and Young[9] later advanced a dual explanation in which effects due to the electrical double-layer are superimposed on effects due to adsorbed gases. That adsorbed gases are not always necessary to explain the effects of potential on friction is shown by the results for amalgamated copper where, for the potential range studied, adsorbed oxygen is absent and the adsorption of hydrogen is very small.

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## Mechanism of Electropolishing

*Electropolishing in molten salts.* I have found that gold, platinum and palladium may be anodically polished using pure ('Analar') molten potassium chloride or sodium chloride as electrolyte. With palladium electrodes of about 1 cm.$^2$ area and 2 cm. apart at about 950° C., etching occurred at low current-density, but gave place to polishing at about 1 amp./cm.$^2$ (calculated on the inner faces only) and 3 volts potential difference. For gold at 970° C. and platinum at 1,020° C., using a 3-cm. diameter nickel crucible as cathode, there appeared to be no clearly defined lower limit to the polishing conditions, but polishing was observed at and above 0·15 amp./cm. and a potential difference of 1·5 volts. Palladium was also polished in an enclosed system with hydrogen bubbling vigorously through the electrolyte around the anode.

'Baser' metals than the three mentioned (for example, iron and copper) give less brilliant results, probably because they are attacked while cooling by the contents of the adhering electrolyte.

*Conditions at polishing and etching anodic surfaces.* The adsorptive conditions at polishing and etching copper surfaces have been directly compared in an arrangement consisting of a vertical cathode (1 cm. square) and a horizontal anode (1 cm. × 5 cm.) with its long axis normal to the cathode and its tip 1 cm. from the centre. In 50/50 v/v phosphoric acid, it was possible to adjust the voltage (*c.* 1·2 V.) so as to produce three differing anodic bands simultaneously: (*a*) polish for 1 cm. from the tip; (*b*) an intermediate area; (*c*) etch on the remainder. When about 1 per cent of 'saturated' mercuric nitrate solution was included in the electrolyte, amalgamation took place on all except the polishing surface (*a*). Similarly, on anodes which had narrow, lightly amalgamated lines drawn along their lengths, mercury was removed in the polishing region but the lines broadened in the etch region. Bands similar to (*a*), (*b*) and (*c*) were produced in an electrolyte of 1 *M* $CuSO_4$ (at *c.* 3 V.) and behaved correspondingly towards mercuric ions, although the area (*a*) was matt and after a few minutes became covered with a dark brown deposit. In both phosphoric acid and copper sulphate, mercury droplets sprayed over the anode would not adhere readily to the area (*a*).

The experiments in molten electrolytes show clearly that electropolishing cannot be explained by postulating layers of oxide, hydroxide, etc., on the anode[1], for in this case the substances corresponding to oxides would be chlorides of the metals concerned, and under the conditions of the experiments the lattices of the chlorides of gold, platinum and palladium could not exist. The possibility of oxide films due to dissolved oxygen is ruled out by the experiment in hydrogen and by the observation that in all cases polishing could be obtained at temperatures well above those at which oxide could survive. Similarly, it is concluded from the behaviour of copper anodes towards mercuric ions in aqueous solutions that the non-adherence of mercury droplets to a polishing surface, reported by Hoar and Farthing[2], is due not to oxide films but to failure to establish a contact-adsorbed film of mercury at the relatively high current-density required for polishing. Further, since the etch-forms and growth-forms of metal crystals are controlled by adsorption[3], the observations indicate that at high current-density etch is inhibited because the formation of regularly adsorbed layers is prevented. Polishing should then follow automatically, since the electric field will be highest at projections. The matt surface of type (*a*) obtained in copper sulphate electrolyte is believed to be due to the formation of solid by-products in contact with the metal, since it resembles that of a copper single crystal which has been attacked by iodine vapour with the formation of solid cuprous iodide.

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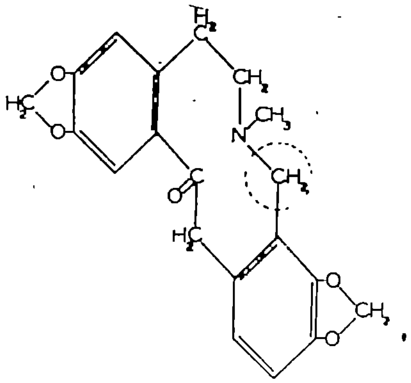
## Origin of the Methylenedioxy Groups of the Alkaloid Protopine

There is a rapidly increasing body of evidence in the literature that all biological methylation processes, as well as many other 'single-carbon' biological syntheses, have a common pattern. It has been shown that the N-methyl groups of the alkaloids



Protopine

hordenine[1,2] and nicotine[3], and the N- and O-methyl groups of the alkaloid ricinine[4], have the same origin as the labile methyl groups in animal metabolism. Similarly, the O-methyl groups of barley lignin have been shown to fit this same pattern[5]. We have recently extended these observations to the methylenedioxy and N-methyl groups of the alkaloid protopine.

The plants used in these experiments were *Dicentra* hybrids (*Dicentra eximia* (Ker.-Gawl.) Torr. × *Dicentra oregana* (Eastwood)), which we have shown produce considerable amounts of protopine under the conditions of these experiments. Three rapidly growing young hybrids were fed, respectively, carbon-14 methyl-labelled L-methionine, carbon-14 methyl-labelled choline and carbon-14-labelled sodium formate. The labelled materials were administered dissolved in the liquid culture solution[6] in which the plants were growing. At the end of a one-week growth period in contact with the labelled materials, all three plants had translocated activity to their topmost leaves and were removed from the solutions and dried in an oven at 110°. The dried plants were extracted with methanol in a Soxhlet extractor, and carrier protopine (500 mgm. per plant) was added to each extract. The protopine from each extract was isolated according to the procedure of Manske[7] and purified to constant specific activity by recrystallization of the free base and its nitrate salt from methanol. The specific activity of the N-methyl group was determined by degrading a portion of the alkaloid according to the methylimino determination of Pregl[8] and trapping the liberated methyl iodide in trimethyl amine. The tetramethylammonium ion was counted as its reineckate. The specific activity of the methylenedioxy groups was obtained by the hydrolysis of a separate portion of the alkaloid with 20 per cent sulphuric acid followed by the isolation and counting of the liberated formaldehyde as its dimedone derivative. The results of these determinations are shown in the accompanying table.

| Metabolite administered | | | Specific activity (c.p.m. per m*M*.) | | |
|---|---|---|---|---|---|
| | Weight (mgm.) | Activity (c.p.m.) | Protopine | Methylenedioxy group | N-methyl group |
| L-Methionine | 82 | $1 \cdot 2 \times 10^7$ | $8 \cdot 8 \pm 0 \cdot 1 \times 10^5$ | $1 \cdot 5 \pm 0 \cdot 1 \times 10^5$ | $1 \cdot 9 \pm 0 \cdot 1 \times 10^5$ |
| Sodium formate | 10 | $5 \cdot 0 \times 10^7$ | $1 \cdot 3 \pm 0 \cdot 1 \times 10^5$ | | |
| Choline chloride | 60 | $3 \cdot 0 \times 10^7$ | 0 | | |

It is seen that methionine methyl serves as a precursor of both the methylenedioxy and N-methyl groups of the alkaloid. Formate also contributes activity to the molecule, although to a considerably less extent than methionine. Formate serves as a precursor of labile methyl in the barley and tobacco plants[1,2], but it could not be shown with certainty that it was a precursor in the present case. The radioactivity in the alkaloid from the formate experiment was so low that significant specific activities for the degradation products could not be obtained. Nevertheless, the results indicate that the methylenedioxy groups arise from the oxidation of an O-methyl group followed by ring closure on an adjacent hydroxyl rather than a formylation followed by reduction and ring closure. If the reverse were true, one would expect the alkaloid from the formate run to be labelled to at least as great an extent as the alkaloid from the methionine run. This follows from the fact that the level of activity fed in the formate experiment was four times that in the methionine experiment. If formate was a more direct precursor of the methylenedioxy groups than was methionine methyl, this high activity which was fed, coupled with the fact that the methylenedioxy groups contribute one-third of the total activity in the methionine run, would lead one to expect a higher level of activity in the formate experiment.

The fact that choline methyl does not contribute activity is not surprising. It has been previously shown, in the case of both barley and *Ricinus* plants, that choline methyl contributes neither to the 'labile methyl' nor 'formate' pools of these plants. The *Dicentra* plants seem to follow the same pattern.

An inspection of the table shows that if one subtracts the activity in the methylenedioxy groups and the N-methyl group from the total activity in the molecule, one is left with a residual activity approximately twice that in the N-methyl group. An inspection of the structure of protopine shows that it could have originated from two dihydroxyphenylalanine residues plus the carbon atom in the dotted circle. It is tempting to postulate that the residual activity is in this carbon atom, which had its biogenesis in the 'formate' pool of the plant. It has been shown that this 'formate' pool is concerned with biosyntheses involving single carbon atoms[9].

We wish to thank Dr. R. H. F. Manske for the plant material used in these experiments and for providing much useful advice. We also thank the Rockefeller Foundation for financial support for this work.

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## Relative Reactivities of the Olefinic and Cyano Links of Acrylonitrile in the Diels–Alder Reaction

THE Diels–Alder reaction, in which a stable six-membered ring is formed by 1,4-addition of an unsaturated linkage to a diene, has wide synthetic application. The role of the olefinic group as a dienophile is well known[1]. More recently, the addition of the cyano group to dienes with the formation of pyridinic products has been reported[2]. Acrylonitrile presents an interesting example in which the groups (C = C) and (C ≡ N), both dienophilic, are present. The present communication reports the results of a study on the reactions of acrylonitrile with butadiene. The relative reactivity of these two links of acrylonitrile in this reaction can be predicted from thermodynamic and kinetic considerations. The free energy changes at 700° K. for the formation of cyano*cyclo*hexene and vinylpyridine are −21 and −14 kcal./mol. respectively. These results are qualitative, since the data for the cyclic products were estimated by the method of group increments[3]; but they show that the two reactions are both thermodynamically feasible in this temperature-range. The ultimate yields are a concern of reaction kinetics. The relative rates of these two reactions, assuming the cyclization to be the rate-controlling step, were calculated from the expression:

$$k_a/k_b = \exp( (S_a^{\ddagger} - S_b^{\ddagger})/R - (E_a - E_b)/RT),$$

using the kinetic data of related high-temperature Diels–Alder associations. From a consideration of the activation energies of the reactions of acrolein[4] and cyanogen[5] respectively with butadiene, a minimum value of − 11·9 kcal. was obtained for $(E_a - E_b)$. The magnitude of $(S_a^{\ddagger} - S_b^{\ddagger})$ for the activated complexes was taken as approximately − 1·1 e.u. from the difference in entropy of 3-cyano*cyclo*hexene and 2-vinyldihydropyridine. Accordingly, at 400° C. in the homogeneous gas phase, it is predicted from these data that the formation of cyano*cyclo*hexene is 5,800 times more rapid than the formation of vinylpyridine.

The experimental study has shown that in the homogeneous reactions at about 400° C., only cyano*cyclo*hexene is found as product of the addition of acrylonitrile to butadiene. This is in accord with the analysis above, that is, very little, if any, vinylpyridine would be formed. In view of the favourable free-energy changes, the reactions were investigated in the presence of a catalyst. With chromium oxide – aluminium oxide as the catalyst system, acrylonitrile reacts by the (C=C) and (C≡N) bonds as predicted from the thermodynamic considerations. Taking yields as a measure of the relative rates of reaction, since both groups are competing for the diene, the reactivity of the (C=C) group is fifteen times greater than the (C≡N) group in the catalysed reactions. A summary of the experimental results is given in the accompanying table.

| Experimental reaction conditions | | | | Yields (mol. per cent) | |
|---|---|---|---|---|---|
| Catalyst | Time | Temp (° C.) | Press (atm.) | Cyano-*cyclo*hexene | Vinyl-pyridine |
| — | 14 hr. | 160 | 1 | 80 | — |
| — | 6 sec. | 390 | 1 | 77 | — |
| 4% $Cr_2O_3$ on alumina | 4 sec. | 480 | 1 | 28·0 | 1·8 |

A detailed account of this work is to be published elsewhere. Acknowledgment is made to the American Cyanamid Company for a fellowship grant in support of this work.

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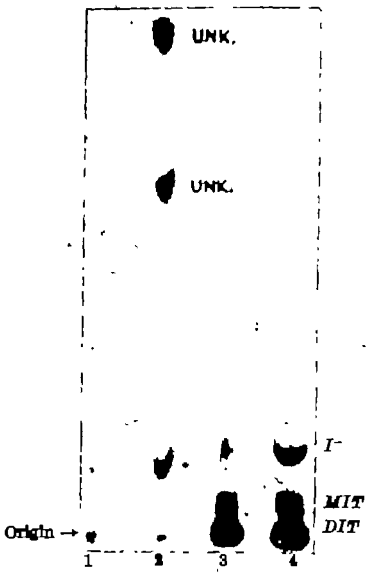
## Artefacts produced from 3-Iodo-Tyrosine and 3 : 5-Di-iodo-Tyrosine by Heating with Alkali

DURING a study[1] of the hydrolysis of native hog thyroglobulin labelled with iodine-131, by a purified protease isolated from hog thyroid glands, fractions eluted from paper chromatograms of the enzyme fission products were treated with 2*N* sodium hydroxide at 105° for 16 hr. Control aliquots were allowed to stand for the same time at 0°. On application of *n*-butanol extracts of the heated and control samples to paper and development of the chromatograms with *n*-butanol – *n*-pentanol – ammonia[2] as solvent, unexpected radioactive spots of high $R_F$ (at 0·52 and 0·68) were observed with the heated samples. Since the original eluates were found to contain free mono- and di-iodo-tyrosine and thyroxine, the action of alkali on purified samples of the iodo-amino-acids was examined.

Labelled iodo-tyrosines and thyroxine were obtained by the micro-iodination method of Lemmon, Tarpey and Scott[3] from L-tyrosine and 3 : 5-di-iodo-DL-thyronine respectively. The products were separated from unreacted iodide and other impurities by paper chromatography. *n*-Butanol – *n*-pentanol – ammonia was found best for the purification of thyroxine, and *n*-pentanol – propionic acid – water (20 : 3 : 10) for mono- and di-iodo-tyrosine, which were readily separated in this system from each other and from iodide. Incidentally, this acidic solvent system may also be used to separate thyroxine, which has an $R_F$ value of 0·80 compared with 0·28, 0·51 and 0·04 for mono-iodo-tyrosine, di-iodo-tyrosine and iodide respectively on Whatman No. 1 paper.

When labelled thyroxine was heated under the above conditions and the product extracted into butanol, a loss of approximately 10 per cent occurred as measured by iodine-131 activity of the extract, but no artefacts were detected. In the case of di-iodo-tyrosine, however, there was a four- to eight-fold increase in activity of the butanol-soluble fraction compared with the corresponding extract obtained from a control solution allowed to stand at 0°. Moreover, application of the butanol extract of the heated sample to paper and development with butanol – pentanol – ammonia gave radioactive spots at $R_F$ 0·52 and 0·72 corresponding to those detected in the hydrolysates from the enzyme fission products. (On the same chromatogram, carrier mono- and



Radioautogram of chromatogram of butanol extracts, washed with water, of an alkali-treated (2*N* sodium hydroxide, 16 hr.) preparation of iodine-131 labelled 3-iodo- and 3 . 5-di-iodo-L-tyrosine 1 and 2: direct extracts of assay (105°) and control (0°). 3 and 4: extracts of assay and control after adjustment of *p*H to 3·5 with hydrochloric acid. *MIT*, *DIT*: mono- and di-iodo-tyrosine. I⁻: iodide. UNK: unknown. Solvent · butanol – pentanol – ammonia. Whatman No. 3 paper

di-iodo-tyrosine and thyroxine were made visible by ninhydrin at $R_F$ 0·03, 0·01 and 0·22 respectively.)

The same radioactive artefacts were produced when labelled di-iodo-tyrosine was heated with alkali in the presence of carrier, also from mono-iodo-tyrosine (but to a lesser extent) and from a mixture of labelled mono- and di-iodo-tyrosine. The accompanying radioautogram is of a chromatogram obtained from butanolic extracts of the alkaline solution (before and after adjusting to *p*H 3·5) resulting from an experiment in which a mixture of the iodo-tyrosines was used. An unheated control was similarly extracted and applied.

So far as quantitative studies have been made, it appears that under the above conditions only about 5 per cent of the activity of labelled di-iodo-tyrosine is transferred to the artefact fraction. Thus, in the assay of thyroglobulin for its thyroxine content in which a butanol extract of the hydrolysate is used, the error would be almost negligible; however, with artificial thyroproteins, owing to the usually higher iodo-tyrosine/thyroxine ratio[4], allowance might have to be made. Friedberg and Reineke have reported recently[5] on the presence of significant amounts of iodine-containing substances other than thyroxine in washed butanol extracts of iodo-casein hydrolysates, but no details are given. It is possible that these substances arise in part from iodo-tyrosines as suggested by the present investigation.

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## Latent Carcinogenic Action of Beta-Irradiation on Mouse Epidermis

A SINGLE application of a carcinogenic hydrocarbon, in itself insufficient to cause tumours, can bring about a change in mouse skin enabling subsequent applications of the non-carcinogenic substance croton oil to result in the formation of papillomas and carcinomas[1]. It seemed of interest to inquire whether a 'latent' tumour change similar to that produced by the hydrocarbon could be induced in mouse skin by the local application of beta-rays in a single, subcarcinogenic dose.

A total of eighty-six female Swiss mice was used in this first exploratory experiment. As in previous investigations of chemical skin carcinogenesis,[1] the interscapular region was chosen for exposure. Thallium-204 was selected as a source of moderately energetic beta-rays, in order to localize the radiation injury to a relatively small volume of skin. The isotope is produced by neutron bombardment of stable thallium-203 by the reaction (*n*γ). Thallium-204 decays to stable lead-204 with the emission of a beta-particle that has a maximum energy of 0·78 MeV.; its half-life is approximately three years. The thallium was supplied by the Oak Ridge National Laboratory of the U.S. Atomic Energy Commission as thallium nitrate with a specific activity of 0·042 mC./mgm. After purification and repeated precipitation, the thallium nitrate was filtered on paper disks 6 mm. in diameter.

The paper disks were then mounted on 'Lucite' holders and fastened to them with a single layer of Scotch tape. The transparent tape absorbed not more than 10 per cent of the radiation. The dosage rate at the surface of the plaques was calculated, since no appropriate instruments for direct measurements were available. The calculated dose was 870 rep./hr. Two of the plaques were assayed in the Radio-Isotope Control Department of the Oak Ridge National Laboratory through the courtesy of J. H. Gillette, who determined a value of about 800 rep./hr.

For exposure, the animals were placed in tightly fitting cylindrical plastic tubes. The interscapular region of the skin was exposed through a square window in the centre of the tube, into which was fitted the 'Lucite' holder with the radioactive plaque. The animals were held in this position by corks at either end of the tube. The plaque could be manipulated so as to be in direct contact with the skin. All animals were uniformly exposed for one hour, receiving approximately 800 rep. The beta-rays of this energy have a penetration in tissue of 2·5 mm. as a maximum, and the greatest damage, therefore, was done to the epidermis and its appendages. The croton oil was applied twice weekly as a 5 per cent solution in mineral oil (croton oil was obtained from Messrs. Boots, Nottingham, and the mineral oil, 'Superla 34', from the Standard Oil Company of Indiana). Croton oil treatment of the irradiated animals was begun one week following the radiation exposure. It is still continuing to-day with the surviving animals.

The radiation reaction was very mild in the group receiving radiation alone. There was slight erythema with minimal epilation two to three weeks after exposure. The hair grew again, and no skin abnormalities have been observed to date in these animals. In the second group of animals, receiving irradiation followed by croton oil, six animals have developed tumours

| Group | No. of animals | Irradiation (rep.) | Croton oil | Animals with tumours | Total No. of tumours | Survivors (8 months) |
|---|---|---|---|---|---|---|
| I | 26 | 800 | 0 | 0 | 0 | 21 |
| II | 30 | 800 | twice weekly | 6 | 13 | 17 |
| III | 30 | 0 | twice weekly | 0 | 0 | 20 |

so far, with an average of two tumours per animal. The first tumour was recorded six weeks after painting was begun. There have been no regressions and no malignancies. Some of the tumours were quite large. The average latent period has been 3·5 months. The animals receiving the croton oil alone showed the typical lesions of the skin associated with this treatment. The results are briefly summarized in the accompanying table.

While the total number of animals with tumours may appear small, it should be remembered that the dosages employed in this first experiment were deliberately made small. They were shown to be non-carcinogenic in the irradiated control animals, none of which has developed tumours so far. They were also considerably smaller than those reported to have been carcinogenic by Raper, Henshaw and Snider[2], who with total body beta-irradiation from phosphorus plaques described skin tumours with 3,000–4,500 rep., many of which regressed later on. Glücksmann has stated recently that he has been unable to produce skin tumours in mice with less than 8,000 rep.[3].

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## Occurrence in Plants Infected with Tobacco Mosaic Virus of a Crystallizable Antigen devoid of Ribonucleic Acid

PURIFIED preparations of tobacco mosaic virus have often been shown to be heterogeneous, some of the separated fractions being non-infective[1]. The latter are to some extent comparable with the 'soluble antigens' of animal viruses and have a bearing on the study of the mechanism of virus multiplication[2]. The following observations have been made on such fractions.

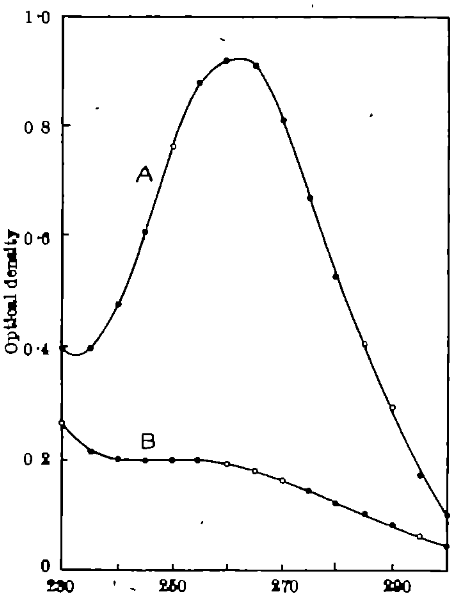
Extracts of the younger leaves of tobacco plants infected two months beforehand were centrifuged for 10–60 min. in a Spinco model *L* ultracentrifuge at 28,000 r.p.m. An aliquot of the supernatant obtained after 60 min. was centrifuged at 40,000 r.p.m. for a further 60 min. Infectivity of the supernatant liquids was compared with that of the initial extract by applying them and several dilutions of the latter to the two halves of leaves of *Nicotiana glutinosa*.

At the same time a sufficient amount of antiserum obtained by injection of tobacco mosaic virus into rabbits was added to equal volumes of the different supernatants, so that the antibody was in slight excess. Controls were prepared from normal serum and extracts of normal plants. The nitrogen content of the precipitates was determined. Results of a typical experiment are given in the accompanying table. It will be seen that centrifugation leads to a considerably more rapid decrease in the number of infective particles than in the total amount of material capable of reacting with the antibody, so that the very slightly infective supernatant obtained at 40,000 r.p.m. contains an important fraction of the total antigen present in the initial extract. Thus, as well as the infective particles with a high sedimentation-rate, the extracts appear to contain a large quantity of non-infective constituents which are immunologically similar, but characterized by a lower sedimentation-rate.

| Duration of centrifugation (min.) | Speed (r.p.m.) | Concentration of infective virus particles (arbitrary units) | Protein N antibody + antigen (μgm.) |
|---|---|---|---|
| 10 | 10,000 | 2,750 | 1,093 |
| 60 | 28,000 | 35 | 308 |
| 60 | 40,000 | 1 | 243 |

On the basis of these preliminary results, one can estimate the sedimentation-rate of the non-infective material remaining in the supernatant after 1 hr. at 40,000 r.p.m. to be at the most 1/30 of that of the infective particles. We attempted to isolate it from the centrifuged extract by the following procedure repeated three times: removal of proteins precipitating at $pH$ 4·7; precipitation at $pH$ 3·8 of proteins remaining in solution, followed by the taking up into solution of this material at $pH$ 7·0. The final precipitate at $pH$ 3·8 is exclusively formed of paracrystalline needles identical with those of the virus. The amount of protein isolated was equal to 1/16–1/20 of the infective virus obtained after 60 min. centrifugation at 28,000 r.p.m. This fraction has the following characteristics. It is non-infective. Like tobacco mosaic virus, it is largely precipitated by the antibody of an antiserum obtained by injection of tobacco mosaic virus, but the precipitate is finely granular instead of flocculent. Except in this last character, no other immunological difference has been found between the two substances. As regards the chemical properties, the non-infective protein contains no ribose (negative orcinol test) and no purine or pyrimidine bases (no characteristic ultra-violet absorption of a 10 per cent perchloric acid extract). It does not contain a measurable amount of ribonucleic acid (see graph).

The solution of this protein contains particles visible in the electron microscope and a quarter to an eighth of the length of the tobacco mosaic virus and comparable thickness. These dimensions do not agree with the fact that this protein remains in the supernatant of the initial extract after 60 min. centrifugation at 40,000 r.p.m.; it would thus have a sedimentation-rate much smaller than the one



Absorption spectra of 10 per cent perchloric acid extracts of equal quantities of virus (*A*) and crystallized non-infective material (*B*)

expected for the visible particles. Isolation processes, however, may be accompanied by partial aggregation of initially smaller units. On the whole, this fraction is strikingly similar to the non-infective protein which accompanies the turnip yellow mosaic virus[3]. It is possible that the presence of similar proteins is a general characteristic of virus diseases in plants. A more extensive study of these proteins will be necessary to give us a clue as to their origin and possible significance for virus multiplication.

We are indebted to Mr. F. C. Bawden for the gift of the purified virus employed and seeds of *Nicotiana tabacum* var. White Burley.

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## Effects of Trichloroacetic Acid on the Extension Growth of Root and Shoot Segments of *Pisum sativum*

It has been established that the sodium or ammonium salts of trichloroacetic acid can be employed for the control of graminaceous weeds in a variety of crops, but little is yet known concerning the physiological effects and the mode of action. Veldstra[1] has shown that, at a concentration of $5 \times 10^{-3}$ *M*, trichloroacetic acid causes curvature in the split pea test, but doubts whether the operative mechanism is similar to that of recognized growth regulators. On the other hand, Holly, a member of this Unit, observed in East African field trials in 1950 that trichloroacetic acid caused ear deformities in *Dactyloctenium giganteum* and *Panicum maximum* which were very similar to those produced in cereals by 2 : 4 dichlorophenoxyacetic acid. Again, in the laboratory, the morphological effects induced in *Lemna minor* were similar to those caused by the dichlorophenoxyacetic acid.

In the course of a general investigation of the physiological effects of trichloroacetic acid a detailed study has been made of the changes in the extension growth of root and shoot segments of *Pisum sativum* (var. Alaska) induced by this acid either alone or in combination with 2 : 4 dichlorophenoxyacetic acid. The techniques employed are those described by Brown and Sutcliffe[2] for the root segments and Thimann and Bonner[3] for the shoot segments.

The changes in root elongation caused by varyin concentrations of trichloroacetic acid are shown i Fig. 1, and it is to be noted that the relationshi is of a most unusual type. At exceedingly low con centrations ($10^{-11}$ *M*) there is some inhibition whic reaches a maximum at *c.* $10^{-9}$ *M*. At higher concentrations there is a reversal in trend such tha growth is not affected at $10^{-4}$ *M*, while betwee $10^{-4}$ *M* and $3 \times 10^{-3}$ *M* the rate of elongation i progressively increased. It is not until a concentratio of no less than $10^{-2}$ *M* is reached that extensio growth is again inhibited. A possible explanation i that there are three independent actions involve an inhibitory effect at low doses, which becom masked by an independent stimulatory effect intermediate trichloroacetic acid concentrations, a a final inhibition probably associated with gro damage to the tissue.

In contrast to the results for root segments, when similar measurements are made on intact roots, as in the cress-root method devised by Audus[4], there is no evidence of accelerated growth and the reduction occurs at a concentration of about $10^{-3}$ *M*. The behaviour of the shoot segments is similar to that of the intact roots, except that there is a more progressive reduction in elongation occurring over the range $10^{-4}$–$10^{-3}$ *M*.

When shoot and root segments are treated with trichloroacetic acid and 2 : 4 dichlorophenoxyacetic acid alone and in combination, statistical analyses show that there are definite and significant interactions. Because of the complexity of the dose

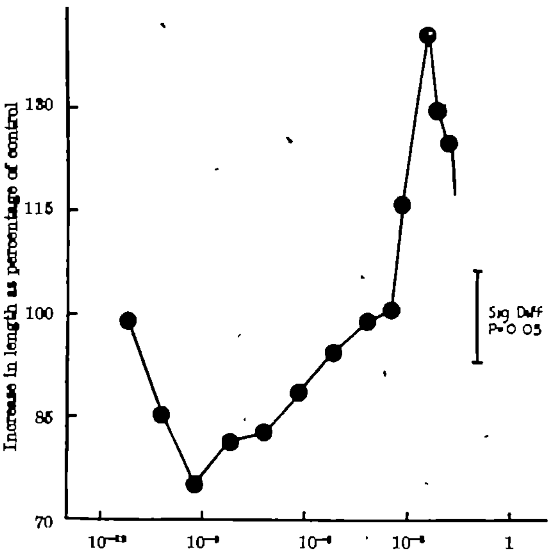

Fig. 1. Elongation growth of pea root segments grown for 24 hr. in nutrient solutions containing varying amounts of trichloroacetic acid

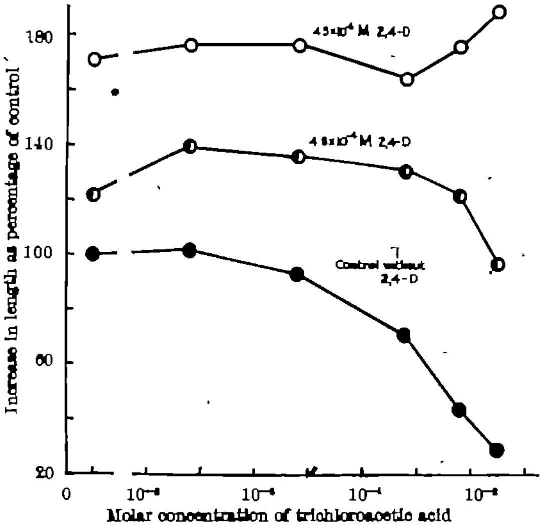

Fig. 2. Elongation growth of pea shoot segments kept for 24 hr. in solutions containing varying amounts of trichloroacetic acid, and 2 : 4 dichlorophenoxyacetic acid

response curves (see Fig. 1) the interpretation of the interactions is complex and a detailed discussion will be published elsewhere, but one aspect is illustrated in Fig. 2. When 2 : 4 dichlorophenoxyacetic acid is added at concentrations of either $4·5 \times 10^{-6}$ *M* or $4·5 \times 10^{-4}$ *M*, then the normal inhibitory effects of increasing concentrations of trichloroacetic acid are largely eliminated. Indeed it is evident that there are combinations where the increase in extension growth brought about by the growth regulator alone will be accelerated by the addition of trichloroacetic acid at a concentration which by itself would have been markedly inhibitory.

It is suggested that the phytotoxic properties of trichloroacetic acid may be related to the auxin status of the plant and that herbicides consisting of mixtures of trichloroacetic acid and 2 : 4 dichlorophenoxyacetic acid may have definite disadvantages.

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## A Cladoceran from the Plankton as a Possible Indicator for the Presence of the Nile Flood off the Israeli Coast

DURING the examination of the plankton collected in the course of the monthly cruise off the Israeli coast in September 1951 an unusual abundance of a cladoceran, identified as *Podon polyphemoides* (Leuck.), was observed in some of the samples. The organism was found to be present along the coast from Askalon in the south to Athlit in the north, being most abundant at a depth of 10 fathoms, its incidence gradually decreasing towards the 75-fathom depth-line.

The relative scarcity of Cladocera in the marine plankton of this part of the Mediterranean in the preceding and following months suggests that the sudden mass occurrence of *Podon polyphemoides* in the plankton of the coastal waters of Israel at this time of the year is due to a current of water flowing along the coast in a northerly direction. This current is induced by the opening of the dams in the Nile delta a few weeks earlier, thus releasing a powerful flow of fresh water into the sea[1].

A striking correlation has been found to exist between the occurrence of *Podon polyphemoides* and a substantial drop in salinity caused by the Nile flood by the time it reaches the stations where sampling took place along the coast.

The organism is mentioned by previous investigators as occurring occasionally in the plankton of the Suez Canal[2] as well as in the plankton of the eastern and western harbours of Alexandria in the month of March[3]. Steuer[4], however, failed to find *Podon* in the plankton while working in that region, but mentioned in another place the ability of the organism to live both in fresh and salt water[5]. The euryhaline and neritic characteristics of this organism have also been stressed by Ramner[6].

Specimens of this cladoceran were sent to Prof. V. Brehm, who kindly confirmed my identification.

It is to be assumed that the mass occurrence of *Podon polyphemoides* along the Israeli coast during the month of September is connected with the appearance of the Nile flood waters in this region, and may serve as a possible indicator for the detection of the Nile flood in this part of the Mediterranean and the direction followed by the current in its northerly course. Work on this subject is continuing.

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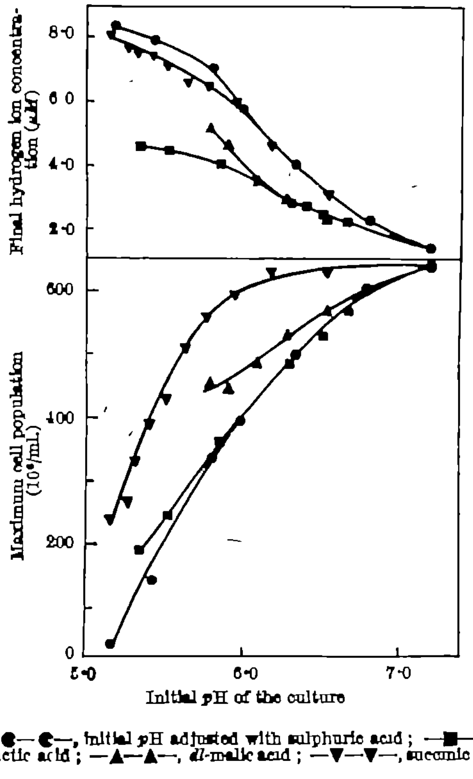
## Anaerobic Growth of *Escherichia coli* in the Presence of Certain Acids

CERTAIN coliform bacteria grow readily under anaerobic conditions in synthetic media containing glucose, ammonium sulphate, phosphate and other necessary inorganic ions. The extent of growth, however, is limited to a definite size of cell population even in the presence of excess concentrations of the substrates, the excess remaining unchanged in the media. This phenomenon has been ascribed to the saturation of the hydrogen acceptor mechanisms, and the evidence supporting this contention is strong[1]. The extent of growth depends also on the initial *p*H and the buffer capacity of the media, being less if the initial *p*H or the buffer capacity is lower. The dependence on buffer capacity has led to criticism of the above suggestion[2]. The growth of such cultures is accompanied by production of acid, but their final *p*H depends on the initial, and growth may stop at a higher *p*H than will permit growth in a fresh medium. Thus, though hydrogen ion concentration is undoubtedly a factor, cessation of growth cannot be due solely to its increase.

Since the production of acid per mole of glucose consumed is considerably greater anaerobically than aerobically[1], it is possible that some of the end-products of the hydrogen acceptor mechanisms are acids and that their production is affected by hydrogen ion concentration. It seemed, therefore, that the effect of adding certain acids to the media would be of interest. The basic medium was buffered with 9·85 gm. per litre potassium dihydrogen citrate adjusted to $p$H 7·2 with sodium hydroxide, and contained sufficient glucose, phosphate and ammonium sulphate to permit the maximum anaerobic growth at this buffer concentration. The organism was *Escherichia coli*, N.C.T.C. 5928, accustomed to the medium and conditions.

In four parallel series of experiments, the effects of additions of lactic, *dl*-malic and succinic acids were compared with those of additions of sulphuric acid. In the diagram, the extents of growth and the hydrogen ion concentrations prevailing as growth ceases are plotted against the initial $p$H. Lactic acid has much the same effect on growth as sulphuric acid, but in all cases the final hydrogen ion concentration is not so great and the difference increases with increase of concentration of lactic acid. At low concentrations the effects of *dl*-malic acid resemble those of lactic acid, but as the concentration increases the results diverge. At concentrations greater than about 6 × $10^{-3}$ *M*, *dl*-malic acid compensates for the decrease in initial $p$H and maintains the extent of growth. Parallel results were obtained with medium at an initial $p$H of 6·2. From 0 to 4 × $10^{-3}$ *M*, succinic acid maintains the extent of growth despite the lower initial $p$H, but does not affect the final hydrogen ion concentration; above this concentration both the extent of growth and the final hydrogen ion concentration are decreased. Above 8 × $10^{-3}$ *M* succinic acid is a more effective inhibitor of growth than sulphuric acid. The three organic acids affect the final hydrogen ion concentration inversely to their own concentration if it lies in a range in which growth is curtailed.



—●—●—, initial $p$H adjusted with sulphuric acid; —■—■—, lactic acid; —▲—▲—, *dl*-malic acid; —▼—▼—, succinic acid

In other experiments with lactic and *dl*-malic acids the initial $p$H was restored to 7·2 by adding appropriate quantities of sodium hydroxide. Up to 9·5 × $10^{-3}$ *M*, either substance decreases the extent of growth down to 500–530 million cells per ml. Thus reduction of the extent of growth can be effected by these acids independently of alterations of the initial $p$H of the medium. Under similar conditions, up to 3·5 × $10^{-3}$ *M* of oxaloacetic acid increases the total growth to 775 million cells per ml. Even without restoration of the initial $p$H, 1·9 × $10^{-3}$ *M* of this acid increases the maximum population to 700 million cells per ml.

The interrelation between inhibition by increase of initial hydrogen ion concentration and by lactic, *dl*-malic and succinic acids would be expected if the undissociated forms of these acids were the inhibitors. The application of this principle could link the capacity of the hydrogen acceptor mechanisms with the buffer capacity of the medium. The three acids studied may be some of the end-products of natural hydrogen acceptor mechanisms; but even if their natural production is not considerable, they would be expected to interfere with a system operating in this manner. It was calculated for experiments in which growth and change of $p$H were small that 1 × $10^{-6}$ *M* of undissociated lactic acid was present. If media containing 6 × $10^{-3}$ *M* of *dl*-malic acid and $10^{-6}$ *M* of undissociated lactic acid at a $p$H of 7·2 are inoculated, growth is restricted to 70 million cells per ml. despite the increase in buffer capacity due to the procedure.

G. A. Morrison

University College of Wales,
Aberystwyth.
Nov. 8.

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[1] Dagley, Dawes and Morrison, *J. Bact.*, 61, 433 (1951).

[2] Ravin, *J. Gen. Microbiol.*, 6, 211 (1952).

## Chromosome Numbers in *Holcus mollis*

Investigations into the interspecific relations of *Holcus lanatus* and *H. mollis* have shown that their $F_1$ hybrids are male-sterile, having only 1–20 per cent of stainable pollen. Chromosome counts have been made on twenty-three of these hybrids with the results given in Table 1.

Table 1

| Cross | Chromosome number in $F_1$ | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 21 | 22 | 23 | 24 | 25 | 26 | 35 | 40 | 42 | |
| *H. lanatus* × *H. mollis* | 1 | 2 | 3 | 5 | 2 | 2 | 1 | – | – | Frequency |
| Reciprocal | – | – | 2 | – | 3 | – | – | 1 | 1 | |
| | 1 | 2 | 5 | 5 | 5 | 2 | 1 | 1 | 1 | |

This unexpected range in chromosome number led to a cytological examination of the parent plants. *H. lanatus* was found to have $2n = 14$, a number which confirms the counts of Avdulov[1] and Litardière[2]. *H. mollis*, however, proved to have $2n = 35$, a new number for this species. Earlier investigators have found two numbers, namely, $2n = 14$ (Ståhlin[3]) and $2n = 28$ (Löve and Löve[4] and Litardière[2]).

The discovery of pentaploid *H. mollis* prompted a survey of chromosome numbers in both species

Preliminary results confirm *H. lanatus* as a diploid, while revealing three chromosome numbers in *H. mollis*: tetraploids ($2n = 28$), pentaploids ($2n = 35$) and hexaploids ($2n = 42$) have been found in this species, with frequencies as shown in Table 2.

Table 2

| Species | Area of collection | Chromosome number 28 | 35 | 42 | |
|---|---|---|---|---|---|
| *Holcus mollis* | Aberystwyth | 7 | 30 | 5 | Frequency |
| | Bayfordbury | – | 1 | – | |
| | Durham | 1 | 4 | 1 | |
| | Exmoor | – | 2 | – | |
| | Malvern | – | 6 | – | |
| | Neath | – | 5 | – | |
| | | 8 | 48 | 6 | |

These results show that pentaploid *H. mollis* is the most frequent form of this species, and that in some areas at least it co-exists with the tetraploid and hexaploid forms. More extensive investigations are being made to determine the distribution and relative frequencies of the chromosome types in various areas and their relation to each other.

A. R. Beddows
Keith Jones

Welsh Plant Breeding Station,
University College of Wales,
Aberystwyth.
Nov. 7.

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[1] Avdulov, N. P., *Bull. App. Bot. Genet.*, etc., Supp. 43 (1931).

[2] de Litardière, *C.R. Acad. Sci., Paris*, 228 (1949).

[3] Stählin, A., *Wiss. Arch. Landw.*, A, 1, 330 (1929).

[4] Love and Love, *Rit. Landbún.*, B, 3 (1948).

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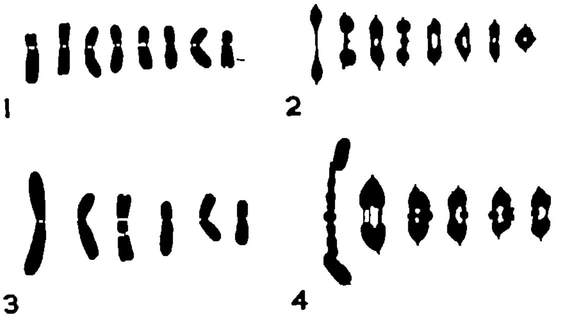
# Species Formation in *Trifolium subterraneum*

Subterranean clover (*Trifolium subterraneum*) is indigenous throughout the Mediterranean region. As an introduced species it is a major component of pastures covering some 10 million acres in Australia, and has contributed largely to the development of the Australian sheep industry during the past thirty years.

A recent paper by Yates and Brittan[1] on *T. subterraneum* reports six varieties, collected in Australia, each with 16 chromosomes ($2n = 16$), whereas two varieties, collected in Israel, had only 12 chromosomes ($2n = 12$). I have examined collections from Australia, England, Israel, Malta, Morocco and Portugal. I found, confirming Yates's and Brittan's report, that the easternmost variety, Israel, had 12, and all the others had 16 chromosomes. I also found that the chromosome complement of the Israel variety, in addition to a general increase in size, includes long chromosomes not present in other varieties (see diagrams).

Thus there are two chromosome races of *T. subterraneum* which are not externally different and one of which has so far been found only in Israel. Further, the Israel race has a new basic number $x = 6$, for the tribe Trifolieæ previously reported[2] only with $x = 7$, 8 and 9. Yates and Brittan compared the size and number of the chromosomes of the Israel variety with those of *Vicia sativa* ($2n = 12$) and suggested parallel evolution from a genus outside the Trifolieæ as a possible mode of origin of the new form.

With regard to size, differences in the size of chromosomes in different plants have been shown to be under genotypic control[3,4] and not necessarily indicative of the origin of the species. Further, Wexelsen[5] has shown differences in chromosome size between different varieties of *Trifolium repens*.



Chromosome idiograms from root-tips: (1) $n = 8$, (3) $n = 6$, and first metaphase configurations: (2) $2n = 16$, (4) $2n = 12$, of *T. subterraneum*. Idiograms drawn from Feulgen squash preparations × 3,000. Meiosis from carmine squash preparations × 1,800

With regard to chromosome number, a more likely suggestion is that the reduction in number is due to rearrangement. If the variety with the reduced chromosome number, $n = 6$, arose in this way from a form with $n = 8$, the changes could have taken place with very little loss of genic material. The greater range in size of the chromosomes of the Israel variety is sufficient to account for the chromosome material from the normal types, even taking into account the general increase in size (see diagram). This rearrangement could result from breakage and reunion of the chromosomes, as suggested by Darlington[4] to account for the different basic numbers in *Fritillaria*. The loss of the centromeres could be explained either by unequal interchanges followed by loss of the very small chromosomes, or by the formation of dicentric chromosomes with extremely short intercentric arms. Such a dicentric would behave as a monocentric chromosome and there would be in effect a fusion of the centromeres.

Such rearrangement has been inferred in *Crepis*[6], where the basic number of the most primitive species, $x = 8$, has been reduced to give species with $x = 7$, 6, 5, 4 and 3. Similarly, in species of *Drosophila* where the primitive species have $n = 6$ and subsequent species $n = 5$, 4 and 3, genetical analysis has confirmed the rearrangement of the chromosomes[7].

The Israel variety of the species has not yet been acclimatized in Australia. Its early-flowering habit would make it of advantage in areas of short seasonal rainfall in Australia. However, its usefulness is limited by its spindly growth habit. All attempts at hybridization with the more leafy types ($2n = 16$) have failed[1]. This inter-sterility and the difference in chromosome number necessitate the recognition of the Israel variety as a cryptic species.

R. D. Brock
(Research Officer, C.S.I.R.O., Australia)

John Innes Horticultural Institution,
Bayfordbury,
Hertford, Herts.
Oct. 31.

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[1] Yates, J. J., and Brittan, N. H., *Aust. J. Agric. Res.*, 3, 300 (1952).

[2] Darlington, C. D., and Janaki Ammal, E. K., "Chromosome Atlas of Cultivated Plants" (London, 1945).

[3] Thomas, P. T., *Nature*, 138, 402 (1936).

[4] Darlington, C. D., "Recent Advances in Cytology", 77, 559 (2nd edit., London, 1937).

[5] Wexelsen, H., *Univ. Calif. Pub. Agric. Sci.*, 2, 355 (1928).

[6] Stebbins, G. L., "Variation and Evolution in Plants", 447 (London, 1950).

[7] Dobzhansky, T., "Genetics and the Origin of Species", 244 (3rd edit., New York, 1951)

## Fog Fever Syndrome in Parasitic Bronchitis

Two years ago, Hudson, working at this laboratory, described a syndrome that he had observed in adult cattle, of which pulmonary œdema was a feature. He suggested that it might be due to an allergy associated with the small number of lungworms that he noticed were present.

Field studies have shown pulmonary œdema and emphysema to be a common feature of parasitic bronchitis in the adult bovine. The helminthological picture in such cases is very variable. At one extreme there may be large numbers of mature worms present, while at the other only a score or so of microscopic worms may be recovered. Since the development of the worms in the resistant host is often inhibited, their size gives but little indication of the time at which they were picked up.

Clinically, outbreaks of husk in adult cattle make themselves manifest either by a qualitatively uncharacteristic cough, or else, where pulmonary œdema or emphysema or both are present, by a syndrome very closely resembling the condition known as 'fog fever'. This is characterized by dyspnœa and crepitant or squeaking rales. The animal stands with its head stretched out, mouth open and tongue protruded, the ribs are held out and breathing is shallow, rapid and abdominal. The temperature is sometimes high, sometimes normal and may even be subnormal. Generally there is a loud expiratory grunt or groan. Coughing is relatively infrequent.

The occurrence of this syndrome is not confined to adults, and we have observed it in calves after three weeks of exposure to exceptionally heavy natural infection with *Dictyocaulus viviparus*.

We have also been having considerable success in producing the syndrome by the artificial administration of the infective larvæ of *D. viviparus* to young cattle kept under worm-free conditions. We are not able to produce the condition in every animal at will; nor is every case as spectacular as the most acute cases encountered in the field; nor yet is the proportion of deaths any higher than it is in naturally occurring outbreaks. In the twenty-four animals of the present series that have survived the first two months of the initial infection, the syndrome has been observed twelve times. There have been three deaths.

The syndrome, as so far observed, may be recognized as occurring at three stages in our experimental husk infections. Six cases occurred about the time that the initial infection was being spontaneously terminated. Two cases were seen some months after the initial infection had been eliminated, and we believe they may have been associated with the resumption of growth by worms that had been inhibited in their development. Four cases occurred about twelve days after the re-infection of animals that had thrown off the initial infection some time before.

The four circumstances in which the syndrome has been observed, that is, three weeks after first exposure to infection, twelve days after re-infection, about the time the initial infection was being thrown off and when previously inhibited forms may have been resuming their development, are all times at which one might reasonably expect some kind of immune response to be taking place. This would suggest that the condition, the pathology of which resembles that of an allergy, may indeed be related to such a response.

It will be noticed that in the three sets of circumstances in which our artificial fog fevers occur, mature worms will be either few in numbers or absent, while in those cases associated with the spontaneous termination of the infection even immature worms may not be present. This possibility means that the value of post-mortem examination in assessing the cause of naturally occurring cases of fog fever is limited. None the less, the examination of lungs from cases that have been diagnosed as fog fever by clinicians has so far revealed the presence of at least a few lungworms in all six of the lungs that have reached us in good condition.

It would appear from these findings that a proportion of fog fever cases are undoubtedly the consequence of lungworm infestation. The possibility that all fog fevers are associated with this cause cannot be discounted at this stage.

J. F. Michel

Ministry of Agriculture,
Veterinary Laboratory,
Weybridge. Nov. 11.

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## Transliteration of Cyrillic Script

In *Nature* of March 28, p. 548, the hope is expressed that other countries which use the English alphabet will adopt the Royal Society's scheme for the transliteration of Russian, Bulgarian and Serbian. It is therefore important to point out that the Permanent Committee on Geographical Names for British Official Use (an inter-departmental advisory body) considers the Royal Society's scheme to be unsuited to cartography. Far from letting things take their own course, the Permanent Committee has come to agreement with the United States Board on Geographic Names about the transliteration of Russian and Bulgarian. Serbian is officially written in both the Cyrillic and the Roman alphabets, and to transliterate Serbian geographical names into an English alphabet would produce objectionable variants of their official forms.

In the issue for February 27, 1890 (p. 397), *Nature* offered a system for the transliteration of Russian which was to "be adopted without delay" in the publications of eight leading British learned bodies, including the Royal Society, and which had the support of Russian and American authorities. So far as I am aware, it was not widely put into use, and for a good reason: a system of transliteration, once established in a big library, cannot be changed without great expense, delay and confusion.

The Royal Society has added one more to the dozen or so systems for the transliteration of Slavonic languages already established in British and American use. If agreement in the English-speaking world be possible, it will not be achieved without the co-operation of such bodies as the American Council of Learned Societies; but different English systems for the transliteration of a given foreign alphabet are required for different purposes. A good international system might be better, at least for postal and documentational purposes, than any good national system; but a bad one would be deplorable.

M. Aurousseau
(Secretary)

Permanent Committee on Geographical Names,
c/o Royal Geographical Society,
Kensington Gore, London, S.W.7.

# FORTHCOMING EVENTS

*(Meeting marked with an asterisk * is open to the public)*

### Monday, May 25—Friday, May 29

Textile Institute (at Llandudno).—Annual Conference

### Tuesday, May 26

Society of Instrument Technology (at Manson House, 26 Portland Place, London, W 1), at 6 p m —Annual General Meeting, at 7 p.m.—Mr. W. A Goldstein: "The Instrumentation of Pilot and Experimental Scale Plant".

### Wednesday, May 27

Royal Statistical Society (at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C 1), at 5.15 p m.—Mr. C A Moser and Mr. A. Stuart: "An Experimental Study of Quota Sampling".

Eugenics Society (at the Royal Society, Burlington House, Piccadilly, London, W.1), at 5 30 p.m.—Prof. D. Baird and Miss E. M. Scott. "Intelligence and Childbearing".*

Royal Microscopical Society (at Tavistock House South, Tavistock Square, London, W.C.1), at 5.30 p m.—Mr D. Causley. "High Speed Automatic Counting of Microscopic Particles—The Flying Spot Microscope".

### Thursday, May 28

Institution of Mining and Metallurgy (at the Geological Society, Burlington House, Piccadilly, London, W.1), at 4 p.m —Annual General Meeting; at 5.15 p m —Prof. J. A. S. Ritson: Presidential Address.

British Association for the Advancement of Science (at the Royal Institution, 21 Albemarle Street, London, W 1), at 6 p m.—Sir Harold Hartley, F.R.S.: "The Life and Times of Sir Richard Gregory" (Alexander Pedler Lecture). (Admission by ticket obtainable from the Secretary of the British Association.)

# APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned

Assistant Lecturer or Lecturer in the Department of Pure Mathematics—The Registrar, The University, Liverpool (May 30)

Biologist—The Secretary, King's College Hospital Medical School, Denmark Hill, London, S.E.5 (May 30).

British Coke Research Association Fellowship—The Registrar, King's College, Newcastle-upon-Tyne (June 1).

Research Assistant to work on the fundamental aspects of filariasis—The Secretary, Department of Entomology and Parasitology, Liverpool School of Tropical Medicine, Pembroke Place, Liverpool 3 (June 1)

Senior Lecturer in Mathematics—The Registrar, College of Technology, Birmingham 1 (June 2).

Assistant (with an honours degree in botany) in the Department of Botany—The Secretary, The University, Aberdeen (June 3).

Junior Fellowship in Electrical Engineering—The Registrar, The University, Bristol (June 5).

Assistant Agricultural Economist—The Registrar, Wye College, Ashford, Kent (June 6).

Assistant Lecturer (Grade 3) or a Lecturer (Grade 2) in Inorganic Chemistry—The Registrar, The University, Bristol (June 6).

Esso Studentship in Chemical Engineering—The Secretary, Department of Chemical Engineering, The University, Tennis Court Road, Cambridge (June 6).

Senior Lecturer in Agricultural Economy, a Senior Lecturer in Agricultural Engineering and Farm Mechanization, a Lecturer in Crop Husbandry, a Research Fellow in Soil Science, a Research Fellow in Soil Chemistry, and Soil Analysts (2), at the University College of the Gold Coast—The Secretary, Inter-University Council for Higher Education in the Colonies, 1 Gordon Square, London, W.C.1 (June 6).

Lecturer in Agricultural Economics—The Registrar, The University, Leeds 2 (June 8).

Lecturer in Organic Chemistry, a Lecturer in Physical Chemistry, and a Lecturer in Biochemistry (special experience of biochemistry of micro-organisms desirable)—The Secretary, The University, Aberdeen (June 8).

Lecturer and Assistant Lecturers (3) in the Department of Biochemistry (one of the appointments will entail research in certain physical aspects of biochemistry)—The Secretary, University College, Gower Street, London, W C 1 (June 8)

Senior Lecturer in Chemistry at the Fourah Bay College (University of Durham), Sierra Leone—The Secretary, Advisory Committee on Colonial Colleges, 15 Victoria Street, London, S W.1 (June 8).

Assistant Lecturer in Geography—The Secretary, London School of Economics and Political Science, Houghton Street, Aldwych, London, W.C.2 (June 12).

Lecturer (Grade 1) in Geography at the University of Ceylon—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C 1 (June 12).

Research Officer (with Ph D. or equivalent standard with special training in microbiological chemistry) to the Animal Health Research Laboratory, Parkville, Victoria, to carry out investigations in the field of microbiological chemistry—The Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W C 2, quoting 201/73 (June 13).

Cochrane Entrance Scholarship in Metallurgy—The Registrar, King's College, Newcastle-upon-Tyne (June 15).

Engineering and Physics Graduates (with first- or second-class honours degree in engineering, physics or mathematics) to join a group working on servomechanisms and controls—The Secretary, University Engineering Laboratory, Trumpington Street, Cambridge (June 15).

Lecturer (with a first- or second-class honours degree in mechanical engineering) in the Department of Applied Mechanics, and a Lecturer (with a first- or second-class honours degree in mathematics) in the Department of Mathematics—The Director of Studies, Royal Naval College, Greenwich, London, S E.10 (June 15).

Wood–Watson–Donkin Memorial Scholarships in Metallurgy or Chemistry—The Registrar, King's College, Newcastle-upon-Tyne (June 15).

Lecturer in Anatomy—The Dean of the Medical College, St. Bartholomew's Hospital, West Smithfield, London, E.C.1 (June 18)

Lecturer in Psychology—The Secretary, The University, Aberdeen (June 20).

Plant Physiologist (with good honours degree) at the A.R C Unit of Experimental Agronomy, Oxford, to work on fundamental aspects of phytotoxicity and action of herbicides—The Secretary, Agricultural Research Council, Cunard Building, 15 Regent Street, London, S.W.1 (June 20).

Chief Lecturer in Physiology at the University of Queensland—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C 1 (June 22).

Coal Survey Officer (with good honours degree or equivalent in a science subject, preferably with a sound background in geology and chemistry) in the Central Coalfield of Scotland—The National Coal Board, Establishments (Personnel), Hobart House, Grosvenor Place, London, S.W.1, quoting TT/633 (June 22).

Lecturer in Electrical Engineering (with experience in (*a*) heavy electrical engineering, (*b*) high vacuum engineering, or (*c*) radio-isotope applications and nuclear energy)—The Registrar, Queen Mary College, Mile End Road, London, E.1 (June 22).

Senior Agricultural Economist (to be largely concerned with liaison work between the Provincial Agricultural Economics Service and the National Agricultural Advisory Service)—The Registrar, The University, Leeds 2 (June 22).

Lecturer/Senior Lecturer (preferably with research experience in the fields of plant biochemistry, radio-biology, or bacterial chemistry) in Biochemistry at the University of Sydney—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (June 27).

Charles Brotherton Scholarship in the Department of Coal Gas and Fuel Industries—The Registrar, The University, Leeds (June 30).

Lecturer in Biophysics (with main research interest in the applications of radioactive tracers in biological and medical investigations)—The Secretary to the University, The University, Edinburgh (June 30).

Research Scholar (with a good honours degree in chemistry)—The Registrar, The University, Reading (June 30).

Foundation Chair of Applied Psychology, the Foundation Chair of Civil Engineering, the Foundation Chair of Mechanical Engineering, and the Chair of Electrical Engineering, in the New South Wales University of Technology, Sydney—The Agent General for New South Wales, 56–57 Strand, London, W.C 2 (July 1).

Chair of Anatomy in the University of Hong Kong—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C 1 (July 10).

Physicist or Engineer (with experience in the field of nuclear accelerators) to take a responsible part in the operation and technical development of the Nuffield cyclotron—The Registrar, The University, Birmingham 15 (July 15)

Assistant Professor in the Department of Civil Engineering—The Registrar, University of British Columbia, Vancouver, B.C, Canada.

Biochemist (non-medical)—Dr. J. M Sherriff, Consultant Pathologist, Hill End Hospital, St. Albans, Herts.

Biochemist (Senior Grade)—The Physician Superintendent, Crichton Royal Mental Hospital, Dumfries.

Head of the Department of Mathematics—The Principal, Borough Polytechnic, Borough Road, London, S E.1.

Lecturer (Grade B) in Physics, and a Lecturer in Physiology—The Clerk to the Governing Body, Battersea Polytechnic, Battersea, London, S.W.11.

Mechanical Engineer in the Public Works Department, Sudan Government—The Sudan Agent in London, Sudan House, Cleveland Row, London, S W.1, quoting "M/Engineer 1824"

Meteorological Forecasting Officer (with good forecasting experience) to the Falkland Islands Dependencies Survey, for service at South Georgia in Sub-Antarctic—The Crown Agents for the Colonies, 4 Millbank, London, S.W.1, quoting M3B/33254/NF.

Physicist for work on (*a*) footwear production and wear problems, (*b*) shoe materials and other products used in the industry—The Director, British Boot, Shoe and Allied Trades Research Association, Satra House, Rockingham Road, Kettering, Northants

Physicist or Electrical Engineer in the Steel Making Division, Sheffield, for research on electric arc furnace problems—The Personnel Officer, British Iron and Steel Research Association, 11 Park Lane, London, W.1, quoting "Arc Furnace".

Research Assistant in Physical or Physical-Organic Chemistry with particular reference to electrochemical or spectroscopic technique—The Principal, Medway Technical College, Gardiner Street, Gillingham.

Senior Research Assistant (with good honours degree in engineering) in the Department of Civil and Mechanical Engineering—The Registrar, The University, Nottingham.

# REPORTS and other PUBLICATIONS

(*not included in the monthly Books Supplement*)

## Great Britain and Ireland

Grain Crops: a Summary of Figures of Production and Trade relating to Wheat, Wheat Flour, Maize, Oats, Barley, Rye and Rice. Compiled in the Intelligence Branch of the Commonwealth Economic Committee. Pp. xxiii+144. (London: H.M. Stationery Office, 1953.) 5s. net. [173

Library Co-operation in Great Britain. Report of a Survey of the National Central Library and the Regional Library Bureaux. By Robert F. Vollans. Pp. xii+139. (London: National Central Library, 1952.) 5s. [193

Science Museum. Handbook of the Collections Illustrating Marine Engineering. By H. P. Spratt. Part 2: Descriptive Catalogue. Pp. 160+13 plates. (London: H.M. Stationery Office, 1953.) 7s. 6d. net. [193

Sotheran's Bibliotheca Chemico-Mathematica: Catalogue of Works in Many Tongues on Exact and Applied Science. Third Supplement. Pp. viii+442. (London: Henry Sotheran, Ltd., 1952.) 42s. net. [193

Royal Institute of Chemistry. Lectures, Monographs and Reports 1953, No. 1: The Chemistry and Toxicology of Organic Fluorine and Phosphorus Compounds. By Dr. Bernard C. Saunders. Pp. ii+18. (London: Royal Institute of Chemistry, 1953.) 4s. net. [193

Acton Society Trust. Nationalized Industry Series 12: Relations with the Public. Pp. iii+39. (London: Acton Society Trust, 1953.) 2s. [193

Ministry of Food. Manual of Nutrition. Third edition. Pp. v+68. (London: H.M. Stationery Office, 1953.) 2s net. [193

University of Cambridge: Department of Engineering. Report of the Acting Head of the Department for the Year 1951–52. Pp. 10. (Cambridge: Department of Engineering, The University, 1953.) [193

Political Activities of Civil Servants. (Cmd. 8783.) Pp. 16. (London: H.M. Stationery Office, 1953.) 6d. net. [193

African Education: a Study of Educational Policy and Practice in British Tropical Africa. (Produced on behalf of the Nuffield Foundation and the Colonial Office.) Pp. xii+187. (London: Crown Agents for the Colonies, 1953.) 8s. 6d. [203

Department of Scientific and Industrial Research. Report for the Year 1951–52. (Cmd. 8773.) Pp. 293. (London: H.M. Stationery Office, 1953.) 8s. net. [203

Handbook of Scientific Instruments and Apparatus, 1953, as shown at the 37th Physical Society Exhibition. Pp. xii+262+A.72. (London: Physical Society, 1953.) [233

Year Book of the Textile Institute and Library Catalogue. No. 5, 1952–53. Pp. 142+M.166. (Manchester: Textile Institute, 1953.) 15s. [233

## Other Countries

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# THE CORONATION

WITH the Coronation the scientist, as such, may appear to have but little concern. Like his fellow citizens, he may be profoundly moved by the pageantry and the tradition to which the Lancaster Herald directed attention in a recent discourse at the Royal Institution, the substance of which is reproduced on p. 948 of this issue. Nor will scientific men be backward in responding to the appeal of the occasion for re-dedication to service to the community in the Commonwealth with which the Queen and her husband have already become so inspiringly associated. Save, however, for those whose interests lead them to probe more closely into the origins of ritual and ceremony and their meaning for the continuity and the structure of society, the interest of men of science in the Coronation is essentially that of citizens rather than of scientists.

Nevertheless, there are reasons why the Coronation and what it represents deserve more than a passing thought from the scientist professionally. It is not simply that the pageantry and solemnity of the proceedings are brought to the ears and before the eyes of many more millions throughout the world than was possible even sixteen years ago, when George VI was crowned. Scientific advance—the astonishing miracle of science—has been the main factor that has made it possible for so many of the Queen's subjects to associate themselves so intimately with her in the very act of consecration and dedication, whereas before they had been limited to the manifestation of loyalty in the thronged processional streets or to viewing later the record of what was already a page of history. In the misgivings with which in some quarters the televising of the ceremony has been regarded, and the anxious debate which preceded that decision, may be sensed an appreciation that the impact of science on society has consequences and implications of which we are as yet only imperfectly aware. The very advances of which science is justly proud have themselves created fresh problems, often of unsuspected significance. The mind and outlook of society as well as its physical environment are being transformed, and the end is not yet apparent.

It would be surprising indeed if in such circumstances the minds of men and women did not turn with fresh and deeper interest to those ceremonies such as the Coronation which, by kindling loyalties and quickening tradition, seem to offer fresh hope of stability and of binding society together in an age when so much tends to erode its fabric. Nor is this all. Men of science are only too well aware of the extent to which, in country after country, the traditional freedom of investigation of the scientist, his right to pursue his investigations and inquiries wherever the disinterested search for truth may take him, has been challenged. The struggle for freedom of investigation and utterance which the nineteenth century deemed to have been won has been re-opened, and in circumstances often far more formidable to freedom than when Milton wrote his noble words in the "Areopagitica".

There are countries where science has at its disposal financial endowments vastly greater than those available in Great Britain, both for fundamental and for applied research. The universal tribute to the pre-eminence of British scientists in fundamental research might well remind us that in no other country does the scientist enjoy greater freedom of investigation and communication, despite all the invasions of that freedom by secrecy requirements arising out of considerations of national security, from which Great Britain, as also other countries, is not immune. So at this time the scientist might well reflect further whether there is not some connexion between that liberty and the nature of our whole system of government of which her gracious Majesty is the titular head.

Between systems of government and the spirit of the communities which they serve there is in fact a close, if intangible, connexion. The scientist never had more reason than to-day for appreciating that, while his professional activities are influencing the community more closely than ever, they are in turn conditioned by the spirit and outlook of the society in which he works and upon whom he depends for support. It is not simply that, to an increasing extent, even fundamental science depends upon public funds for support: the fields in which science can advance, and the rate at which the results of scientific advance are applied, are determined increasingly by public opinion. Indeed, in more countries than one it has become evident that there is real danger that scientific advance may be impeded by mass hysteria and misunderstandings amounting to what has been an antagonism which may constitute a definite anti-scientific trend.

It is in such circumstances that the amateur tradition of science is so important. Scientific advance has always owed much to the work of the amateur. That is still true to-day; and particularly science depends upon the help of the amateur in spreading an understanding and appreciation of what science is doing and the benefits it could bring to mankind. For this reason it is appropriate to recall, as Sir Arthur MacNalty does on p. 951 of this issue, the encouragement which the sovereigns of this realm have given to the pursuit of science and its teaching. The interest and understanding which Queen Elizabeth showed earlier this month at the Royal College of Surgeons was only the latest of a number of occasions on which she and her husband, the Duke of Edinburgh, have given encouragement which scientists, and perhaps especially it should be mentioned, the younger scientists, deeply appreciate and will ever remember.

Lastly, with a Sovereign who has herself shown her interest in science by accepting the fellowship of the Royal Society, the comparisons commonly being made between the present time and the first Elizabethan age cannot but stir the imagination of the historically-minded scientist. When the first Elizabeth ascended the throne, the founding of the Royal Society lay a full century in the future. Already, however, the discovery of America and the circumnavigation of the world had widened men's horizons, and the new learning, notably through the work and teaching of the Oxford 'humanists', More, Grocyn, Colet and Linacre, had started a ferment in men's minds which led in due course to Bacon's "New Atlantis" and to Newton.

No more than the first Elizabethans can we yet discern the new age that is waiting to be born. During the past four centuries, the limits of the physical world have been well-nigh explored. Save for Everest and the increasing mastery of the air, the feats of geographical exploration seem to have been accomplished, and it is with the world of the minute that the future seems likely to be most intimately concerned, whether we think in terms of nuclear research leading to the atom bomb or industrial power, or the way in which the electron microscope and other new tools are laying bare the structure of living tissues. Wherever that may take us, it is increasingly clear that not in the physical world will man find the wisdom and understanding that will enable him to face the future with courage and confidence. The foundation of society in the new Elizabethan age is to be found in the same moral and spiritual values that inspired the greatest of our forbears of that earlier age. The solemnity of the Coronation should take our minds back to that central truth, and as we pledge our loyalty to the Queen who is to be crowned on June 2, we should remember also that in such loyalty and in the respect for and clearer understanding of human values lies the condition both of scientific advance and of social well-being and order.

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# INTERNATIONAL TABLES FOR X-RAY CRYSTALLOGRAPHY

International Tables for X-Ray Crystallography (Published for the International Union of Crystallography.) Vol. 1: Symmetry Groups. Edited by Norman F. M. Henry and Kathleen Lonsdale. Pp. xi+558. (Birmingham: Kynoch Press, 1952.) 105s.

At a conference in Zurich in 1929 an international group of X-ray crystallographers met to work out the plans for a standard set of tables on space groups and of functions and data needed in practical crystal-structure analysis. The need for such tables arose in the minds of all those who were authors or prospective authors of books on structure analysis. At that time the application of space-group theory had become an accepted practice; furthermore, experimental methods had been standardized and corrections devised for obtaining the most accurate data. In a text-book, therefore, the author had either to include a great volume of already published tables, or to put up with the fact that his book could not be of practical use. Besides, different formalisms and nomenclatures were likely to spread and become firmly established in the schools of the various countries, and this was apt to lead to a great complication of the international literature. The establishing of a single plan for the tables required some sacrifice of pet ideas on the part of each of those who took part in the planning, but the result of the conference and of the subsequent work of the various schools, the "Internationale Tabellen zur Bestimmung von Kristallstrukturen" (Borntraeger, Berlin, 1935; referred to later as "Tab.'35"), have fully justified the advantages of the give-and-take then exercised. Not only have these tables in the original edition and in a war-time photo-offset re-issue done great service in all X-ray analysis laboratories as well as in the teaching of students, but they have also led to a great saving of effort by the acceptance of standard symbolism and methods.

In the twenty years that have passed since the preparation of "Tab.'35" enormous progress has been made in the development and application of new methods of crystal-structure determination, such as the development of new instruments (Buerger precession camera, Geiger counter technique), computing techniques (punched card methods) and theoretical methods (phase inequalities, statistical detection of symmetry elements, Fourier refinement methods). It seems natural that a full re-edition of such tables would be preferable to a minor revision. Besides, the ground had meanwhile been prepared for an easier co-ordination on an international scale than was possible by individual initiative in 1929. The International Union of Crystallography at its very foundation (London 1946, Harvard 1948) set up a committee to prepare a modern set of tables, and, thanks to the untiring activity of its chairman, Prof. Kathleen Lonsdale, the committee has now published the first of the three volumes which will form the complete work.

To start by the 'habit', the volume of five hundred pages is beautifully published for the Union of Crystallography by the Kynoch Press. Paper, binding and print are an impressive sample of craftsmanship, and no misprints have been noticed. The layout, especially for the simpler space groups, is lavish, with an impeccably white lower half of the page inviting one to scribble down notes. The price is kept low by subsidies which the Union received from the United Nations Educational, Scientific and Cultural Organization and from United States sources through the United States National Committee for Crystallography.

Vol. 1 of "Tab.'52" presents the symmetry groups in fundamentally the same way as Vol. 1 of "Tab.'35". The bulk of the volume is formed by the description of each of the 230 space groups. Most of the figures of "Tab.'35" have been taken over; changes had to be made in cases where a more extended description was given, for example, in referring rhombohedral groups to hexagonal axes. The figures for cubic space groups have been omitted. Now it is true that in the cubic system figures are necessarily more schematic than in systems where the presence of at least one singular direction facilitates the orientation; yet I must confess that I feel rather lost without the neat figures of "Tab.'35" by which M. Mauguin found an acceptable solution to an intricate problem of spatial representation. Co-ordinates require careful reading, whereas the diagrams give at a glance a vivid impression not only of the equivalent positions but also of the right- or left-handedness of the surroundings of each equivalent atom.

A major change from "Tab.'35" is the partial separation of the space-group descriptions in physical space from the equivalent in Fourier space: the structure factors are collected for all space groups in Table 4.7 (150 pages), whereas the 270 pages of space-group description, forming Table 4.3, after listing the co-ordinates of equivalent points, do not go beyond a listing of the absent reflexions, omitting previously listed information (for example, subgroups) which was considered of minor practical value. While the present separation and curtailment may not inconvenience the practical worker, yet the old arrangement had the unquestionable advantage of offering at one place a complete dual description of each space group in crystal and in Fourier space.

In the monoclinic system the twofold symmetry axis is traditionally taken as the *b*-axis; this orientation is generally accepted throughout the older crystallographic and mineralogical literature. On the other hand, a unique axis is taken as the *c*-direction in all other crystal systems, and the derivation and handling of space groups is slightly more unified if this convention is also adopted in the monoclinic system. The authors of "Tab.'52" have tabulated monoclinic groups in both settings. It is to be hoped that the users of "Tab.'52" will be aware of the recommendation of the Stockholm Assembly (see *Acta Cryst.*, **4**, 569; 1951) that "the use of the *c*-axis as the unique axis is acceptable where there is a special reason for this setting, in which case the reason should be stated". Normally, therefore, the second setting should be used in "Tab.'52" so as to avoid a clash with the very extensive existing literature.

Among the novel material of the space-group tables a list of the symmetry properties of $|F|$ must be mentioned. For $P4_1$, for example, this takes the form:

$$|F(hkl)| = |F(\overline{hkl})| = |F(h\overline{kl})| \neq (F(\bar{h}kl)|\,;$$
$$|F(\bar{h}kl)| = |F(h\overline{kl})|.$$

This statement is far from expressing completely the symmetry properties of $|F|$. What about $|F(hkl)| = |F(\bar{k}hl)|$, the result of the fourfold axis? Throughout the reported symmetry relations, the order of the indices $(hkl)$ in the argument of $F$ is preserved; in other words, only the symmetry of $|F|$ which is caused by twofold axes or $x$, $y$, or $z$ reflexion planes is listed. On the other hand, the obvious centrosymmetry of $|F|$ is repeated for every single space group. The extensive introductory note of the structure-factor tables offers no help in understanding the principle of this selective listing of the symmetry of $|F|$.

Some tables of "Tab.'35" have been omitted as being of minor practical value: these are mainly the collective tables on lattice complexes, which formerly occupied twenty-six pages, and the list of lattice complexes, non-generating symmetry elements and sub-groups which were provided under the heading of each space group. Part of this material is offered in a condensed form in Table 5.2 (three pages) on sub- and super-groups of the space groups. References in the explanation of this table might well have included "Tab.'35", where a full list is to be found.

The progress in methods of using experimental data is reflected in the inclusion of the expressions for Fourier synthesis, that is, the explicit form of the Fourier series for $\rho(x, y, z)$ in each space group. This important information was not contained in "Tab.'35" and was first published in Prof. Lonsdale's "Structure Factor Tables" (George Bell and Sons, Ltd., 1936). Also new are Tables 5.3 (space-group determination by methods outside the Friedel law) and 5.4 (inequalities arising from symmetry elements), both occupying about one and a half pages. The latter lists the special forms of Harker–Kasper inequalities in the presence of symmetry elements; the former section is mainly a description of the statistical treatment of intensities along the lines inaugurated by Dr. A. J. C. Wilson.

Further welcome additions are tables on the space groups of lower dimensionality, namely, the two linear and the seventeen planar groups (that is, the two groups on a line and the seventeen groups in a plane). These are important for the classification of the symmetry of projections of space groups or of sections through space groups, and have been fully tabulated. Of perhaps greater physical importance are the groups with one translation (seven in the plane (borders), thirty-one in space) and the eighty groups (nets) with two translations in which the particles are allowed to lie in three-dimensional space (for example, a woven tissue). These have been mentioned but not tabulated in the note on p. 56; more general knowledge of these groups seems desirable, and inclusion in the present volume would have greatly improved their accessibility.

The text explaining the tables and their use is clearly and carefully written; it offers more explanation than that of "Tab.'35". Altogether, one notes the tendency to facilitate the use of the tables by workers who have little more than a general idea of space groups. This is an acknowledgment of the fact that this rather mathematical tool is being used to an ever-increasing extent by chemists and biologists whose main training cannot include the details of an intricate mathematical theory. Examples of the use of the tables are often given, and I agree wholeheartedly with this; on the other hand, I feel strongly that a volume of tables should not attempt to teach methods, like a text-book. Neither is it the place for a historical article surveying the development of space-group theory and crystal-structure analysis (pp. 1–5). A very welcome innovation, however, is the last table, Table 7 (five pages), which is a dictionary of crystallographic terms in English, French, German, Russian and Spanish; this in a way replaces the trilingual text of "Tab.'35". The rather embryonic dictionary seems to be limited to terms occurring in the text of Vol. 1, but it is a good start for a more general dictionary of terms likely to be encountered in papers on structure analysis. Some rather unusual German terms and others which have been omitted have been noted: for 'Habit' *Tracht* should have been given, since *Habitus* is easily recognizable. The expression *Hydrostatischesmodul* (*sic*) for *Kompressionsmodul* is unlikely to be encountered. The use of *Stab* for line in *Reflexionsstab* and in *Symmetriestab* is new to me, but may be a modern development. Thermal vibration is usually *Wärmeschwingung*, and the correct rendering of 'moving-film method' would be *Goniometermethode* and not the impossible *bewegend-Film-Methode*.

The foregoing criticism of detail should not detract from the fact that the authors and in particular the editors, Dr. N. F. M. Henry and Prof. K. Lonsdale, have performed a splendid and most unselfish service to the large group of crystallographers who benefit by the use of such tables. The new work is an adaptation of the results of theory by experimentalists of long standing for the benefit of experimentalists, and is based on the experience obtained with the older set of tables. Some innovations are obvious improvements, others appear questionable, but only the prolonged use of the tables will bring out fully their virtues and their foibles. P. P. EWALD

## ADVANCES IN AGRONOMY

Advances in Agronomy

Prepared under the auspices of the American Society of Agronomy. Vol. 3. Edited by A. G. Norman. Pp. x+361. (New York: Academic Press, Inc., 1951.) 7.80 dollars.

MANY sciences now have their annual volumes of "Advances", consisting of summaries of particular sections of the subject written by specialists. Agronomy, the study of crop production and soil management, began to be so surveyed in 1949 by the American Society of Agronomy with authors working under Dr. A. G. Norman as editor. The third volume has now appeared. In so wide a field there is abundant choice of material, and almost any subject considered over an area as varied in its conditions as the United States presents a formidable array of data, with the result that most of the contributions are necessarily lengthy and carry numerous references to the literature. Papers such as that on the subsoil, and one dealing with the chemistry of soil potassium, are not, nor are they intended to be, easy reading. The student has to work for his information, but the material is clearly set out to enable him to do so.

In addition to the two papers mentioned above dealing with various aspects of the soil, two deal with legume and herbage plants, two with systems of management of soil conservation and irrigation, and one with a disease problem—the control of soil nematodes. Vol. 3 also contains an excellent survey of recent changes in British agriculture by J. A. McMillan, of the National Agricultural Advisory Service.

In evaluating soil the surface soil commonly receives more attention than the subsoil. It is true that as a seat of soil nutrients the subsoil is generally, though not always, much inferior to the surface, but its properties in respect of root penetration and drainage are of great importance. In the article on this the author deals with the physical properties, clay minerals and fertility-levels of subsoils in the broad soil classes of the United States and discusses at length the characteristics of the various subsoil pans that occur. Interesting sections deal with the difficult and sometimes unsolved problems of the management of subsoils exposed by soil erosion, and the bad effects of subsoil compaction caused by the use of heavy tractors, especially in wet conditions.

A comprehensive paper on soil conservation summarizes the position reached and scientific problems raised by work carried out under the large government schemes that have operated since 1933. The problems are not entirely technical; in fact the most obstinate ones arise from the fact that no farmer takes kindly to alterations in his system which cost money, involve learning fresh skills and may, at the outset at any rate, result in lower returns.

Rather similar treatment is accorded to the subject of irrigation and soil research. The emphasis here is on the need for complete and reliable scientific information derived from both laboratory and pilot farms before a big scheme is launched. This applies to surface irrigation in the arid areas and also to overhead supplemental irrigation in wetter districts. The modern factorial field experiment is essential in studying the inter-relation of fertilizers, water supply and cultivations. The effect of big schemes on the water economy of whole districts needs to be looked into.

A very readable article on chemical treatment of the soil for nematode control shows that soil fumigation has got past the purely experimental stage; the author estimates that fumigants sufficient for a hundred thousand acres were produced in 1950, the chief being ethylene dibromide. As yet, the process is only warranted for high-value crops, and the eelworm population is checked rather than wiped out.

# THE BIRTH OF NEO-POSITIVISM

## The Vienna Circle

The Origin of Neo-Positivism; a Chapter in the History of Recent Philosophy. By Prof. Victor Kraft. Translated from the German 'Der Wiener Kreis' by Arthur Pap. Pp. xii+209. (New York: Philosophical Library, Inc., 1953.) 3.75 dollars.

HOWEVER rapidly philosophical climates may change, and whatever may prove to be the capricious nature of their characteristic cycles, there are certain epochs which will always stand out. One of them is assuredly that of the Vienna Circle. Postponing for the moment a more detailed consideration of its *Lebenslauf*, it is meanwhile worth recollecting that to many scholars in Great Britain it was always 'Der Wiener Kreis", a sure token of affectionate regard; and this in spite of a healthy determination to be the candid friend, avoiding like the plague all semblance of merely polite approval. Thus, as the author says, in Britain and in the United States its purpose found understanding and its tenets secured respect. Not so, however, in contemporary Germany, wherein many cross-currents (not all of them wholly fortuitous) combined to make very heavy weather for the evangelists of neo-positivism.

It is essential to see Prof. V. Kraft's book against such a background. Further, one may dislike the Circle's particular criterion of verifiability and its rather facile (and over-frequent) use of the adjective 'meaningless'—in fact, much of the stock-in-trade—and yet agree what great things it has accomplished. For this is a close-up view, not so much of the creed as of the people who fashioned it, and who passionately believed in it. For those reasons alone, a version in the English language is welcome. Would that—even allowing for its production on the western side of the Atlantic—it was a better version. Epistemological German is notoriously hard to translate, and even harder to make live; but *ebenso*, some of the text as it now appears is far from lovely, and moreover, many of the blemishes upon it are utterly needless.

The core of the volume consists of two long sections: logic and language, and empiricism. As might be expected, these form a commentary—and a very just one—upon the work of Carnap, Wittgenstein and their colleagues, on one hand, and of the critics on the other. The basic division is between the 'logic of science' and the special sciences. The latter are held to be concerned solely with questions of fact, to be validated by experience. Epistemology must have nothing to do with such things; its task is to deal with the logical structure of scientific knowledge. At the same time, philosophical method itself is required to conform to scientific principles.

Towards the end, we find a noble attempt to face up to the axiological import of the Vienna Circle's outlook. Obviously, it was heavily conditioned by a reaction against German metaphysics. Yet, conceptual poetry and even personal wisdom are not denied: upraised on their own pedestal they stand, but qualified as subjective and unverifiable in that they lack universal validity, and therefore the title, to represent knowledge.

Nobody can rightly quarrel with such a statement, the result of years of labour, thrust and counter-thrust by honest men engaged in the quest for truth. But they themselves would be reluctant to claim that the last word had been spoken: the Circle has been disrupted and its members scattered, some luckily to find shelter in calmer waters. Down the years, too, death has taken a heavy toll, but the search goes on, at once courageous (sometimes perhaps almost foolhardy) and relentless. F. I. G. RAWLINS

# BENJAMIN THOMPSON, COUNT RUMFORD

## An American in Europe

The Life of Benjamin Thompson, Count Rumford. By Egon Larsen. Pp. 224+28 plates. (London: Rider and Co., Ltd., 1953.) 15s. net.

THIS book is described by the publishers as "the first popular yet authoritative biography" of Benjamin Thompson, Count Rumford, and its publication was timed to coincide with the bicentenary in March 1953 of his birth. It is a very readable short account of his life and activities, or certain aspects of them. Mr. E. Larsen has been at great pains to collect information in the various places where Rumford lived and worked, and we are indebted to him for some new and interesting particulars—for example, the information on the laying out and subsequent history of the English garden in Munich and that on the house at Auteuil which was Rumford's last home. Some of the illustrations, which are good, are from photographs by the author.

It is not a book to go to for an estimate of Rumford's achievements as a man of science. The references to his fundamental researches on heat are scanty, and the author has not attempted anything in the nature of a connected account of his scientific work. There is a fuller and more satisfactory treatment of his measures of reform in Bavaria, his work for the poor in Munich, and the methods of fuel economy and designs of stoves and fireplaces which he introduced in his workhouses and military establishments. Emphasis is rightly given to his pioneering efforts in the application of scientific principles to purposes of this kind.

A chapter is devoted to his later period in England and his activities in connexion with the founding of the Royal Institution. At the end of the book a well-chosen series of extracts from Rumford's essays, indicating the varied nature of his interests, extends to some forty pages.

It is, however, on a personal and biographical thread that this book hangs, and if the treatment of such matters as Rumford's relations with his daughter and with his second wife, the widow of Lavoisier, is somewhat journalistic, it is none the less interesting. Biographical writing on Rumford begins with Ellis's invaluable "Memoir", published in 1876, and, although much has been written since, the character of the man remains in certain respects somewhat shadowy. In his more personal affairs he covered up his tracks, and the impression persists that the full story of his life has yet to be written.

T. MARTIN

# TRADITION AND THE CORONATION*

## By ARCHIBALD G. B. RUSSELL, C.V.O.

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THE solemnity of the coronation of kings and queens has from the earliest days taken a supreme place in the imagination of the people. How much more so is it the case to-day, since it has come to typify in a very real sense the unity of the British Commonwealth of Nations under the Crown.

Westminster has been the scene of the coronation since it was chosen by William the Conqueror as the place for his own coronation. The earliest Christian coronation of an Anglo-Saxon king of which record remains is that of Egfrith, whom his father, Offa, King of Mercia, had crowned as his successor in 785†.

In the tenth century it was usual for coronations to take place at Kingston-on-Thames. It was on the 'King's Stone', which is still treasured there, that kings were crowned. The use of a sacred stone for this purpose follows a very ancient tradition which was later carried on with the Stone of Scone down to the present day.

Westminster Abbey as it now stands was in greater part built under the direction of King Henry III in the middle of the thirteenth century. It replaced two previous churches on the same site. Its immediate predecessor was the church built by Edward the Confessor and consecrated in 1065, which replaced the original Saxon church and in which the Confessor himself was buried. It was in this church that William the Conqueror and his successors were crowned. It was part of the original plan that the church built by Henry III should be used for coronations, as is evidenced by the unusual feature of the space left between the Choir and the High Altar. It is upon a raised platform erected upon this space, known as the Theatre, that the greater part of the coronation ceremony takes place.

A manuscript of the life of King Edward the Confessor in the Cambridge University Library contains two beautiful drawings, in each of which the artist seeks to convey the impression of religious exaltation. In one of them the King is being anointed with the holy oil. It is this King who is venerated as a national saint, and to whose kingly virtues we owe the greatness of the Palace and Abbey of Westminster. The other drawing depicts the coronation of Queen Edith, his consort.

In the coronation scenes which decorate the exterior walls of the King's Chantry Chapel in Westminster Abbey there is a carved group representing the coronation of King Henry V. It is at once a historical document and a valuable work of art. The crown is being set upon the King's head by the Archbishop of Canterbury and the Abbot of Westminster. The then Abbot was the famous William of Colchester, the 'grand conspirator' of Shakespeare's play. The monumental grandeur of the presentation and the noble pattern of the Royal Arms which accompanies it give it a place as a work of sculpture among the most moving of any produced in Britain. The majestic stillness of the central figure of the King is superbly enhanced by the upward movement of the flanking figures.

### The Banquet

Of the services referable to the banquet which formerly succeeded the coronation, in the Great Hall at Westminster, that done by the King's Champion surpasses all others in its romantic appeal.

This privilege has been in abeyance since the discontinuation of the banquet, which was last held on the occasion of the coronation of King George IV. The service is associated with the ownership of the Manor of Scrivelsby in Lincolnshire, which was held from very early times by the family of Dymoke. In lieu of this service, the Union Standard will be carried by Captain J. L. M. Dymoke at the forthcoming coronation.

A lively study of the Champion appears in a tinted drawing accompanying the pedigree of Dymoke in the original Visitation of Lincolnshire of 1564 at the College of Arms. It is the likeness of Sir Edward Dymoke of Scrivelsby, who was Champion at the coronations of King Edward VI, Queen Mary I and Queen Elizabeth I. His fancifully decorated armour of astonishing richness and the superb trappings of the horse are characteristic of the first Elizabethan Age. He is depicted at the dramatic moment when, after issuing his challenge and offering to combat with the "false traitor . . . who shall deny or gainsay our sovereign lord the King", he is about to fling down his gauntlet.

### The Earl Marshal

The Duke of Norfolk, who holds the hereditary office of Earl Marshal of England, is responsible for the whole of the arrangements for the coronation, with the exception of the church liturgy, which is ordered by the Archbishop of Canterbury. The Duke holds hereditary office, granted to his family by King Charles II in 1674, who conferred it on Henry Howard, Earl of Norwich, afterwards Duke of Norfolk, and his heirs.

The office derives from that of Marshal of England, which was one of the five great offices of state. The earliest holder of the office of whom we have record was one, Gilbert, whose descendants adopted the surname Marshal in virtue of their office. Later it passed to the Bigods and to the Mowbrays and afterwards to the Howards, though it did not actually become hereditary in their family until 1674.

Charles II, in his declaration of the authority of the Earl Marshal, described him as "the next and immediate Officer under Us for determining and ordering all matters touching Arms, Ensigns of Nobility and chivalry", and the officers of arms as "Ministers subordinate to our said Earl Marshal".

### The Officers of Arms

The Kings, Heralds and Pursuivants of Arms who assist the Earl Marshal in the coronation preparations and who take part in the Abbey processions have also certain other duties to perform on the occasion. Among these are the handing over of the canopy to the Knights of the Garter who hold it over the Queen for the anointing, and the leading up of the senior peer of each degree to pay homage to Her Majesty. Scottish Heralds are also present, headed by Lyon King of Arms, and Ulster is now represented by Norroy and Ulster King of Arms.

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* Substance of a Friday Evening Discourse delivered at the Royal Institution on April 24.

† For certain of the historical data I am indebted to the several publications of Mr. Lawrence E. Tanner, keeper of the Muniments and Library, Westminster Abbey.

Officers of Arms are known to have been in attendance at coronations from the time of that of King Henry IV, and it may, I think, be assumed that they did so at an earlier date.

The tabard which they wear on all state occasions is probably the most ancient ceremonial garment still in use, dating back to the second half of the fifteenth century and deriving from the court dress of that period. The tabards of the Kings of Arms are of velvet, those of Heralds satin, and those of Pursuivants damask silk.

On the death of the Sovereign the accession of the new Monarch is proclaimed by one of the Officers of Arms at four different centres in London. At a later date the coronation is proclaimed by the same four Officers at the same places.

The Officers of Arms are appointed by letters patent under the Great Seal of England. They are, under the Earl Marshal, responsible for the granting of arms, the marshalling of state ceremonies and other duties. The coronation is, of course, by far the most important of the state ceremonies with which they are concerned.

## Sir Robert Vyner

Sir Robert Vyner, who was responsible for making nearly all the items of the present Regalia to replace those destroyed at the Commonwealth, began his career as a goldsmith as the apprentice of his uncle, Sir Thomas Vyner, who served the office of Prime-Warden of the Goldsmiths' Company. Sir Robert was born in Warwick in 1631, and in 1661 he received a grant of the office of 'King's Goldsmith'. Like his uncle, he served as Prime Warden of the Goldsmiths' Company. He was on intimate terms with Charles II, and made the Regalia for Charles's coronation at a cost of more than £30,000. He died at Windsor Castle in 1668 and was buried at St. Mary's Woolnoth, Lombard Street, London.

## St. Edward's Staff

St. Edward's Staff was in early times delivered into the Sovereign's hands on entering the Abbey. It is now borne in the procession and this time will be carried by the Earl of Ancaster. The present Staff is part of the 1661 Regalia. The original, which was one of the relics of St. Edward, was a long iron-shod sceptre, and was reputed to contain a piece of the True Cross. The present Staff is surmounted by a golden orb, and the foot is tipped with steel.

## The Maces

The two Maces were made by Sir Robert Vyner for the coronation of King Charles II. The heads are divided into four panels, each containing an emblem surmounted by a crown, and representing the constituent elements of the United Kingdom. Above is an arched crown, on the rim of which are alternate crosses and fleurs-de-lis. The crown is surmounted by an orb and cross. The Maces are carried by the Serjeants-at-Arms.

## The Coronation Chair

The Coronation Chair was made for King Edward I, and was designed to hold the Stone of Scone which he removed from Scotland in 1296. The chair is of oak and was completed in 1300–1. It has been used for all coronations since that of King Edward II.

The back of the chair was originally painted with a seated king. Few traces of this now remain, and much of the original enrichment of gold and colours has perished. A superb early fourteenth century illuminated manuscript in the library of Corpus Christi College, Cambridge, portrays the Chair as it appeared not long after it was made. In this the four lions now supporting the Chair are absent, so presumably these were a later addition. The Chair, which has suffered much in the passage of time, is a rare example of the cabinet work of its day, and is probably to be regarded as the most venerable object associated with the coronation.

The Stone of Scone is first heard of in the thirteenth century, when it was preserved in the Abbey of Scone and was used in the consecration of Scottish kings. It is of reddish-grey sandstone, and was probably quarried in the neighbourhood of Scone. It has been identified in legend with the stone upon which Jacob rested at the time of his vision of the Ladder.

## The Recognition

The coronation ceremony is initiated by the act of Recognition. This is a survival from the remote past when the choice of a sovereign rested upon an electoral basis.

## The Oath

The Recognition is followed by the Oath. The form of the Oath has from time to time undergone revision from the fourteenth century onwards. The latest substantial alteration followed the reign of James II, who was a Roman Catholic, and at the coronation of King William and Queen Mary it was drastically changed with the view of ensuring the maintenance of the Protestant faith. A further innovation introduced at that time was the presentation to the Sovereign of the Bible as "the most valuable thing that this world affords".

## The Anointing

In accordance with ancient tradition, it is with the anointing of a Sovereign with oil, rather than the actual crowning and the investiture with the Regalia, that the climax of the coronation ceremony is reached. The Monarch has been held in the past to assume a mixed personality of a semi-sacerdotal character. For Melchizedek, the priest-king, has remained through all time the type of kingly perfection; in fact, the name may mean 'kingly righteousness'. The antiquity of the rite of the anointing of kings is recalled in the anthem which is sung beginning "Zadok the Priest and Nathan the Prophet anointed Solomon the King".

During the Anointing a canopy is held over the Queen by four Knights of the Garter. She is thus nearly concealed from view during the rite in view of its secret and mystic character.

The Ampulla is an eagle of gold containing the holy oil with which the Sovereign is anointed, the oil being poured out through its beak. It has been suggested that the Ampulla may be in essentials an original work of the time of Henry IV, the engraved decoration and the pedestal upon which the eagle is mounted being the work of Sir Robert Vyner. Against this view is the fact that descriptions of the medieval Ampulla speak of it as a "dove of gold set with pearls and stones", while the existing Ampulla is stated to show no signs of ever having been set with precious stones.

The anointing Spoon escaped destruction in 1649, and is the oldest piece of plate used at the coronation. The bowl may have been re-worked by Vyner; but the stem, which is of exquisite workmanship, dates from the twelfth or early part of the thirteenth century. The Spoon is of silver heavily gilt, and ornamented with elaborate gold chasing, enamels and pearls. The bowl is engraved and is divided with a central ridge.

### The Spurs

The ceremony of the Spurs follows the Anointing. They are brought from the Altar, and the Queen touches them with her hand, for they are emblems of knightly chivalry. They are of gold, with straps of crimson velvet, and were made for the coronation of Charles II.

### Swords

Five ceremonial swords are borne at the coronation. The two-handed Sword of State is the most imposing. It is also carried at state openings of Parliament. Two other swords are known as the Pointed Sword of Spiritual Justice, or Second Sword, and the Pointed Sword of Temporal Justice, or Third Sword. The Queen's personal sword is known as the Jewelled Sword.

But historically the most interesting sword is Curtana. This is the Pointless Sword of Mercy. It was first mentioned by name at the coronation in 1236 of Queen Eleanor, wife of Henry II. The earliest representation of this Sword that I know of occurs in the portrait belonging to the Society of Antiquaries. This portrait has long been regarded as the likeness of Richard III; but I find it difficult to endorse this identity. I suggest that the sitter may in fact have been Henry Percy, fourth Earl of Northumberland, who, at Richard's coronation in 1483, is recorded as carrying "the pointless Sword, naked in hand, which signified Mercy".

The word 'Curtana' is doubtless derived from the Latin *curtus*, meaning shortened or curtailed.

### Armillæ*

The coronation Stole, formerly known as the Armil, or Armilla, is not, strictly speaking, a stole. In religious ceremonies the Stole succeeds the Alb immediately; but in the coronation service it succeeds the Dalmatic, as it did in the eleventh and twelfth centuries, and it is still worn by deacons of the Orthodox Church. Its assumption at the coronation accordingly preserves the medieval custom which the Western Church has lost. It is a strip of material worn about the neck, having depending ribbons at its extremities which were there for a very particular purpose. In length, this strip should be an ell, that is, forty-five inches. Now, such a strip cannot be a stole, which is a vestment as long again. (The stole is intended to remind its wearer of the halter put about Christ's neck when on His way to be crucified.)

The appellation 'Armil' may be explained in the following way. At former coronations extending to that of Queen Elizabeth I, the Sovereigns were invested with wristlets (or bracelets) or armlets. Queen Elizabeth I is said to have worn 'garters' on the upper part of her arms. It is probable that this short strip of material placed about the neck of the Sovereign was not intended to be a stole but merely a means of preventing the slipping-down of the Armils which were attached to it by means of double ribbons at each extremity. Hence the name given to it, which either became confused in the course of time with the Stole or, after the Tudor period, made to serve both to restrain the armlets or bracelets or as a stole proper.

When the Regalia were made for Charles II in 1661 wristlets or bracelets were provided; but they have never been used. They may still be seen in the Jewel House in the Tower of London. It may be remarked that no words accompany the putting on of the Stole, which might support the view that it was only a means of restraining the armlets formerly worn. The last recorded occasion of the use of the Armillæ was at the coronation of Edward VI. It is not known whether they were used at that of Queen Mary I. They are not mentioned in the ceremonials of Kings James I and Charles I, and the pair that were in the Regalia were, in all probability, destroyed when the rest of the royal ornaments were broken up during the interregnum. Another pair was produced in 1661 for the coronation of Charles II, though they were not used, and they have not been brought forward at any succeeding coronation.

Armillæ were well known in the histories of ancient nations, and are mentioned in the Old Testament as having been worn by King Saul. They were the distinguishing marks of the king and warrior. At the forthcoming coronation, the Archbishop of Canterbury when investing the Queen with the Armillæ will say the prayer beginning: "Receive the Bracelets of sincerity and wisdom". These words appear in the order of the service recorded in the *Liber Regalis* of the fourteenth century.

The Armillæ, which were made in 1661, bear enamelled representations of roses, thistles, shamrocks and fleurs-de-lis. The pair that have just been made are of plain gold unadorned, except for a spiral floral design near the edges, and the snap, which is formed of a Tudor rose. They are the combined gift to the Queen of the Governments of Australia and of Southern Rhodesia.

### The Orb

The Orb is a sphere of gold surmounted by a jewelled cross set upon an amethyst. It dates from King Charles II's coronation, and is a symbol of the sovereignty of Christ. A representation of the Orb appears upon a number of early Great Seals of British kings; but it is not mentioned in connexion with any medieval coronation.

### The Ring

The Ring is put by the Archbishop on the fourth finger of the Queen's right hand. It is described as "the ensign of kingly dignity, and a defence of the Catholic Faith". It is set with a sapphire, with a cross in rubies on it. The ceremony of the investiture with the Ring goes back at least as early as the tenth century.

### The Sceptre with the Cross

The Sceptre with the Cross, or Royal Sceptre, symbolizing power and justice, was made for the coronation of King Charles II. It is of gold, and is three feet long. The largest portion of the Star of Africa, cut from the Cullinan diamond, was inset in the head in 1911. Above is an orb of amethyst surmounted by a diamond and enamelled cross. Sceptres as emblems of kingly power are, of course, of great antiquity.

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* For the data relating to the Armillæ I am indebted to Mr. Gerald Henderson.

### Rod with the Dove

The Rod with the Dove is the symbol of equity and mercy, the Dove being the emblem of the Holy Ghost. It is part of the 1661 Regalia. The gold staff is decorated with jewelled bands. The Dove, which in medieval times was of gold, is now of white enamel.

### St. Edward's Crown

St. Edward's Crown in its original form was his own Crown taken from his grave in 1269. This was ordered by Cromwell to be destroyed with the other Regalia in 1649. The new Crown, much in its present form, was made by Sir Robert Vyner for King Charles II. It has been suggested, however, by Mr. Martin Holmes, that the original crown of St. Edward's was not in fact destroyed, and that it formed the basis of that made by Vyner.

The circlet, or rim, of the Crown, which is of gold, bears alternate crosses and fleurs-de-lis, and from the crosses rise the intersecting arches with, at the top, a globe surmounted by another cross, the whole being richly encrusted with precious stones.

The Crown, after the anointing, and the successive stages of the Investiture, is set upon the Queen's head by the Archbishop of Canterbury.

### The Imperial State Crown

The Imperial State Crown was made for Queen Victoria, and has been slightly altered for subsequent coronations. In the front is the famous gem known as the Black Prince's Ruby. On the rim beneath it is another portion of the Cullinan Diamond. The sapphire in the cross surmounting the Orb at the top is traditionally believed to have come from the Confessor's ring; but it has been recut in modern times.

The Imperial State Crown replaces that of St. Edward shortly after the crowning has taken place.

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## SCIENCE AND THE SOVEREIGN

By Sir ARTHUR MacNALTY, K.C.B.

At this time of Her Majesty's Coronation, it is appropriate to remember the encouragement which the sovereigns of this realm have given to the progress of science and its teaching.

The Middle Ages were intolerant to science. Roger Bacon, who made discoveries in optics and chemistry, had his books banned and was imprisoned for "suspected novelties"; Bolingbroke, mathematician and astronomer, "the greatest clerk of his age", was hanged and quartered as a wizard.

Then came the great invention of printing which gave to letters and to science the precision and durability of the printed page. Edward IV bestowed his patronage on Caxton, and Richard III during his brief reign encouraged the new invention.

In the reign of Henry VII the light and wisdom of the Italian Renaissance was brought to England by the Oxford "Humanists", Grocyn, Colet and Linacre. Henry VIII, whom Erasmus termed the "scholar king", was a highly accomplished monarch. He wrote excellent Latin, spoke French, Italian and Spanish, was musician, poet, naval architect, a master of ordnance, an amateur of medicine and a good mathematician. He delighted to converse with his learned subjects, appointed astronomers royal, and elevated medicine and surgery in status by founding the College of Physicians on Linacre's advice in 1518, and uniting the barbers and the surgeons as the Barber-Surgeons' Company in 1540, probably at the request of his serjeant-surgeon, Thomas Vicary. He also founded regius professorships of physic at Oxford and Cambridge. He first bestowed the honour of knighthood on two physicians, Sir Thomas Elyot and Sir William Butts. Edward VI knighted his surgeon, Sir John Ayleff. With royal approbation, Edward Wotton (1492–1555), of Padua and Oxford, and physician to Henry VIII, published the first systematic treatise on natural history, and William Turner, Dean of Wells, was the first Englishman to study plants scientifically. His "Herbal" of 1548 marks him as the father of English botany.

Queen Elizabeth I encouraged science. William Gilbert, president of the Royal College of Physicians, who founded the sciences of magnetism and electricity, was her physician and was awarded a pension by the Queen to enable him to conduct his researches, which Francis Bacon quoted in the "Novum Organum" as examples of the method of experiment. John Caius (1510–73), also a president of the Royal College of Physicians, the friend and pupil of Vesalius, was physician successively to Edward VI, Mary and Elizabeth. He wrote a treatise on the sweating sickness, and was a good classical scholar, anatomist and zoologist. Gesner, in a letter to Queen Elizabeth, termed him "the most learned physician of the age". She was a judge of scientific merit, and on her visits to Oxford and Cambridge was accustomed to preside over the disputes in the Physic Act for medical degrees. To James I, Francis Bacon dedicated his philosophy of inductive science which improved instructed thought and commended to the King the regeneration and restoration of the sciences.

The ill-fated Charles I was an enlightened patron of science as well as art and letters. William Harvey was his physician and the King showed the liveliest interest in his researches, being personally present, as Harvey records with pride, at a demonstration of the circulation of the blood and giving him facilities to use the deer in the royal parks for his pioneer work in embryology. King Charles also nominated Harvey as warden of Merton College, Oxford.

One of the greatest royal patrons of science was King Charles II. He founded the Royal Society in 1662, presented it with a silver-gilt mace, and presided at its inaugural banquet and at several meetings of the Society. He studied anatomy and chemistry, and his cousin, Prince Rupert, made several discoveries in chemistry. The King was always interested in new discoveries in the realm of science, as Pepys and John Evelyn tell us. King Charles "had yet skill to discover excellence and virtue to reward it", as is shown by the knighthoods he bestowed on Sir William Petty, the founder of the science of political economy, and the erudite Sir Thomas Browne.

The outstanding discoveries of Isaac Newton were recognized by William III, who appointed him master of the Mint in 1699, and by Queen Anne, who knighted him in 1702. All the four Georges encouraged science. George I is said to have boasted of his two subjects, pre-eminent in science, Newton in England and Leibniz in Hanover. Sir Hans Sloane, president of the Royal Society and of the Royal College of Physicians, the founder of the British Museum, collector and naturalist, was created a baronet by George I, and George II made him his first physician. George III solved the difficulties of the Corporation of Surgeons by establishing the Royal College of Surgeons by royal charter, discussed the *Philosophical Transactions of the Royal Society* with Dr. Johnson, and bestowed a baronetcy on Sir Humphry Davy. The King incorporated the Royal Society of Edinburgh by royal charter in 1784. Sir Joseph Banks, president of the Royal Society for forty-one years, acted as the King's scientific adviser; it was he who directed the dispatch of collectors abroad for enrichment of the gardens at Kew. In the establishment of the Royal Botanic Gardens there the Crown has promoted the studies of botany and horticultural science. On Banks's advice, the Linnean Society was given a royal charter in 1802. George IV was liberal to science. In 1825, he founded two gold medals to be awarded annually by the President and Council of the Royal Society for important contributions to science. These medals have been continued by his successors. The King also granted a supplementary charter to the Royal College of Surgeons in 1822, and gave the site at a nominal rent for the new College of Physicians in Pall Mall, opened in 1825. In 1826, largely through the influence of Dean Buckland, the Geological Society was incorporated by royal charter.

It is, however, in the Victorian Age that science reached a position of fame and authority. This progress was achieved through the great discoveries made by Owen, Darwin, Wallace, Huxley, Lister and others; but the opposition and hostility the claims of science might have aroused were overcome or silenced by the support they received from Queen Victoria and the Prince Consort. Elected chancellor of the University of Cambridge in 1847, Prince Albert established the Natural Sciences Tripos in 1848, which gave a notable impetus to study and research. Aided by Prof. Owen, he urged a similar departure on Oxford which was soon afterwards followed. He initiated the Great Exhibition of 1851, which displayed the wonders of applied science to the public, and the invested profits of which supply grants to students of science to this day. The Prince's influence was available in every movement for promoting the interests of art and science, for developing the education and improving the material welfare of the nation. After his death, Queen Victoria continued his work.

This royal encouragement of science was promoted by the Queen's successors. King Edward VII was especially interested in social welfare, in the prevention of tuberculosis, and in medical research. King George V followed in his footsteps, although his modesty prevented him from accepting the presidency of the British Association, which King Edward VIII, when Prince of Wales, accepted, giving an admirable presidential address at Oxford in 1926. King George VI throughout his heroic reign encouraged science, and one of his last public acts was to open the new laboratories of the Medical Research Council at Mill Hill. Queen Elizabeth II has already shown her interest in science by accepting the fellowship of the Royal Society; and the Duke of Edinburgh, alike as president of the British Association at Edinburgh in 1951 and by his acceptance of the membership of other learned societies, shows an equal appreciation of the value of scientific work in this atomic age when so many new fields of endeavour open out before it.

That for centuries the natural sciences have received unfailing support from successive rulers of the United Kingdom has helped to smooth the onward path of those "who search out and study the secrets of Nature by way of experiment".

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# THE ADELIE PENGUIN

By Dr. W. J. L. SLADEN

Falkland Islands Dependencies Scientific Bureau, London, and Edward Grey Institute of Field Ornithology, University of Oxford

THIS summary of the breeding routine of the Adelie penguin (*Pucheramphus adeliæ*) differs in many respects from what has been written before. A full account of the work is in preparation (to appear in the forthcoming series, F.I.D.S. Scientific Reports). The study was made during two breeding seasons at Hope Bay, Graham Land, 1948–49, and Signy Island, South Orkneys, 1950–51, while serving with the Falkland Islands Dependencies Survey. The rookeries at Hope Bay and Signy exceeded 50,000 and 10,000 nests, respectively.

Evidence for the conclusions in this paper have been provided chiefly from marked and dissected birds. Approximately 1,300 Adelies were temporarily marked with paint, 338 banded with aluminium rings, many of which were also painted, and more than 800 dissected. The methods of marking penguins, including a new method using flipper rings, have already been described[1]. The large number of dissections was possible only because our 20–60 sledge-dogs, when at base, had to be fed on seal or penguin meat. Particular care was taken to cause no unnecessary waste of life.

## Suggested Age-Groups

Adelies live among the pack-ice during the winter, returning to rookeries on land to breed during October–February. At Signy, in 1950, adults started to return during the first week in October; but the largest population was not counted until the first week in November (Fig. 1). Eggs were first seen on October 29, and fresh eggs were still being found on November 19, this variation and other differences in breeding efficiency being due, not only to variation among individuals, but also to age and breeding experience. I therefore propose to divide the population at the rookery into the following four provisional groups, hoping that it will be possible to confirm the first three later by studying birds of known age.

### 'Experienced' or 'Established' Breeders

These are probably four or five years old and more and have had at least one, and probably two, years breeding experience.

*Successful breeders.* Ten pairs of breeding Adelies were ringed at marked nests at Hope Bay in November 1946[2]. In 1948–49 twelve returned to the nest-sites where they had been originally ringed, and five of the original pairs were still intact. Two more were found at adjacent nests in November 1947 and again in November 1948. The remaining six were not found. These results suggest that established pairs return each year to the same place and keep the same mates. Their behaviour also suggests that they can locate their old sites even under snow and can recognize their mates from the previous season.

The partners return from their winter quarters within a few days of each other; but if one of a pair comes back first, it will often keep company with another bird of the opposite sex until its true mate returns. A flight, male versus male or female versus female, may ensue in which the true mate usually wins. Should the mate of an established bird fail to return, the pair-bond may be established with its new partner.

Once arrived at the rookery, it was very rare for a breeding Adelie, either male or female, to return to sea until the nest of stones had been built and two eggs laid in it. During this period of about three weeks the pair were together; but as soon as the last egg had been laid, the female departed to sea to break her fast, leaving her mate to incubate alone. This normal routine (in which the sex of the males was confirmed by more than fifty dissections) could be upset by human or dog interference. Thus, if the male was killed before the female departed, she continued incubating for a few days but ultimately deserted when her weight dropped below about 3·5 kgm.

The male did not leave the rookery until his mate returned about two weeks later. While away, she regained most of the weight lost during her fast. Average fasting periods of seven marked males and females showed that the males fasted at least forty days, the females twenty-one (Fig. 2). A continuous fasting period of forty days by a bird is exceeded only by the male emperor penguin (*Aptenodytes forsteri*), which fasts for sixty days during incubation[8].

The weight of the females fell from 5–5·5 kgm. to about 3·5 kgm. and their blubber from 6–7 mm. thick to nothing. The males, starting at a higher level of 5·5–6 kgm., lost weight more gradually, reaching about 3·5 kgm. after their fast, when their blubber had diminished from 7–8 mm. thick to nothing. Males were at sea for about two weeks and came back, having regained most of their lost weight, to relieve the females on the eggs, who left again for a short period. When they returned, the eggs were usually hatched or hatching (early and mid-December). The average incubation period was thirty-six days.

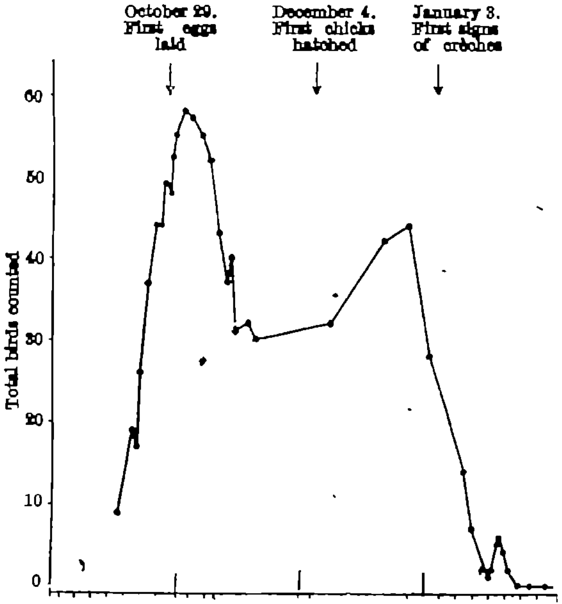

Fig 1. Population of a small colony at Signy Island, 1950–51, to show typical fluctuations during the breeding season

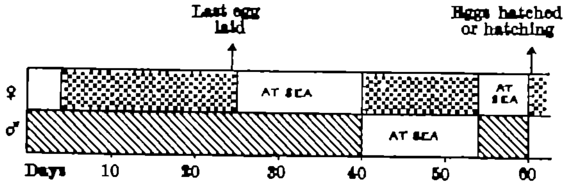

Fig. 2. Diagrammatic nest-history up to hatching of eggs made from the averages of seven males and seven females ringed at Signy Island on October 17 and 18, 1950. (Note: the first birds observed back at the rookery were seen on October 8, so the first fasting periods may be slightly longer than stated.) Male fasting periods at nest (hatched); female fasting periods at nest (dotted)

The parents shared care and feeding of chicks until they were large enough to be left alone. 'Crèches' were then formed in which the chicks congregated together in groups of a hundred or more, presumably for additional protection from the skuas (*Catharacta skua*). By marking birds during both years of study, it was found that parents recognized and fed their own individual chicks. The young left the rookery independently of their parents when they had lost their down, about two months after hatching.

*Unsuccessful breeders.* If the eggs were lost, the nest was deserted; but it was usually re-occupied between the time when the chicks of other pairs were hatching and crèche formation. The second peak in the population curve (Fig. 1) during December is partly due to this return of unsuccessful breeders. Nests were rebuilt, the original pair-bond (at least in 'experienced' birds) was almost certainly maintained, and the usual behaviour patterns (including copulation) seen in the pre-egg stage were observed again, though on a reduced scale. No second clutch was laid, though there was a noticeable enlargement of the gonads. The male was more faithful to his nest territory than his mate and often came back earlier and remained longer, usually alone, at his pile of stones. These unsuccessful breeders have been mistaken by previous writers for 'parent guards' of the crèche, a function they do not perform.

## 'Inexperienced' or 'Unestablished' Breeders

These are probably three or four years old and breeding for the first, or perhaps the second, time. Their behaviour differs somewhat from that of the 'experienced' birds, though with some overlap due to individual variation. They often arrive back later and take up territories on the periphery of the colonies, or fill vacant places within them. They are the cause of most of the fighting. Courtship behaviour is more prolonged, egg and chick mortality higher, breeding efficiency lower. Thus Fig. 3 shows a badly built nest on a rock slab. The male is beside his mate, who has inadvertently scraped away the egg with her feet. Sheathbills (*Chionis alba*) are waiting near by. Such eggs fall an easy prey to these scavengers, which pay more attention to badly looked-after nests than to those of 'experienced' birds.

## Non-breeding 'Wanderers'

These two- or three-year-old birds wander around the rookery in small parties and even visit rocky outcrops 1,000 ft. above sea-level far away from the breeding area. Some of them build poor nests or

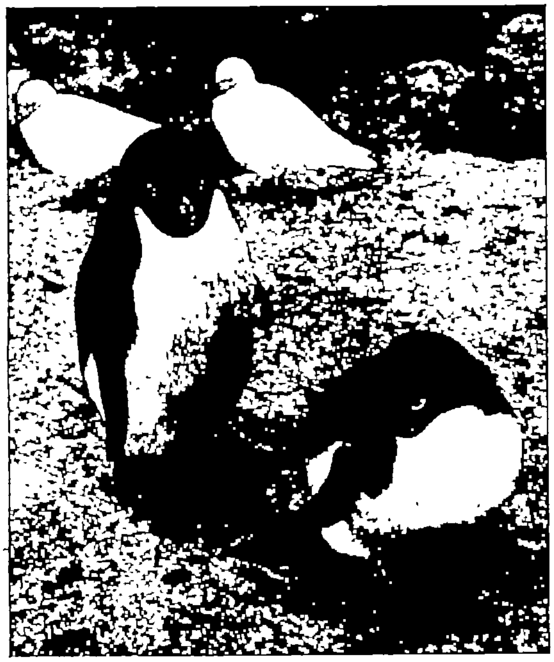

Fig. 3. 'Inexperienced' breeders. Sheathbills (*Chionis alba*) waiting behind in hope of securing egg

occupy vacant sites for a short time before moving elsewhere or being turned out by older birds. A proportion of these 'wanderers', when dissected, showed undeveloped gonads despite their adult plumage. It is this age-group, together with some of the 'inexperienced' birds, that, under favourable conditions, will establish themselves in new ground and thus extend the range of the species.

### Birds in Immature Plumage, or Yearlings

These are last season's young, easily recognized by their white throats. This immature plumage is carried for twelve months and moulted in February. They normally live among the pack-ice, but are occasionally seen at the rookery, where they associate with the 'wanderers'. Several were seen building nests in a half-hearted way on the periphery of a colony; but, like the 'wanderers', they never stayed in one place for long.

### Individual Recognition

The problem of individual recognition is fundamental in interpreting the behaviour of breeding Adelies. Undoubtedly the two birds of a pair recognize each other from the time they are paired, before egg-laying, up to the time when the chicks go into the crèche. Previous literature summed up by Murphy[4] suggests that the pair-bond among adults is not maintained in subsequent seasons and that it is unlikely that the parents recognize their own offspring once the crèches have been formed. In their two papers on the Adelie, Sapin-Jaloustre and Bourlière[5,6] do not contradict this. Richdale[7] has, however, shown that the yellow-eyed penguins (*Megadyptes antipodes*) recognize each other as individuals.

In 1948–49 I placed coloured rings around the flippers of the chicks of marked parents before they went into the crèches and discovered that the parents found and fed their own offspring when in the crèche. Andrew and Roberts[8] have shown that adults return to the same nests and maintain the same pair-bond, and I believe this pair-bond is maintained, not merely because they return to the same nest-site, but because they recognize each other as individuals, even after a winter among the pack-ice.

Three important factors enter into this recognition: territory, visual and auditory recognition, and the so-called mutual display. Territory brings both members of a pair, and parents feeding chicks, back to known ground. A few chicks moulting their second down were marked and transferred to another crèche still within view of their own area but a quarter of a mile away. Most were back within twenty-four hours. But the actual nest-site is less important than visual recognition, since, though chicks may move out of a crèche and lie in their old nest-site when hungry, a parent is still able to recognize its chick should it be in a crèche several yards away.

Field experiments also showed that parents adopted chicks from other nests if small, but very rarely ones that were large enough to stand up. I believe that visual recognition is perhaps the most important single factor, being slowly acquired during the early stages of chick growth and fully developed by the time the chicks move into the crèche. Similarly with members of a breeding pair: the 'experienced' breeder may keep company with another bird, but be re-united to its true mate should the latter return to the nest later. Further, in at least three cases, a pair shifted their nest-site and yet remained together.

In the mutual display two birds stand facing each other and sway their necks from side to side with bills pointing upwards and flippers close to the side. The display may be 'loud' or 'quiet', when loud being accompanied by much noise with bills wide open, whereas in the quiet mutual display there is less neck movement and a soft 'squaw' with closed bill (Fig. 4) or no sound. The mutual display was seen most frequently before the eggs were laid, during nest-building; but was repeated each time one of a pair returned from the sea to take over incubation, or feeding duties, before the crèches were formed. The

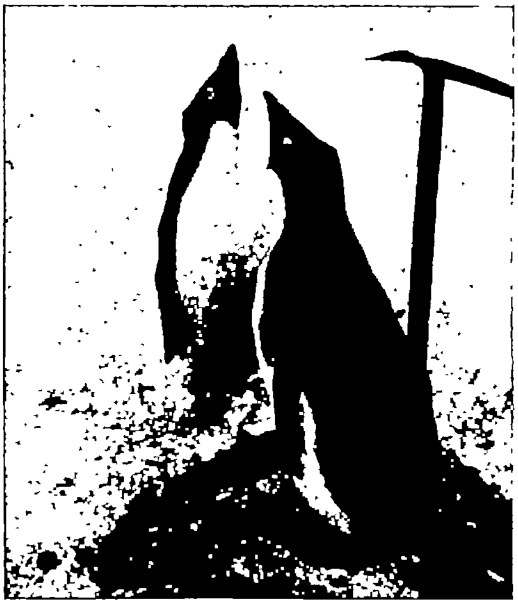

Fig. 4. The 'quiet' mutual display between a pair of adults at their nest. The ice-axe by the nest is for scale

bird returning from the sea comes straight to its nest. Their usual behaviour and directness of purpose suggest they recognize their mates from a distance. The loud mutual display follows immediately they meet and is repeated several times, followed by the quiet display. There is usually a recrudescence of the loud display when the incubating bird walks off the eggs or chick and the new arrival takes its place.

A small chick at first pays little attention to this noise and movement, but soon begins to associate it with a fresh supply of food. As it grows bigger, its simple piping changes into a quivering call which has the same pattern as the sound made in the loud mutual display and is, as a large chick, accompanied by the same movements as seen between two adults (Fig. 5). The display and change of voice are well developed between parent and chick by the time the chick goes into the crèche and are repeated between parent and chick each time the parent returns with food. I therefore believe the most important function of the mutual display and call to be a confirmation of visual recognition. The parent probably recognizes its chick with greater certainty than the chick its parent. I have seen marked chicks pestering different parents for food ; but have only once seen a marked parent feeding a marked chick not its own, and then for one brief and harassed mouthful, after which its own chicks, which were smaller, received the food.

Once it is established that adult pairs, and parents and chicks, recognize each other, it seems reasonable to suggest that this flightless bird, less than two feet in height, is helped in finding its way to its nest in the crowded rookery by recognizing its neighbouring adults.

## The Ecstatic Display

The other most prominent display of the Adelie is the so-called 'ecstatic', originally described by Wilson[8] and Levick[9] and admirably re-described by Sapin-Jaloustre and Bourlière[6]. A subsidiary stage of this display appears to have been missed by previous writers.

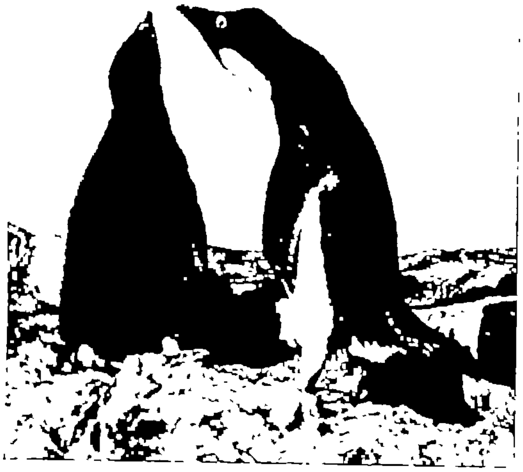

Fig. 5. The 'quiet' mutual display between a chick and parent on return of the parent from the sea with food

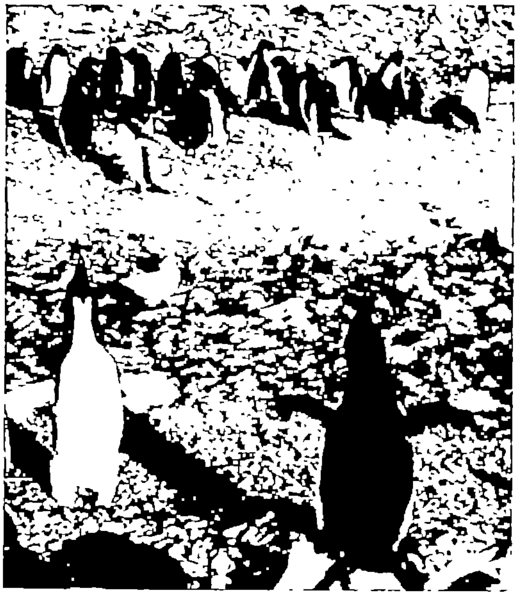

Fig. 6. Two Adelies in the ecstatic display alone in their nests

In the main display, with bill pointing upwards, the bird stretches to its full height and, beating its flippers backwards and forwards, emits a characteristic guttural throbbing sound (Fig. 6). The display is often contagious, but is not taken up by all the birds in a colony. It was seen most often early in the season and more among the unpaired 'inexperienced' and 'wanderer' males, particularly when attempting to establish themselves, than among the paired 'experienced' breeders. A sample of nearly a hundred dissected birds showed that the display was confined to the male up to the time when the chicks had, or should have, hatched, but thereafter was found in both sexes. I never saw two birds in one nest both in the ecstatic display. If the male displayed, the female by his side usually went through the same motions as seen in the quiet mutual display. A lone male standing in his nest would often by this display attract a 'wanderer' or 'inexperienced' or even an unsuccessful female to his side, and I consider its most important function to be in pair formation. When seen, less commonly, in lone marked birds incubating eggs or standing over chicks, it often appeared to be associated with stress.

In the subsidiary display, usually seen in lone birds before or immediately after the main display, or as a separate display, the bird rocks its head from side to side with bill directed either to the left or right axilla. The flippers continue to beat rhythmically backwards and forwards as in the main display. A soft "*gurr-gurr-gurr-gurr-gurr*" accompanies these movements which is characteristic of this particular display. Its function is, at present, obscure.

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[2] Andrew, J. D., and Roberts, J. M., *Ibis*, 94, 540 (1952).

[3] Stonehouse, B., *Nature*, 169, 760 (1952).

[4] Murphy, R. C., "Oceanic Birds of South America" (Amer. Mus. Nat. Hist., New York, 1936).

[5] Sapin-Jaloustre, J., and Bourlière, F., *Alauda*, 19, 65 (1951).

[6] Sapin-Jaloustre, J., and Bourlière, F., *Alauda*, 20, 39 (1952).

[7] Richdale, L. E., "Sexual Behaviour in Penguins" (University of Kansas Press, 1951).

[8] Wilson, E. A., Aves. British Nat. Antarctic Exped., 1901–4, Vol. 2, Zoology (1907).

[9] Levick, G. M., Natural History of the Adelie Penguin (British Antarctic (Terra Nova) Exped., 1910, Zoology, Vol. 1, No. 2, 1915).

# NEWS and VIEWS

## Prof. W. Pauli, For.Mem.R.S.

Prof. Wolfgang Pauli, who has just been elected a foreign member of the Royal Society, is best known for the exclusion principle, or 'Pauli principle', which he formulated in 1925, and which at once cleared up many unexplained features of atomic structure and atomic spectra. This principle, which states that no two electrons, or nucleons, can be in the same quantum state, is logically independent of the other laws of quantum mechanics. It applies to all elementary particles of half integral spin, and Pauli himself showed in a later investigation that a system in which such particles did not obey the principle, or in which it applied to photons or other particles of integral spin, could be described without logical contradictions, but would lead to physically unreasonable consequences. Besides the work on the exclusion principle, for which he was awarded the Nobel Prize for physics in 1945, Pauli has made many important contributions to theoretical physics, beginning with an article on the theory of relativity, which he wrote while he was a research student, simultaneously with his thesis on the quantum theory of the hydrogen molecule ion, and which has remained until now the standard text on the subject. He initiated the modern electron theory of metals by applying the exclusion principle, extended by Fermi to the statistic of many-particle systems, to the paramagnetism of metals. More lately he has contributed to the theory of mesons, and he has always been interested in a clear formulation of the basic concepts of quantum theory. His enthusiasm and insistence on fundamentals have inspired many collaborators and pupils, and by incisive criticism he teaches them to beware of loose thinking.

## Technical Assistance to South and South-East Asia

The report for 1952 of the Council for Technical Co-operation in South and South-East Asia (pp. 16 ; London : H.M.S.O., 1953 ; 6d. net), which deals with the technical co-operation scheme of the Colombo Plan, indicates a marked increase in the flow of technical assistance over that for 1951 ; 90 experts and 538 training places were provided, as against 45 and 309, respectively, in 1951, but the limiting factor remains not the availability of funds, but the willingness of individual experts to accept appointments overseas. The increasing world-wide demand for technologists, and full employment in the supplying countries accentuate the problem, and improvement is due chiefly to improved administrative arrangements, to the maintenance of a sense of urgency in meeting the needs of under-developed countries and to the way in which the idea of the Colombo Plan has caught public imagination. Most of the experts provided during the year were engaged for specific projects where their duties included the training of local personnel as well as some measure of executive responsibility for the scheme, but the demand for experts whose main duties will be training local personnel is increasing. Schemes which combine capital and technical assistance have also increased. Ceylon, India and Pakistan have taken 118 of the 135 experts so far supplied and sent 689 of the 847 trainees. They have also supplied five of the experts and facilities for fifty-seven trainees. The United Kingdom has provided 67 experts and 279 training places in all, the corresponding figures for Australia being 40 and 286, for Canada 6 and 106, and for New Zealand 17 and 119. The demand for, and provision of, equipment for use by experts and for training and research institutions also increased ; but although the sums involved are considerable, by December 31, 1951, only £400,000 out of the eight million pounds set aside for the Scheme had actually been committed, and in April 1952 it was agreed that the scheme should be co-terminous with the Colombo Plan and operate until June 30, 1957. The assistance provided has been mainly in the fields of medicine and health, agriculture and forestry, engineering, industry and trade, and transport and communications. In addition, the United Nations and the Specialist Agencies have provided the area with 502 experts and 564 trainees, and the corresponding numbers supplied by the United States are 210 and 403.

## Universal Copyright Convention

The text of the Universal Copyright Convention which was signed at Geneva last September by the delegates of thirty-six countries, including the United States and the United Kingdom, has now been published by the United Nations Educational, Scientific and Cultural Organization (pp. 24 ; 125 francs, 2s. 6d. or 50 cents. Paris : Unesco ; London : H.M.S.O., 1953). The Convention seeks to supplement existing copyright conventions, such as the Berne Convention, to which some forty countries (but not the United States or any Latin American countries, except Brazil) are parties. Ratification of the Convention by the United States and by Britain would greatly facilitate the obtaining of copyright protection in the United States for the work of British authors. At present, works in the English language can only secure protection in the United States if, in addition to registration at the Copyright Office in Washington, D.C., they are printed in the United States from type set up in that country. Under the Universal Convention, however, a country which requires compliance with formalities as a condition of obtaining copyright agrees to regard such conditions as satisfied, so far as works of foreign origin are concerned, if such works bear the symbol 'C' written in a circle, indicating that copyright protection is claimed, together with the name of the copyright proprietor and the year of first publication. This provision will facilitate the protection of British works, both in the United States and in many other countries outside the Berne Convention, where registration is often required as a condition of copyright protection. In other respects, works will be protected in each contracting country in accordance with the domestic law of that country, but no country will be required to give a longer term of protection than that to which a work is entitled in its country of origin. The Convention will come into force when ratified or formally accepted by twelve countries, of which at least four are not parties to the Berne Copyright Convention.

## Planetary Influences on the Sun

A paper entitled "Planetary Influences on the Sun", by M. Kopecký, P. Mayer and V. Borovičková, of the Central Astronomical Institute, Ondřejov (*Bull. Cent. Astro. Inst. Czech.*, 3, No. 3 ; 1952), contains the results of their work on sunspot activity and the positions of the planet Mercury. In a previous paper (2 ; 1950) certain results were given by the same authors on the planet Venus, and it was found that the period of variation of the relative number was approximately equal to the synodic rotation of the sun with reference to the planet. Owing to the comparatively large eccentricity of the orbit of Mercury, perihelion and aphelion conjunctions are dealt with separately, and the material was reduced to those conjunctions for which the most outstanding effects would be expected: these are at inferior conjunction when both the earth and Mercury are in perihelion; and at superior conjunction when Mercury is close to perihelion and the earth to aphelion. Next, the results were analysed for the least favourable conditions, that is, when Mercury is in aphelion and the earth also in aphelion at inferior conjunction and when Mercury is in aphelion and the earth in perihelion at superior conjunction. The results are shown by a number of curves, but the correlation between the sunspot-characteristic and the synodic revolution of Mercury is not so well defined as in the case of Venus. It is suggested that this may be due to the large eccentricity of Mercury's orbit, which makes the statistical results more difficult, or to a smaller hypothetical influence of Mercury. Nevertheless, analogical forms of the curves of sunspot-characteristics for Mercury as for Venus have been obtained, and it is possible to assume that Mercury has an influence in the production of sunspots.

### Rock Engravings in the Kilimanjaro Area

In the November and December numbers of *Man* there is an important article by H. A. Fosbrooke, sen., a sociologist of Tanganyika Territory, and Petro I. Marealle, chief of the Vungo division of the Chagga tribe, on the engraved rocks of Kilimanjaro and their meaning and use in initiation ceremonies. Rocks covered with apparently meaningless engraved lines are known from many parts of Africa. It is not suggested that the explanation given for the ones of Kilimanjaro applies in all cases; but it may well be that the others were used for some analogous purposes. In the November number, Fosbrooke describes the engraved rocks and supplies a couple of pages of excellent illustrations. In the December number, Marealle describes the use and explanation. "From the body of the youths of the age set are chosen 12 who are the children of people of importance. . . . The stone itself is engraved thus. The elder who is the instructor goes with the 12 youths to the stone. He wears a ring of hide, and says to them 'you see this stone and its engravings: look this is your whole country. The youths of old who made these marks were led by an elder who like myself knew much wisdom'. . . . Then the elder gives one of the 12 a little axe and shows him how to cut a line on the stone. The youth cuts a small mark from two to six inches long." Thus the rocks become more and more covered with engraved lines apparently meaningless. The ceremony, of course, continues, but enough has been quoted to give the gist of the explanation. This seems to be the first time such an account of such a ceremony and of the reason why these rocks get covered with engraved lines has ever been given; and it is factual, given by a man who formerly was an instructor, and is not an explanation produced out of the fancy of a psychological anthropologist.

### High-frequency Electric and Magnetic Shielding

The third monograph of the series issued by the Research Institute of Applied Electricity, Hokkaido University, Sapporo, Japan, is entitled "Some Researches on High-Frequency Phenomena and Electrical Direct Heating" (Monograph Series No. 3; pp. 105; 1952) and contains four papers, two of which deal with the important problem of electrical shielding of high-frequency apparatus. In the first of these, Y. Asami, the director of the Institute and editor of the monograph series, and A. Matsumoto discuss in general terms the various sources and methods of suppression of electromagnetic leakage in high-frequency apparatus and then consider theoretically the principles of electric and magnetic shielding. They follow this by a description of a number of experiments performed with special care to detect the defects of apparatus made in Japan, and it is concluded that radio interference from high-frequency apparatus can be almost eliminated by application of the suggestions made. It is emphasized that, as some kinds of wire-nettings used for screening are subject to rapid deterioration, good netting resistant to deterioration must be selected and used. The second paper, by T. Matsumoto, is a continuation of the one, on the theory of electromagnetic shielding by a shielding room of wire-netting, which appeared in No. 1 of the series. Several fresh problems are briefly considered: the effects of finite dimensions of the current-loop wave source, and of the eccentricity of its position relative to the centre of the shielding room; and the theories of double shielding formed by two concentric spherical walls of wire-netting, and of shielding by a shielding room consisting of a cylindrical cavity with perfectly conducting walls and with a wire-netting bottom.

### Seasonal Variation in the Reproductive System of Garter Snakes

Although many papers have been written, there is still much that is not understood concerning the external and internal factors responsible for the cyclic nature of reproduction in reptiles. Investigations of the seasonal fluctuations in various parts of the reproductive system of several species of lizards, snakes and turtles have revealed interesting species differences. For a more complete understanding of reptilian reproduction it would appear that detailed descriptions of the seasonal changes of many species are desirable (*J. Morph.*, 90, No. 3; May 1952). Such a study was carried out by Wade Fox on the common garter snake (*Thamnophis*), several species and subspecies of which could easily be obtained throughout the year in the vicinity of San Francisco Bay. These investigations showed that the gonads of the male garter snake, *Thamnophis elegans terrestris*, exhibit marked seasonal variation. The testes begin to increase in size in the early spring, reach their maximum size and weight in late July, decline in the autumn, and are of minimum size during the winter months. These macroscopic fluctuations are accompanied by corresponding histological changes.

### Collections of British Birds and Eggs

In the March number of the *Museums Journal* Mr. Colin Matheson (National Museum of Wales) has performed a useful service in that he has collated much information regarding the present location of museum collections of British birds and eggs. In order to add to the value of such notes, he has included collections which are known to have been destroyed during the Second World War. Changes in outlook, as well as in economic and social conditions, make it unlikely that many more large collections will be formed, and hence it is important that ornithologists should know the whereabouts of the material available for study.

## Technical and Technological Education in Britain

In his presidential address to the Association of Teachers in Technical Institutions, delivered at Leeds on May 24, Mr. C. L. Bott, principal of Southport Technical College, referred to the lack of progress in secondary technical education in Britain, and to the need for careful thought as to what exactly the secondary technical schools are intended to do. Mr. Bott visualizes them as catering for three groups of students: a few who would proceed to a university or college of technology; those of a less academic type who require the stimulus of a more practical type of training; and those who would ultimately be trained as technicians. He emphasized the necessity for effective and continuous education from the secondary technical schools whether to a university or to a technical college, but he made the surprising remark, in view of what has been said, for example, at recent conferences of the Federation of British Industries, that firms now find difficulty in training workers themselves and look more and more to the technical colleges. He also commended the provision of sandwich courses: both education and industry are convinced, he said, that such schemes could ensure a sound integration and correlation of works and college training, and he thought that the scope and number of such schemes could be extended with advantages both to students and the community as a whole. In his reference to higher technological education, Mr. Bott was less happy, pursuing the chimera of a national award, which the Government has wisely rejected; he passed over the vital questions of adequate resources and conditions which will attract staff of high calibre, both of which are essential to enable the technical colleges to contribute significantly to the supply of technologists. Nor did he distinguish clearly between technician and technologist, or discuss the importance of an appropriate numerical balance between the two.

## National Research Council of Canada: New Members

Three new members have been appointed as follows to the National Research Council of Canada for a three-year term ending on March 31, 1956: Dr. R. F. Farquharson, Sir John and Lady Eaton professor of medicine and head of the Department of Medicine, University of Toronto; Dr. E. G. D. Murray, professor and chairman of the Department of Bacteriology and Immunology, Faculty of Medicine, McGill University; Dr. David L. Thomson, dean of the Faculty of Graduate Studies and Research and chairman of the Department of Biochemistry, McGill University. In addition, the following three members, who have already served one term on the Council, have been reappointed for another three years: Dr. C. W. Argue, dean of science and professor of biology, University of New Brunswick; Dr. A. G. McCalla, dean of agriculture, University of Alberta; Dr. G. M. Shrum, professor and head of the Department of Physics, University of British Columbia. The National Research Council consists of a president, two vice-presidents and seventeen members. The members serve in an honorary capacity for a three-year term which may be renewed once; they are appointed by Order-in-Council and are chosen to represent the universities and industry, the selection being made in such a way as also to provide adequate geographical representation.

## Colonial Service: Recent Appointments

The following appointments have recently been made in the Colonial Service: N. R. Fuggles-Couchman (agricultural officer, Tanganyika), regional assistant director of agriculture, Tanganyika; W. B. Mason (senior agricultural officer, Gold Coast), assistant director of agriculture, Gold Coast; W. V. Rose (agricultural officer, Nyasaland), deputy director of agriculture, Barbados; F. E. Hughes (conservator of forests, Gold Coast), deputy chief conservator of forests, Gold Coast; H. S. H. Watson (senior assistant conservator of forests, Northern Rhodesia), deputy conservator of forests, Northern Rhodesia; A. T. Crow (geologist, Gold Coast), senior geologist, Gold Coast; F. H. Fitch (senior geologist, North Borneo), deputy director of geological surveys, North Borneo; E. G. Davy (assistant director of observatory, Mauritius), director of observatory, Mauritius; E. G. B. Jones (agricultural instructor, British Guiana), agricultural officer, Jamaica; Miss C. McGlade (clerk, grade I, Statistical Department, East Africa), statistician, Statistical Department, East Africa; J. C. Williams (engineering surveyor, Water Development Department, Tanganyika), topographer, Department of Geological Survey, Uganda; S. J. A. Williams, agricultural officer, British Honduras; J. Armour, veterinary officer, Nigeria; N. St. G. Hyslop, veterinary research officer, Kenya; W. P. Unsworth, veterinary officer, Department of Agriculture, Trinidad; C. S. Eastman, assistant conservator of forests, Nigeria; M. Garstang, assistant meteorologist, British Caribbean Meteorological Service, Trinidad; V. E. Sills, biochemist, Agricultural Department, Fiji.

## Physical Society: Officers

At the annual general meeting of the Physical Society held on May 15 the following officers were elected: *President*, Prof. R. Whiddington; *Honorary Secretaries*, Mr. C. G. Wynne and Dr. H. H. Hopkins; *Honorary Treasurer*, Mr. A. J. Philpot; *Honorary Foreign Secretary*, Prof. E. N. da C. Andrade; *Honorary Librarian*, Dr. R. W. B. Pearse; *New Members of Council*, Prof. P. M. S. Blackett, Prof. N. Feather and D. W. Fry.

## Fourteenth International Congress of Zoology

The Fourteenth International Congress of Zoology will take place in Copenhagen during August 5–12, and more than five hundred zoologists from forty-four countries outside Denmark have already indicated that they will be present. The president of the Congress will be Dr. R. Spärck, professor of zoology, University, Copenhagen, and the secretary-general, Dr. Anton Fr. Bruun, Zoological Museum of the University, Copenhagen. Those who wish to become members of the Congress are invited to apply to the Secretariat, Krystalgade 27, Copenhagen K, Denmark. The membership fee is 100 Danish kroner (about £5). Associate membership costs 50 Danish kroner, but does not entitle the member to receive the proceedings of the Congress. Accommodation may be arranged through any travel agency, and the secretariat is also prepared to arrange hotel accommodation for members but applications should be made as early as possible. A preliminary list of twenty sections of zoology has been suggested, so that it will be possible for members to meet their colleagues in fairly restricted fields, but more sections may be established depending upon the communications offered by members. Zoologists wishing to be present at this Congress should make application through their bankers on Form *T.2* for special allotment of exchange for the purpose of attending the Fourteenth International Congress of Zoology.

## The Night Sky in June

NEW moon occurs on June 11d. 14h. 55m., U.T., and full moon on June 27d. 03h. 29m. The following conjunctions with the moon take place: June 8d. 08h., Venus 8° S.; June 13d. 07h., Mercury 0·1° N.; June 21d. 16h., Saturn 8° N. In addition to these conjunctions with the moon, Mercury is in conjunction with Mars on June 2d. 10h., Mercury being 1·0° N. Mercury is an evening star, setting at 21h., 21h. 55m. and 21h. 35m. on June 1, 15 and 30, respectively. Venus, a morning star, rises at 2h. 20m., 1h. 55m. and 1h. 30m. at the beginning, middle and end of the month, respectively; the stellar magnitude of the planet averages − 0·4, and the visible portion of the illuminated disk varies from 0·36 to 0·54. Mars is an evening star, setting at 21h. at the beginning of the month, but, as it is gradually drawing closer to the sun, it is badly placed for observation during June. Jupiter, a morning star, rises about the same time as the sun on June 1, and at 3h. and 2h. 10m. on June 15 and 30, respectively, but will not be favourably placed for observation until later than the middle of the month, when it can be seen in the constellation of Taurus. Saturn is visible until the morning hours, its times of setting on June 1, 15 and 30 being 2h. 10m., 1h. 20m. and 0h. 20m., respectively, and it can be seen a little north of Spica during this time. No occultations of stars brighter than magnitude 6 take place in June. Summer solstice occurs on June 21d. 17h.

## Announcements

PROF. IRENE MANTON, professor of botany in the University of Leeds, has been elected an honorary member of the Danish Academy of Sciences and Letters.

SIR ERIC RIDEAL, professor of chemistry in King's College, University of London, has been appointed chairman of the Advisory Council on Scientific Research and Technical Development of the Ministry of Supply in succession to Sir John Lennard-Jones.

MR. J. T. SAUNDERS, secretary-general of the Faculties in the University of Cambridge, and formerly lecturer in zoology in the University, has been appointed principal of University College, Ibadan, in succession to Dr. Kenneth Mellanby.

THE Council of the Royal Society has appointed Mr. A. S. Laughton, of King's College, Cambridge, to be John Murray travelling student in oceanography and limnology. Mr. Laughton will carry out research on the physical properties of sediments, part of the work being carried out at the Lamont Geological Observatory, Columbia University, New York, during 1954.

THE following changes in the University of Sheffield have recently been announced. *Appointment:* Dr. A. F. Ruston, senior lecturer in pure mathematics. *Resignations:* D. K. Roberts, lecturer in mechanical engineering and sub-warden of Ranmoor House; R. M. Haythornthwaite, lecturer in civil engineering; Dr. K. Burton, lecturer in biochemistry; and F. Newby, information officer and librarian to the Department of Glass Technology.

THE Oliver Memorial Fund is offering an award worth £50 to a British subject for original work or services in connexion with research, organization or the donor aspect of blood transfusion. Applications or information directing attention to suitable candidates must be submitted before August 31 to the honorary treasurer of the Fund, F. W. Mills, c/o National Provincial Bank, Ltd., Holborn Circus, London, E.C.1.

A CONTINUATION of the seminar on polymer science (cf. *Nature*, 171, 65; 1953) will take place on June 29; a programme and abstracts of lectures can be obtained from the Chemistry Department, University College, London, W.C.1.

THE Royal Microscopical Society will hold a conversazione in its rooms at Tavistock House South (Entrance *D*), Tavistock Square, London, W.C.1, during June 9–10 (7.30–10 p.m.) in honour of the Coronation of H.M. the Queen, Royal Patron of the Society. The conversazione will comprise demonstrations illustrating the development of the microscope and the advances in microscopical technique made from the time of the granting of the Royal Charter by Queen Victoria to the present day. The exhibition will be open to the public during June 11–12.

THE Institute of Physics has awarded Bowen Prizes of fifteen guineas each to the following for their papers published in the *Journal* of the Institute: G. T. Wright, University of Birmingham (a single-channel pulse-height discriminator of high speed and stability); G. D. Dew, National Physical Laboratory, Teddington (preservation of groove form in replicas of diffraction gratings); H. Aspden, Trinity College, Cambridge (measuring the magnetic permeability of rod specimens). These Prizes are provided by the Scientific Instrument Manufacturers' Association of Great Britain, Ltd., from a fund established by the late Mr. William Bowen, and are awarded to persons not more than thirty-five years of age whose papers are judged to be the best in respect of originality, scientific value, practical utility to instrument makers and users, and presentation.

ON the recommendation of a joint committee of the Institution of Mining and Metallurgy and the Institute of Metals, Capper Pass awards have been made as follows for papers, the subjects of which are shown in brackets, published during 1952 in either the *Transactions of the Institution of Mining and Metallurgy* or the *Journal of the Institute of Metals*: E. Davis and S. G. Temple, jointly (batch and continuous annealing of copper and copper alloys), C. P. Paton (batch thermal treatment of light alloys), Dr. E. C. Ellwood and T. A. Henderson, jointly (formation and control of magnetite during copper smelting operations), P. M. J. Gray (production of pure cerium metal by electrolytic and thermal reduction processes) and E. A. Hontoir (determination of sulphur in iron pyrites). The awards are each for £50, except the last-named, which is worth £25. They are made annually from a sum of £200 given each year by the firm of Capper Pass and Son, Ltd., Bristol, and are intended to encourage the publication of papers on processes and plant used in extraction metallurgy, assaying and on processes and plant used in all branches of the non-ferrous metal industry.

# BIRKBECK COLLEGE, LONDON

## NEW BUILDING

AT three o'clock in the morning in the "Crown and Anchor" public house in the year 1823, Dr. Birkbeck was elected president of the London Mechanics' Institution, then and there founded. That institution has grown and thriven for more than a hundred years and still serves the student who has to pursue learning and earn his living at the same time. The adoption of the name "Birkbeck College" in 1907 symbolized the growing claim to university status, and the admission of the College as a School of the University of London in 1920 marked the accomplishment of ambitions which long existed among its teachers and students. In 1930 the Court of the University set aside part of the University site in Bloomsbury for a new building for the College, the premises in Fetter Lane of which, though referred to at their opening in 1885 as "spacious and convenient", had become quite inadequate.

In spite of generous benefactions from many sources, sufficient money was not accumulated until 1939 when the new building was started. However, operations had to be abandoned in 1940 with only the steel skeleton erected. Work was resumed after the War, and the hopes and labours of so many years culminated on April 28 when H.M. Queen Elizabeth the Queen Mother, patron of the College, visited the new building. In the presence of a distinguished gathering in the Senate House of the University, Her Majesty was welcomed to the College by the Master, Dr. J. F. Lockwood. The president of the College, the Right Hon. Lord Justice Denning, then invited the Queen Mother to declare the new building open. In her address, Her Majesty referred to the "absorbing story" of the College's development and to those whose enterprise turned what might have been a story of disaster into a record of triumph. "To you," she concluded, addressing the students, "we confidently look for the preservation and enrichment of our civilization."

Having unveiled a commemorative inscription in the entrance hall, Her Majesty inspected part of the new building. She was received in the Psychology Department on the fourth floor by Prof. C. A. Mace and Mr. A. Rodger. During the inspection of the Psychological Laboratory, Her Majesty was shown experimental studies on perception, learning, fatigue and other topics representative of the normal work of a psychological department. Among research activities in applied psychology displayed in the laboratory were an investigation into new methods of plotting the movements of aircraft, and the training of a blind worker by a blind instructor in skilled assembly work. A case study in vocational guidance was also in progress during the visit.

On the third floor, occupied by the Chemistry Department, Her Majesty was received by Prof. W. Wardlaw, Dr. D. J. G. Ives and Dr. D. H. R. Barton. She passed through the main teaching laboratory, with accommodation for ninety students, where she watched a practical class in progress, and spoke to some of the students.

The Queen Mother then inspected the library, which includes a particularly large and attractive reading room. Before leaving, Her Majesty took tea in the Council Chamber.

In addition to the Departments already mentioned, the new building houses the Departments of Physics (Prof. J. D. Bernal), Zoology (Prof. W. S. Bullough), Geology (Dr. A. T. J. Dollar), Botany (Prof. C. T. Ingold), Geography (Prof. W. G. East), and Mathematics (Prof. A. C. Offord).

The Faculty of Arts has accommodation for its staff in Malet Street; but most of its teaching is done in space kindly provided by neighbouring institutions.

Of the 214 degrees awarded to Birkbeck students during the session ending July 1952, forty were postgraduate. The facilities which are now available for research will make possible a wide extension of opportunities for students who wish to prepare for the higher degrees of the University of London.

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# HUMAN PERFORMANCE

THE third symposium of the Ergonomics Research Society was held in the Department of Human Anatomy, University of Oxford, during April 13–16, the subject being "Human Performance, its Measurement and Limitations". The diversity of disciplines related to the study of the relation between man and the environment in which he works was well illustrated by the number of scientific departments represented; among the hundred and thirty members and visitors who attended were leading workers from many parts of the world, including, in particular, Scandinavia, Finland, Germany, the Netherlands and the United States. The deliberations fell into two main categories: those with a predominantly physiological approach to the efficiency of performance in hard manual work, and those of a psychological nature dealing with some of the lighter industrial work processes. The discussions revealed a clear realization of the complementary roles of these different methods of assessing human performance and the necessity of relating them realistically to the problems actually confronting the production engineer. They also indicated the gap that exists between fundamental work and the application of relevant results to industrial work.

In his opening address, the chairman, Prof. W. E. Le Gros Clark (Oxford), directed attention to the interplay of fundamental and *ad hoc* research on which successful ergonomic investigation depends. As long as the ergonomic research worker, stimulated by some practical problem, has the freedom to develop his interest in the more fundamental aspects, the subject can be regarded as a suitable one for university departments. Of the various difficulties attending such research, he stressed in particular the inadequacy of the present supply of human subjects for laboratory tests.

Sir Charles Lovatt Evans (consultant physiologist, Ministry of Supply), in an introductory address, dealt with the contributions which human physiology can make to the improvement of work and working conditions. Human physiology has reached a stage in its development where, generally speaking, it possesses the necessary basis of method and theory for the study of almost any physiological process which might be of interest in human activity—in industry, sport or war. He illustrated this by an account of the history of muscle physiology and showed how our present understanding of the anatomical, dynamic and energy characteristics of muscle action has been attained and can be employed in ergonomics. Dr. O. H. Wansborough Jones (chief scientist, Ministry of Supply) discussed ergonomics from the point of view of the user and posed a number of general questions for the consideration of the symposium. A distinction should be drawn between the 'all-out' character of war-time ergonomic and operational research and that of peace time, where the objective should be increased productivity without increased strain. Looking to the future, one should bear in mind the change that will come about with the virtual elimination of the human operator; it means that ergonomics will have to re-orientate itself increasingly to the problems of maintenance and transport. At the present time, said Dr. Jones, these are rather neglected. It is also not sufficiently appreciated that the duties of the administrator and executive officer present ergonomic problems, for this type of work is often done at very high pressure and inordinately long hours, particularly so in the higher posts in business and the Civil Service.

A number of the papers dealt with the physiological methods of work-study in the laboratory and the factory. Techniques for the continuous registration during exercise (on a bicycle ergometer with electrical braking-system) of ventilation-rate, oxygen consumption, carbon dioxide production and pulse-rate were described by Dr. F. H. Bonjer (Leyden). For the gas analyses he uses a Kipp diaferometer employing the Noyons principle whereby the composition of the gas mixture can be measured by changes in the electrical resistance of a heated wire. The cardiotachometer depends on photo-electric recording of fluctuations in the light transmission through the ear-lobe. The usefulness of estimations of heart-rate and metabolic cost in work study cannot be over-emphasized, and hence there is a great need of methods which can be used at the work bench. Special attention was devoted in a number of papers to the portable instruments devised at the Dortmund Max Planck Institute for these purposes, the Kofranyi–Michaelis respirometer and the Müller photo-electric pulsometer. The *K–M* respirometer was used in laboratory investigations described by Passmore at Glasgow to determine individual variation in metabolic cost of standardized stepping and walking. The reliability of this last-named instrument, even in the very difficult environmental circumstances of underground work, was proved by J. G. Durnin, R. C. Garry and R. Passmore in an investigation of the metabolic cost of a variety of coal-mining activities. The information obtained gave a picture of the daily pattern of work of underground miners, and comparisons could be made with findings in the Ruhr and other coal-fields. Dr. O. G. Edholm (London) showed how by keeping a detailed diary of the complete 24-hourly routine (as carried out on a group of military cadets), it was possible to obtain a reasonably accurate evaluation of the energy requirements of the group. In this investigation it was only necessary to make Douglas bag metabolic determinations for a few tasks and, by using figures obtained by other workers, the estimate (3,420 kcal.) was found to agree quite well with the calorie intake (3,700 kcal.) as determined by a dietary survey carried out simultaneously by Prof. R. A. McCance and Miss E. M. Widdowson.

The close relationship between the intensity of the work measured by the metabolic cost and the heart-rate during work indicates the value of the pulse-rate as an index of effort. This relationship was demonstrated by Miss I. Ryhming (Stockholm) in a cycling and a step test modified from the well-known Harvard pack test. The new test gave similar results to the bicycling test and was easier to use in the factory. In an outstanding paper Prof. E. A. Muller (Dortmund) discussed the factors governing the pulse-rate/metabolic relationship, in particular the type and efficiency of the work, the cross-section of the muscles used and the extent of the static effort demanded by the work. For many patterns of work there existed a level of activity which could be sustained for hours. The energy expenditure at this optimal condition varied with the factors mentioned; but the pulse-rate difference between work and rest did not exceed about 35 beats/min.

How these findings can be applied to the analysis of the complete daily shift of industrial work was elucidated by Prof. G. Lehmann (Dortmund) and Prof. E. H. Christensen (Stockholm). Prof. Lehmann has used physiological measurements to obtain a more rational spacing of rest pauses in heavy industry and to eliminate the extra stresses imposed by unsuitable posture, static effort and adverse environmental temperatures. As a yardstick one can take an energy expenditure of 4 kcal./min. as the normal average output of a heavy worker. With a higher output per minute, rest pauses will usually be required to reduce the average output to 4 kcal./min. It is necessary to take full account not only of permitted rest periods but also of the arbitrary and enforced pauses which appear in all types of work and to rearrange these as recognized pauses so as to prevent the onset of fatigue. The pulse-rate determinations can be used extremely effectively in doing this, and the portable pulsometer and respirometer has made such investigations possible at the work place. Prof. Christensen's approach was complementary to that of the Dortmund workers, and he reported on ninety-odd different jobs studied in a steel factory. The heart-rate expected from the oxygen usage in these different tasks was compared with that actually observed, and, where this was excessively high, the cause was sought in the arrangement of the work, the methods used and the design of machinery, or often in the high temperatures prevailing. Changes could then be made and the degree of improvement evaluated. The performance of work, representing probably the limit of sustained human output, was the subject of a paper by Dr. M. J. Karvonin (Helsinki). He described the activities of lumberjacks taking part in the four-day national forest competition of Finland, a task which required an average daily consumption of 5,460 kcal., of which 40 per cent was derived from fat and 12 per cent from protein. The ability to work at this rate depended partly on the possession by lumberjacks of a physique quite different from that of the average Finn, but also on the incentive of the competition.

Apart from the more classical methods of determining the physiological cost of work, Dr. A. Lundervold (Oslo) indicated the value of electromyography. He described the results of his studies on typewriting in which he determined the muscles participating and the sequence of their activity. He also showed how the degree of their activity was increased by various forms of stress such as increased rate of work, fatigue and poor environmental conditions. The possible relationship between the increased static activity imposed by these stresses and myalgia was indicated. Dr. H. Seyffarth (Stockholm) emphasized the importance of ordinary clinical examination in studies such as these; examinations which can afford considerable insight into the conditions of the muscles. Dr. Gerda Seidelin (Copenhagen) also represented the clinical approach and stressed the limitation of activity that can be caused by poor body mechanics inducing pain. The pain may be relieved by the conventional physiotherapeutic methods; but permanent results are only achieved by correcting the posture, and this can be done only by studying the patient at the work which has produced the condition.

Of the contributions of the applied psychologists, the main emphasis was on the possible application of information theory to the measurement of man's overall performance in complex tasks. The place of the theory in the quantitative prediction of man's responses to known stimuli and *vice versa* was discussed by Dr. W. E. Hick (Cambridge). He stressed, however, that the position of the theory in this sphere is not clear and that, if established, will not replace more specific methods of investigation. Dr. W. D. Garvey (Washington, D.C.) described experiments in which he obtained a measure of the time necessary for a subject to code information by arranging that the display and response were constant. The results support earlier conclusions that the appropriate coding of information which the subject receives is an important factor in determining how much of it will be usefully dealt with. A different approach to the study of the application of information theory was reported by Mr. E. R. Crossman (Cambridge), who, by the use of a simple card-sorting task, showed that the overall time taken is mainly a function of the amount of choice made.

Illustrating the more specific criteria used in the study of man's performance were the papers of Dr. A. Leonard (Cambridge) and Dr. Shirley Spragg (Rochester, New York), both of which were concerned with display-control tasks. Dr. Leonard reported on experiments to determine the value of advanced information in such tasks, and Dr. Spragg on the effects of different relationships between the movement of the control and that of the display on tracking performance.

Work study was the subject for discussion at the concluding session. The importance of the practice was stressed because of the part it can play in increasing productivity and in coping with the ageing population; but it was pointed out by Mr. C. R. Wynne-Roberts (London) that, although it is an essential technique, it is only one of those available in industry for increasing individual efficiency. The present stage in the development of work study was outlined by Dr. D. Seymour (Birmingham), who considered that the advances being made are due to the application of pre-existing information rather than to an increase in fundamental data. The latter, though, is essential for the proper development of work study, and some improvement can be achieved by the dovetailing of the work of the psycho-physiologist and the engineer. A rather similar suggestion was put forward by Mr. R. Conrad (Cambridge), who stressed the need for bridging the gap between laboratory investigations and *ad hoc* studies in the factory. In his opinion, this can be done only by a willingness on the part of the psychologist to take the experimental methods at his disposal on to the shop floor and for the work-study engineer to present appropriate problems for laboratory investigation. Finally, Mr. L. G. Humble (London) gave a picture of the practical problems experienced in applying the results of work study, due to the resistance that is encountered both from the management and from the worker.

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# INDUSTRY AND THE UNIVERSITIES IN BRITAIN

## CONFERENCE IN NOTTINGHAM

THE report of the conference on industry and the universities, organized by the Federation of British Industries North Midland Regional Council and the University of Nottingham, and held at Nottingham on September 24, 1952, has now been published*. It was the sixth regional conference of its kind to be held since the national conference on this subject held in November 1949, and the report includes the text of the following addresses: by Lord Hives on what industry requires from the universities; by Prof. J. A. Pope on whether universities can contribute to the needs of industry; by Sir Edward Herbert on what is the best training for the university student who wants to find a career in industry; and by Dr. F. A. Wells on the study of industrial organization and management as an academic discipline, and the contribution which industry itself can make in this field.

Lord Hives, who began by describing the methods used by Rolls Royce, Ltd., in dealing with an annual intake of about thirty university graduates, emphasized that his firm does not expect the universities to supply ready-made technicians, designers, metallurgists or chemists. It expects the universities to turn out men who are capable of thinking and who have received the basic training in the fundamental sciences essential to their future work; whose brains have been trained to tackle problems; and who, of their own initiative, can follow a problem through, step by step and logically, taking advantage of previous experience on allied work. Furthermore, said Lord Hives, his firm liked good citizens—men who can express themselves well and hold their own in the conference, and can report clearly and concisely on their work. Lord Hives does not believe that the universities can deal with specialized technological education satisfactorily; he is of the opinion that they are too remote from the rapidly changing requirements of industry, and they cannot afford the extensive and complicated equipment used in modern industrial engineering investigations.

For these reasons he said that he is doubtful as to the value of the proposal to establish an institute of technology and inclines to prefer graduates who come direct from their three years at a university to those who come from the Massachusetts Institute of Technology or one of the Continental technological institutes. The engineering industry, is, however, disturbed at the inadequate numbers of men coming from the universities, and Lord Hives suggested that the balance between arts students and those studying science and engineering is out of keeping with the

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demand. He stressed the importance of the appointments officers of the universities and suggested that they deserve better support. As regards quality, more first-class graduates are required and, particularly in the average man, an improvement in quality is desirable.

Sir Edward Herbert's address in some respects overlapped that of Lord Hives. He too agreed that industry recognizes that the first function of a university must always be that single-minded pursuit of learning and continual advance of knowledge which are essential to the existence and growth of a civilized society. The value of a university graduate in industry, or in any other walk of life, lies in the trained and flexible mind which the three or four years of mental discipline may be expected to produce. It does not lie in the possession of any particular body of knowledge, and Sir Edward suggested, in considering what qualities industry looks for in its recruits from the universities, that we should look not at the graduate starting his first job, but at the man he hopes to become at thirty-five or forty on the threshold of major responsibilities. His future would then turn, not on his specialized knowledge but on his capacity to assume responsibility.

Accordingly, Sir Edward thought, industry would seek for such future leaders a combination of three main categories of ability. First, the ability to equip oneself thoroughly with expert knowledge of the particular aspect of the business in which one is engaged; this provides the basis of genuine authority. Second is the ability to relate this specialist function to the conduct of the business as a whole, including not merely the problems of the industry but also of the community which that industry serves. The third is the ability to sustain the moral burden of responsibility. Sir Edward made no suggestion as to what formal part the university can hope to take in preparing a man for this last responsibility; but a university should, he thought, be able to foster a lasting regard for other human beings, and it should strive to instil the conception of duty and service. All who hold authority in a community should be constantly aware of the human implications of the decisions they have to make from day to day, but Sir Edward believed that professional training in business administration and management should come some time after the degree course, and not form part of it. Finally, he stressed the immense value of a friendly understanding between the universities and industry and the need for industry to become much more imaginatively alive to its own opportunities and achievements.

The importance of co-operation between the universities and industry was also stressed by Prof. Pope, who pointed out that, with the adequate financial assistance now available, practically all able boys and girls from the grammar and secondary schools in Britain are proceeding to a university; as a consequence, the direct entry into industry from schools has suffered considerably, and this is a problem which has been considered more particularly at a subsequent conference of the Federation of British Industries held last October. Apart from the professional qualifications, Prof. Pope maintained that a university education should discipline a person to be intellectually honest and to be capable of a balanced view of issues as they arrive.

While Dr. Wells also stressed the need for more and closer personal relations between industry and the universities, particularly on the social science side, his address was largely a plea for specific assistance from industry in providing material for economic studies. First, he said, more opportunities are needed for studying the organization of firms and for investigating their problems at first hand. Secondly, there is the desirability of having access to business records, particularly old historical records; and thirdly, the assistance of industry in developing the method of teaching based on case study. Fourthly, it is desirable to know more about the associations of the business world, such as the Federation of British Industries, the British Employers' Confederation and some of the more important sectional organizations. Far more, he said, is known of the trades union movement than of its counterpart on the employers' side.

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# SOUTH AFRICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

## FIFTIETH ANNIVERSARY

WHEN the South African Association for the Advancement of Science met last year, during July 7–12, in the buildings of the University of Cape Town, it was to celebrate the golden jubilee of its foundation, for, though the date did not exactly coincide with fifty years, the occasion was fitting in that it was in Cape Town on September 12, 1901, when the constitution of the Association was drawn up, and on April 27, 1903, also in Cape Town, when the first annual meeting was held. The meeting last year, which was under the presidency of Dr. B. F. J. Schonland, of the Bernard Price Institute of Geophysical Research, Johannesburg, was marked by the invitation of the following distinguished guests from overseas: Sir Lawrence Bragg (Cambridge) and Sir Edward Salisbury (Kew Gardens); Prof. L. E. J. Brouwer (Amsterdam) and Prof. J. H. Oort (Leyden); Canon G. Lemaître (Louvain) and Prof. G. Magnel (Ghent); Dr. H. Vallois (Paris); and Prof. A. da Silva Rego (Lisbon). The official representatives of other bodies were as follows: for the sister Associations in Australia and New Zealand and in the United States, Sir Kerr Grant, the Australian physicist, and Dr. J. D. J. Hofmeyr, of Pretoria, respectively; for the Royal Society of South Africa, the oldest scientific society in the country (which, incidentally, was celebrating its seventy-fifth anniversary), Prof. R. W. James, of the University of Cape Town; and for the Suid-Afrikaanse Akademie vir Wetenskap, Dr. T. E. W. Schumann, director of the Weather Bureau of the Union of South Africa.

The activities of the meeting are recorded in the October–November issue of the Association's journal, the *South African Journal of Science*, and in this issue are published a brief description of the meeting, Dr. Schonland's presidential address and the texts of eleven papers, included in which are those of overseas visitors—namely, Dr. Vallois, Canon Lemaître, Prof. Oort, Prof. Rego, Sir Lawrence Bragg, Sir Edward Salisbury and Prof. Brouwer.

Dr. Schonland began his address by outlining the inception of the Association under the presidency of Sir David Gill, then H.M. Astronomer at the Cape, and showed how the early enthusiasm of the first meeting, at which 703 full members and 36 associates attended, led to a membership of 1,322 in 1906, which has never been since surpassed. Dr. Schonland expressed disappointment that the membership in recent years has been but a little more than a thousand, for South Africa has expanded enormously since 1906 and with this expansion the need for, and potential value of, such a body as the Association. The general aims of the Association have not changed at all with the passing of years: "We exist," he said, "primarily to create and foster a scientific fraternity in South Africa, not to publish original work. We exist to provide a common meeting-ground for South African scientists and a forum for general discussion of the problems of this country from the scientific angle." He defended the use of Afrikaans by those who preferred it, for "we were intended by our founders to be parochial, and we should pride ourselves on being parochial. I would suggest that if we try to be anything else we will have mistaken our real aim".

Having thus firmly and, most people would agree, wisely placed the Association in its proper perspective, Dr. Schonland went on to make some concrete suggestions. The *South African Journal of Science* should have a series of semi-popular articles reviewing and surveying the new ideas of science and so bridge the gap between those who teach and do advanced research work and those who pay for it. This, he thought, is the proper function of the *Journal*, and it is but one aspect of the Association's duty, as representative of all sections of scientific opinion in South Africa, "to take a stronger, a more continuing and a more active interest in all scientific developments, national and university, in South Africa and to study carefully what is being done in other countries".

Besides his plea that the Association needs to form a standing committee to watch over scientific education in schools, Dr. Schonland suggested that the Association might consider taking a part in the formation of a body on the lines of the British Parliamentary and Scientific Committee and also help in the creation of better facilities for advanced research in South Africa. On this last-named point, he cited the instances of the National University in Canberra and the Institute for Advanced Studies in Dublin, but he made the interesting suggestion that a more acceptable solution might be the creation of a number of specialized institutes for advanced study, attached to and forming part of those universities which for one reason or another are best suited for them.

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# BASIS OF TECHNICAL EDUCATION

GENERAL education to-day should be planned so as to enable the ordinary citizen to adapt himself to the needs of technological society and to understand what is happening and what is required of him. This was the theme of an international conference convened by the United Nations Educational, Cultural and Scientific Organization at Unesco House in June 1950*.

Broadly, the Conference found that organized social foresight is essential to enable the educational system of a country to prepare children for the type of life and work they are likely to encounter, and that a substantial development of technical education is required at all levels: at present it is wholly inadequate for future needs, while the practical content of general education is also inadequate for the needs of future citizens of a technological society. The cultural content of technical education is also generally inadequate; technical education requires special consideration, and training for adaptability is an outstanding requirement in an age of ultra-rapid technological change. The education of women and girls also demands particular attention in view of their dual role as workers and home-makers, and improved administrative arrangements are essential if education is to fulfil its true function in such a society.

The report does not suggest that all these propositions apply equally to every country, though the Conference considered that, so far as its knowledge extended, they are generally valid for the world as a whole. The stress is laid on the need for adapting technology to man, not man to technology. The questions formulated in this report—and which merit attention in current discussions on the expansion of both technical and technological education in Great Britain—are raised in the belief that mastery of the machine by man is not an end in itself: it is a means to the development of man and of the whole society.

The distinction between technician and technologist is not always kept clear in this report, particularly in the chapter on the content of technical education. Nevertheless, the report directs attention to some fundamental issues which no sound policy for either type of education can disregard. In both fields it must be recognized that we are concerned not simply with the efficiency of production, but also with the fundamental attitude which the men and women of to-morrow will adopt in facing the problems of a technological society. Both, too, in seeking to foster flexibility, must recognize that flexibility is determined not only by education and training but also by social, economic and technical conditions; and the administrative measures required to ensure that education becomes more adapted to the needs of a changing technological society are themselves likely to be most effective when they are informal and varied rather than concentrated and uniform. The administrator, no less than the teacher and student, has need of frequent opportunities of contact with the industrial world, and requires experience of the difficulties and problems created by technological development in society; just as the teacher and student should keep abreast of developments in research and of practical applications in industry.

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* Education in a Technological Society: a Preliminary International Survey of the Nature and Efficacy of Technical Education. (Tensions and Technology Series.) Pp. 76. (Paris: Unesco; London: H.M.S.O., 1952.) 200 francs; 4*s*.; 75 cents.

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# GENETICAL IMPLICATIONS OF THE STRUCTURE OF DEOXYRIBONUCLEIC ACID

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THE importance of deoxyribonucleic acid (DNA) within living cells is undisputed. It is found in all dividing cells, largely if not entirely in the nucleus, where it is an essential constituent of the chromosomes. Many lines of evidence indicate that it is the carrier of a part of (if not all) the genetic specificity of the chromosomes and thus of the gene itself.

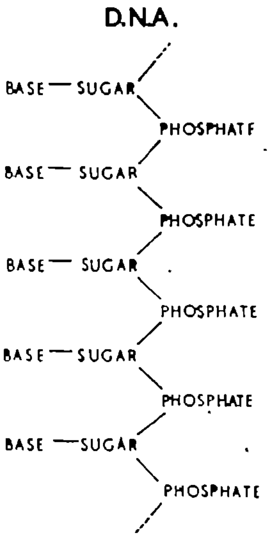

Fig. 1. Chemical formula of a single chain of deoxyribonucleic acid

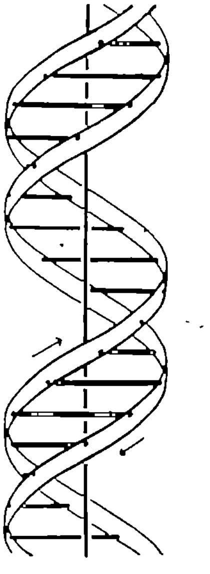

Fig. 2. This figure is purely diagrammatic. The two ribbons symbolize the two phosphate-sugar chains, and the horizontal rods the pairs of bases holding the chains together. The vertical line marks the fibre axis

Until now, however, no evidence has been presented to show how it might carry out the essential operation required of a genetic material, that of exact self-duplication.

We have recently proposed a structure[1] for the salt of deoxyribonucleic acid which, if correct, immediately suggests a mechanism for its self-duplication. X-ray evidence obtained by the workers at King's College, London[2], and presented at the same time, gives qualitative support to our structure and is incompatible with all previously proposed structures[3]. Though the structure will not be completely proved until a more extensive comparison has been made with the X-ray data, we now feel sufficient confidence in its general correctness to discuss its genetical implications. In doing so we are assuming that fibres of the salt of deoxyribonucleic acid are not artefacts arising in the method of preparation, since it has been shown by Wilkins and his co-workers that similar X-ray patterns are obtained from both the isolated fibres and certain intact biological materials such as sperm head and bacteriophage particles[2,4].

The chemical formula of deoxyribonucleic acid is now well established. The molecule is a very long chain, the backbone of which consists of a regular alternation of sugar and phosphate groups, as shown in Fig. 1. To each sugar is attached a nitrogenous base, which can be of four different types. (We have considered 5-methyl cytosine to be equivalent to cytosine, since either can fit equally well into our structure.) Two of the possible bases—adenine and guanine—are purines, and the other two—thymine and cytosine—are pyrimidines. So far as is known, the sequence of bases along the chain is irregular. The monomer unit, consisting of phosphate, sugar and base, is known as a nucleotide.

The first feature of our structure which is of biological interest is that it consists not of one chain, but of two. These two chains are both coiled around a common fibre axis, as is shown diagrammatically in Fig. 2. It has often been assumed that since there was only one chain in the chemical formula there would only be one in the structural unit. However, the density, taken with the X-ray evidence[2], suggests very strongly that there are two.

The other biologically important feature is the manner in which the two chains are held together. This is done by hydrogen bonds between the bases, as shown schematically in Fig. 3. The bases are joined together in pairs, a single base from one chain being hydrogen-bonded to a single base from the other. The important point is that only certain pairs of bases will fit into the structure. One member of a pair must be a purine and the other a pyrimidine in order to bridge between the two chains. If a pair consisted of two purines, for example, there would not be room for it.

We believe that the bases will be present almost entirely in their most probable tautomeric forms. If this is true, the conditions for forming hydrogen bonds are more restrictive, and the only pairs of bases possible are :

adenine with thymine ;
guanine with cytosine.

The way in which these are joined together is shown in Figs. 4 and 5. A given pair can be either way round. Adenine, for example, can occur on either chain ; but when it does, its partner on the other chain must always be thymine.

This pairing is strongly supported by the recent analytical results[5], which show that for all sources of deoxyribonucleic acid examined the amount of adenine is close to the amount of thymine, and the amount of guanine close to the amount of cytosine, although the cross-ratio (the ratio of adenine to guanine) can vary from one source to another. Indeed, if the sequence of bases on one chain is irregular, it is difficult to explain these analytical results except by the sort of pairing we have suggested.

The phosphate-sugar backbone of our model is completely regular, but any sequence of the pairs of bases can fit into the structure. It follows that in a long molecule many different permutations are possible, and it therefore seems likely that the precise sequence of the bases is the code which carries the genetical information. If the actual order of the

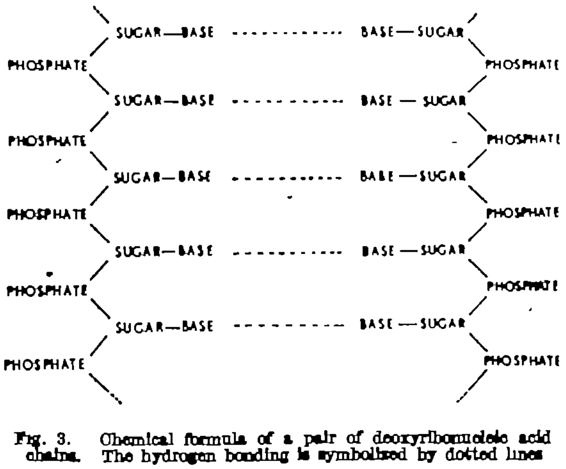

Fig. 3. Chemical formula of a pair of deoxyribonucleic acid chains. The hydrogen bonding is symbolized by dotted lines

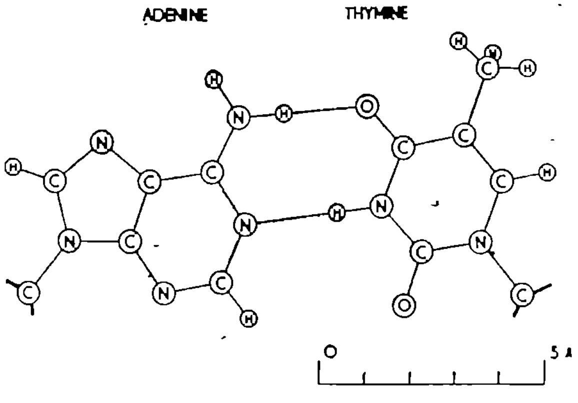

Fig. 4. Pairing of adenine and thymine. Hydrogen bonds are shown dotted. One carbon atom of each sugar is shown

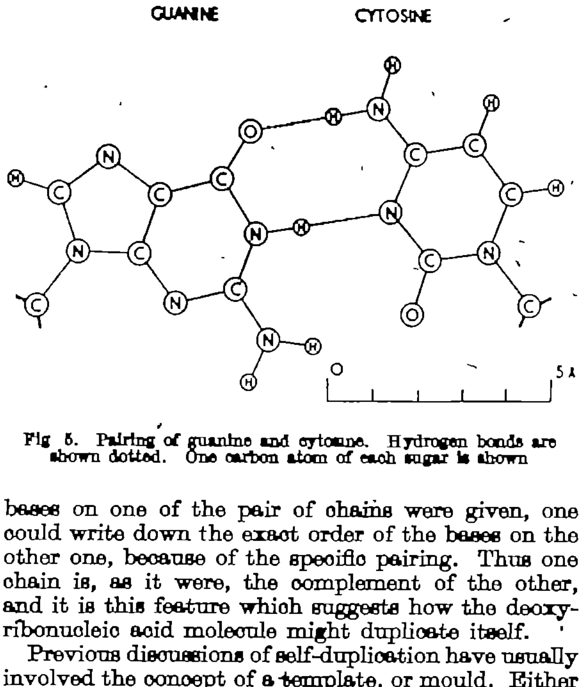

Fig 5. Pairing of guanine and cytosine. Hydrogen bonds are shown dotted. One carbon atom of each sugar is shown

bases on one of the pair of chains were given, one could write down the exact order of the bases on the other one, because of the specific pairing. Thus one chain is, as it were, the complement of the other, and it is this feature which suggests how the deoxyribonucleic acid molecule might duplicate itself.

Previous discussions of self-duplication have usually involved the concept of a template, or mould. Either the template was supposed to copy itself directly or it was to produce a 'negative', which in its turn was to act as a template and produce the original 'positive' once again. In no case has it been explained in detail how it would do this in terms of atoms and molecules.

Now our model for deoxyribonucleic acid is, in effect, a *pair* of templates, each of which is complementary to the other. We imagine that prior to duplication the hydrogen bonds are broken, and the two chains unwind and separate. Each chain then acts as a template for the formation on to itself of a new companion chain, so that eventually we shall have *two* pairs of chains, where we only had one before. Moreover, the sequence of the pairs of bases will have been duplicated exactly.

A study of our model suggests that this duplication could be done most simply if the single chain (or the relevant portion of it) takes up the helical configuration. We imagine that at this stage in the life of the cell, free nucleotides, strictly polynucleotide precursors, are available in quantity. From time to time the base of a free nucleotide will join up by hydrogen bonds to one of the bases on the chain already formed. We now postulate that the polymerization of these monomers to form a new chain is only possible if the resulting chain can form the proposed structure. This is plausible, because steric reasons would not allow nucleotides 'crystallized' on to the first chain to approach one another in such a way that they could be joined together into a new chain, unless they were those nucleotides which were necessary to form our structure. Whether a special enzyme is required to carry out the polymerization, or whether the single helical chain already formed acts effectively as an enzyme, remains to be seen.

Since the two chains in our model are intertwined, it is essential for them to untwist if they are to separate. As they make one complete turn around each other in 34 A., there will be about 150 turns per million molecular weight, so that whatever the precise structure of the chromosome a considerable amount of uncoiling would be necessary. It is well known from microscopic observation that much coiling and uncoiling occurs during mitosis, and though this is on a much larger scale it probably reflects similar processes on a molecular level. Although it is difficult at the moment to see how these processes occur without everything getting tangled, we do not feel that this objection will be insuperable.

Our structure, as described[1], is an open one. There is room between the pair of polynucleotide chains (see Fig. 2) for a polypeptide chain to wind around the same helical axis. It may be significant that the distance between adjacent phosphorus atoms, 7·1 A., is close to the repeat of a fully extended polypeptide chain. We think it probable that in the sperm head, and in artificial nucleoproteins, the polypeptide chain occupies this position. The relative weakness of the second layer-line in the published X-ray pictures[3,4] is crudely compatible with such an idea. The function of the protein might well be to control the coiling and uncoiling, to assist in holding a single polynucleotide chain in a helical configuration, or some other non-specific function.

Our model suggests possible explanations for a number of other phenomena. For example, spontaneous mutation may be due to a base occasionally occurring in one of its less likely tautomeric forms. Again, the pairing between homologous chromosomes at meiosis may depend on pairing between specific bases. We shall discuss these ideas in detail elsewhere.

For the moment, the general scheme we have proposed for the reproduction of deoxyribonucleic acid must be regarded as speculative. Even if it is correct, it is clear from what we have said that much remains to be discovered before the picture of genetic duplication can be described in detail. What are the polynucleotide precursors ? What makes the pair of chains unwind and separate ? What is the precise role of the protein ? Is the chromosome one long pair of deoxyribonucleic acid chains, or does it consist of patches of the acid joined together by protein ?

Despite these uncertainties we feel that our proposed structure for deoxyribonucleic acid may help to solve one of the fundamental biological problems—the molecular basis of the template needed for genetic replication. The hypothesis we are suggesting is that the template is the pattern of bases formed by one chain of the deoxyribonucleic acid and that the gene contains a complementary pair of such templates.

One of us (J.D.W.) has been aided by a fellowship from the National Foundation for Infantile Paralysis (U.S.A.).

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# GEOPHYSICAL AND METEOROLOGICAL CHANGES IN THE PERIOD JANUARY–APRIL 1949

In a recent article[1] Lewis and McIntosh have considered the geophysical data for the period January–April 1949, which we presented in an earlier communication[2]. On the basis of certain probability criteria they appear to show that the apparent regular variations in ionospheric and meteorological phenomena which occurred in that period were not significant. We have studied their article and made a separate statistical analysis of the *unsmoothed* data, and conclude that in all respects our original suggestions seem to be valid.

In our original article we presented graphs showing five-day moving averages in four parameters: (*a*) ground pressure, $p$; (*b*) $E$-layer critical frequency, $fE$; (*c*) $F$-layer critical frequency, $fF2$; and (*d*) $K$-index of geomagnetic activity. The connexion between ionospheric and geomagnetic phenomena is well known. Thus, Appleton and Ingram[3] in 1935 established the correlation between geomagnetic activity and depressions in $fF2$. It is worthy of note that in the period under discussion the inverse correlation between $K$ and $\Delta fF2$ is, as Lewis and McIntosh point out, considerably less striking than that between $p$ and $\Delta fE$ (cf. Figs. 1 and 2 in our original article). It would seem, then, that if statistical analysis can be successfully applied to show that there is no significance between the variations in $p$ and $\Delta fE$, it is, *a fortiori*, evident that a similar analysis might, in the present instance, be used for discrediting the established relationship between $K$ and $\Delta fF2$. Conversely, of course, the fact that a phenomenon appears to be statistically significant over a short period must likewise be treated with reserve. The need for the utmost care in the application and interpretation of statistical analyses to such a limited time series is thus clear.

From inspection of our graphs it seemed to us that, so far as $p$ and $\Delta fE$ were concerned, the period was unusual in three respects: (i) there appeared to be four oscillations in ground pressure showing a progressive diminution of amplitude, with an average period of about 27 days; (ii) in like manner there appeared to be four marked oscillations of period about 27 days in $\Delta fE$; (iii) oscillations (i) and (ii) appeared to be almost exactly out of phase. In addition, we noted that the period was characterized by an unusual 27-day recurrence of great sudden commencement (S.C.) magnetic storms.

In our original communication we merely directed attention to these matters, and suggested that there might be some connexion between them. We did not then suggest, nor do we now suggest, that from a period of length only four months any conclusions can be drawn regarding the general behaviour over a long period of any of the geophysical parameters considered. The severely limited number of observations available, together with the fact that there is considerable uncertainty about the correct statistical approach to time series analysis, seemed to us sufficient reason for not entering into an extended statistical analysis.

However, the contrary conclusions reached by Lewis and McIntosh (see below) have prompted us to re-examine the data. Briefly, their conclusions are: (i) the 27-day oscillation in ground pressure is of no significance, since the amplitude is no more than would be expected from mere chance considerations; (ii) the 27-day oscillation in $\Delta fE$ is probably significant; (iii) oscillations (i) and (ii) are exactly in anti-phase; (iv) there is no significant correlation coefficient between the $p$ and $\Delta fE$ data; (v) our conclusions arise from smoothing of the data.

We shall now outline our own analysis. In various communications[4–6], Kendall has made it abundantly clear that most of the methods generally used for studying periodicities in time series (for example, periodograms, Fourier analysis, etc.) may yield very misleading results when applied to the kind of time series with which we are here concerned. He has also questioned the reliability of the usual significance tests for periodicities when applied in time series analysis. Kendall has shown that the most reliable approach is that of serial correlation coefficients as exhibited in the correlogram. He points out that although the correlogram may be insensitive, it does give a lower limit to the oscillatory effects, and that if it oscillates there is almost certainly some systematic oscillation in the primary series explored. Figs. 1 and 2 show the correlograms for $\Delta p$ and $\Delta fE$ respectively for the period under consideration. In both of these the original *unsmoothed* data have been used.

It is important to note that there is a marked trend in the pressure data, and to eliminate this we have dealt with values of pressure departures, $\Delta p$ (as with the $fE$ data), rather than with the absolute magnitudes $p$. The oscillations in both correlograms are clear, with a maximum at 26–27 days in each case. These correlograms provide strong support for our original deductions (based, as they were, on simple inspection of graphs), and make it essential for us to repeat Lewis and McIntosh's calculations.

At the outset we must again stress that the pressure data exhibit a marked downward trend (approximately linear), and it is imperative initially to eliminate this before proceeding with any numerical analysis. It appears that Lewis and McIntosh have overlooked this point, and as a result have arrived at quite contrary conclusions. This will be clear from an examination of Table 1, in which we present the results of calculations made by us using (i) pressure, $p$, (ii) pressure departures, $\Delta p$, and (iii) $fE$ departures, $\Delta fE$. The nomenclature employed ($c$, $\varphi$, $\sigma$, etc.) is that used by Lewis and McIntosh.

Without going into details, it can be stated that there is little significant difference between the present results *using pressure*, $p$, and those given by Lewis and McIntosh. The slight differences in the values of amplitude $c$ and first serial correlation coefficient $r_1$ are of no significance and can be ascribed to different ways of deducing the amplitude and phase of a 27-day oscillation from data covering four such oscillations, or to rounding-off processes used in the calculations. However, the significance criteria $P_S$ and $P_F$ are very sensitive to small changes in the 'modified amplitude ratio' $a'$, and the net values obtained by us are somewhat lower than those given by Lewis and McIntosh. In this calculation we have not eliminated the trend in the pressure values; the amplitudes, etc., really refer to oscillation about the arithmetic mean of all the data. Clearly, when there is a marked trend in the data, this is an incorrect procedure.

Table 1

| | $c$ | $\varphi$ | $\sigma$ | $a$ | $r_1$ | $a'$ | $P_S$ | $P_F$ |
|---|---|---|---|---|---|---|---|---|
| (i) $p$ | 5·8 mb | 244° | 8·8 mb. | 0·47 | 0·65 | 0·25 | 0·033 | 0·891 |
| (ii) $\Delta p$ | 6·6 mb. | 251° | 8·1 mb. | 0·59 | 0·57 | 0·34 | 0·003 | 0·079 |
| (iii) $\Delta fE$ | 0·06 Mc/s. | 63° | 0·09 Mc./s. | 0·49 | 0·29 | 0·37 | 0·0006 | 0·021 |

Table 2

| | $c$ | $\varphi$ | $\sigma$ | $a$ | $r_1$ | $a'$ | $P_S$ | $P_F$ |
|---|---|---|---|---|---|---|---|---|
| $\Delta p$ | 7·4 mb. | 271° | 8·1 mb. | 0·65 | 0·57 | 0·37 | 0·0008 | 0·029 |
| $\Delta fE$ | 0·07 Mc/s. | 85° | 0·09 Mc./s. | 0·55 | 0·29 | 0·41 | 0·00015 | 0·004 |

Thus, when we eliminate the effect of the trend in the pressure data, it is seen that the modified amplitude ratio $a'$ is now some 35–40 per cent larger, with the result that $P_S$ and $P_F$ are reduced by factors of more than ten. The present values of $P_S$ and $P_F$, namely 0·003 and 0·079, may be compared with the 0·057 and 0·989 respectively given by Lewis and McIntosh. It is clear that, far from being a chance phenomenon, the amplitude of the 27-day pressure oscillation even on the Fisher probability criterion is nearly within the 5 per cent significance level. So far as the $\Delta fE$ calculation is concerned, our modified amplitude ratio $a'$ is slightly larger than that deduced by Lewis and McIntosh, but this alone is sufficient to reduce both $P_S$ and $P_F$ by a factor of more than 2, such that $P_F$ is now well within the 5 per cent significance level.

A careful examination of Figs. 1 and 2 shows that in each case the peak of the correlograms occurs nearer 26 than 27 days. Accordingly, we have repeated the above statistical analysis for $\Delta p$ and $\Delta fE$ for the case of a 26-day oscillation. The results are summarized in Table 2.

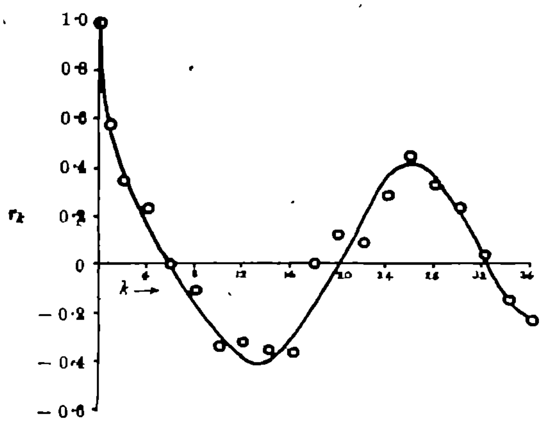

Fig. 1. Correlogram for pressure departures

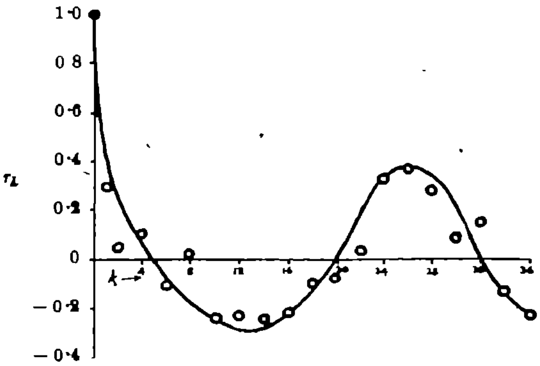

Fig. 2. Correlogram for $fE$ departures

In this case, it will be seen that the amplitudes for both series are larger than in the 27-day case, and the values of the probability criteria are in all cases extremely small, indicating that the oscillations are indeed quite significant.

The three lines of approach which we have now considered—direct inspection of the original graphs, the correlograms of Figs. 1 and 2, and the statistical analysis outlined above—are in agreement, and all point to the reality of these 26–27-day oscillations *in this particular period*. We should add that we have examined data over many years of the kind considered above and have not found any similar period having such striking variations as characterized this particular 4-month period. It would seem that the large 27-day variations apparent here, and supported by statistical analysis, are probably of rare occurrence.

One further point might be considered. Apart from the fact that each series $\Delta p$ and $\Delta fE$ separately exhibits a 26–27-day oscillation, it is also worth noting that the two oscillations are almost exactly in antiphase. The correlation coefficient between $\Delta p$ and $\Delta fE$ for 105 available pairs is $-$ 0·37. (In their analysis of $p$ and $\Delta fE$, Lewis and McIntosh used ninety pairs of correlates. The additional fifteen $fE$ values used by us were obtained by interpolating missing noon values from measurements made at 1100 and 1300 hr.). In testing the significance of this correlation coefficient, we must make due allowance for the effect of coherence in the daily observations. This is usually done by reducing the number of observations by a factor $\varepsilon$ (called the equivalent number of repetitions). Bartels[7] has given a relationship between $\varepsilon$ and the successive serial correlation coefficients of a series (equation (2) of Lewis and McIntosh's paper). Using this, we obtain $\varepsilon \doteqdot 4$ for the $\Delta p$ series, and $\varepsilon \doteqdot 2$ for the $\Delta fE$ series. The number of independent pairs must thus be taken as lying between 26 and 52. Using the approximation due to Fisher (quoted by Lewis and McIntosh), we then find a probability of 0·06 that 26 pairs will have a correlation coefficient $\geqslant$ 0·37; for 52 pairs the probability is 0·008. These figures are to be compared with the probabilities 0·436 and 0·148 respectively given by them. The considerable differences between these figures arise here, as in the Fourier analysis considered above, from the fact that they omitted to eliminate the trend in the pressure data. Concerning the values of $\varepsilon$, it might be argued that such a difference in degree of conservation is evidence against direct physical connexion between the parameters. However, too much significance should not be placed on the actual values, since (a) we have here only a very limited sample of data, and (b) the accuracy of measurement of $fE$ is somewhat less than that of $p$, and this diminished degree of accuracy in itself tends to reduce the calculated value of $\epsilon$. The fact that the $\epsilon$'s are different and that the correlation coefficient between $\Delta p$ and $\Delta fE$ is not particularly large may perhaps be taken to indicate that there is little direct physical connexion between the variations in $p$ and $fE$, but that both might be affected by a common extraneous cause.

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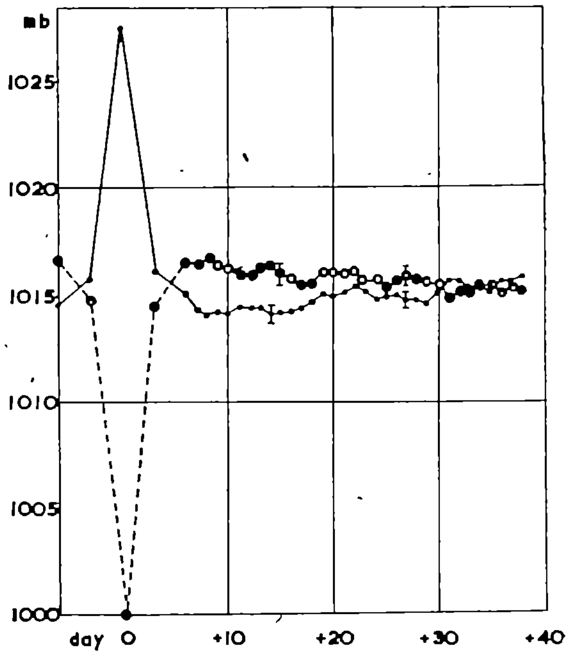
We should like to make the following comments on the communication by Beynon and Brown.

(1) The fact that the correlation between $K$ indices and $fF2$ is not necessarily significant over the period under discussion cannot "discredit the established relationship", because this correlation is known to persist as more and more data are taken; the lack of significance is due to the smallness of the sample. (In fact, the correlation coefficient between $fF2$ and corresponding daily sums of $K$ indices was $-0{\cdot}21$, that is, almost the same as that between $p$ and $\Delta fE$.)

(2) The use of correlograms adds nothing to the previous graphical representation of smoothed variations, since no numerical significance test is applied.

(3) The differences between our results and those obtained by Beynon and Brown result from their use of values of $\Delta p$ rather than $p$. We did not overlook the fact that there is an apparent downward trend in the pressure data, but we did not on that account use $\Delta p$ instead of $p$ for the following reasons. The monthly means of $fE$ closely depend on the sun's zenith angle, and the variation of $fE$ with factors other than the sun's zenith angle is clearly best considered by taking departures ($\Delta fE$) from the smooth curve joining the monthly means, as was done in both analyses. In contrast, pressure at Kew shows no annual variation ascribable to a simple physical cause: monthly means of $p$ at Kew are widely scattered for corresponding months from year to year, and the long-period means show a small and irregular annual variation. An apparent 'trend' in any individual period is consequently as much a part of the true variability of $p$ as are the 'departures' ($\Delta p$) from the 'trend', and should not be eliminated before applying numerical tests. (It may be remarked that in Beynon and Brown's original paper $p$, and not $\Delta p$, was plotted and discussed.)

(4) It is difficult to conceive the possible nature of a physical agency responsible for causing world-wide variations in $fE$ and simultaneous—but geographically very restricted—large variations in surface pressure. We would re-emphasize that this difficulty makes it very necessary for the $p$ and $\Delta fE$ variations to be shown to be much closer than may be explained by the method of choice of this particular period, namely, the sequence of four maxima in $p$ at 27-day intervals. We consider the facts as presented in our analysis to be entirely compatible with a chance general similarity of $p$ and $\Delta fE$ with therefore no common physical cause.



Mean variation of Kew surface pressure at midday around 600 selected days of pressure-peak (●—●—) and of pressure-trough (○--○--) during 1926–50

(5) Independent evidence of the existence of a direct effect of variations of solar radiation on those of surface pressure is given by the results of a study we have made of pressure-recurrence tendencies. Our method followed that used so successfully by Chree and Stagg[1] for demonstrating the effect of the solar rotation period on geomagnetic disturbance. Two days of clearly defined mid-day pressure maximum at Kew were selected for each month in the period 1926–50. Independence was secured by ensuring that no two maxima in the whole pressure series were nearer than 7 days. The statistical variation of pressure was then determined from 6 days before to 38 days after the 600 selected pressure-peak days. The variation of pressure was also determined around 600 pressure-trough days selected in a similar way. The results are shown in the accompanying graph, in which the standard errors of the means are indicated.

The curves indicate complete randomness in the occurrence of lengths of interval separating pressure peaks and also in those separating pressure troughs. Subdivision of the data according to season and sunspot epoch gave similar results. It may be noted in particular that in neither case is there evidence of any systematic pressure effect after an interval of about 27 days. The method of analysis is independent of changes of phase or intermittency. Beynon and Brown state that in many years they have found no recurrence of the large 27-day pressure variation: our result shows that an oscillation of about this length had no more than random occurrence during 1926–50.

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# LETTERS TO THE EDITORS

*The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications*

## Functional Relations of the Adenohypophysis and Hypothalamus

THE means by which the pars distalis of the adenohypophysis ('the anterior lobe of the pituitary' or 'anterior lobe') adjusts its secretions to the requirements of the body continue to be the subject of much inquiry and speculation. Apart from the reciprocal interaction of the anterior lobe with such endocrine organs as are under its control (for example, the adrenal cortex and gonads), it is generally accepted that the gland is able to respond to changes which are mediated through the nervous system. For example, it is known that the reproductive organs of the ferret, which in Great Britain breeds only between March and August, can be activated during the winter months if the animal is exposed to additional light. This response is dependent on the presence of (*a*) the retina, (*b*) the pituitary, and (*c*) the gonads, and the presumption is that nerve impulses, first transmitted along the optic pathways, in some way stimulate the anterior pituitary to secrete gonadotrophic hormone. Unfortunately, attempts to track the actual pathways by which the impulses are relayed from the optic pathways to the gland have in large part failed[1]. Moreover, while it is definitely established that the whole neurohypophysis is innervated by hypothalamic nuclei, there is no agreement that nerve fibres reach the pars distalis of the adenohypophysis from this region of the brain[2]. Such sympathetic and parasympathetic fibres as enter it on the walls of the blood-vessels are usually assumed to be mainly vasomotor in function[3].

Attention has recently been focused on the hypophysial-portal system of vessels as the controlling link between the pituitary and the hypothalamus, and in elaborating this view Harris has suggested[3,4] that impulses from the hypothalamus, which is connected by fibre tracts to most parts of the brain, stimulate the secretion of some 'chemotransmitter' substances within the median eminence in the floor of the third ventricle, and that these then pass down the portal vessels into the sinusoids of the anterior pituitary to modulate the activity of the secretory cells of the pituitary. Harris, whose experiments have been performed on rabbits and rats, also suggests that the persistence of normal anterior pituitary function after section of the pituitary stalk is due to the reconstitution of the portal vessels; and he indicates that pituitary function is scarcely likely to be normal if the vessels do not regenerate.

Some general issues which need to be resolved if this attractive hypothesis is to be sustained have been discussed elsewhere[5]. The present and preliminary note describes certain experiments which show that ferrets can become oestrous as a result of artificial illumination in the winter even after the elimination of the hypophysial-portal system of vessels.

In these experiments the pituitary stalk was divided by means of an operative procedure described elsewhere[6]. In some animals the stalk was just sectioned; in others a small fragment of muscle was gently inserted between the pituitary and the base of the brain; in a third series, a small piece of waxed paper was used instead of muscle. With few exceptions, histological examination showed that the paper had been eliminated from the wound some time between the operation and autopsy.

Seven of twenty-three ferrets submitted to these procedures, and in which the stalk had been completely sectioned (with the consequent disappearance of the processus infundibularis), failed to come into heat when illuminated by means of electric light during the winter months. In all these animals the distal end of the proximal stump of the stalk had become either adherent to the superior surface of the anterior part of the pituitary, or closely connected to it by reaction tissue. In both cases there was a clear anastomosis between the vessels in the two structures. In most of these seven animals the pars distalis was smaller than normal, and the arrangement of its constituent cells also appeared abnormal.

The remaining sixteen animals came into heat. In six, histological examination of the base of the brain and the sella turcica showed that the stalk had been incompletely severed, and that the processus infundibularis had not involuted. In the remaining ten, the stalk had been completely divided, and the processus infundibularis had disappeared. In most of these the proximal stump had either become adherent to the pars distalis, or the two had become connected by means of reaction tissue. In a few of these it could safely be said that the vessels in the stalk, including portal vessels, had re-established a connexion with the sinusoids of the pars distalis. In others, the anastomosis was more doubtful, and it was possible that, in addition to communicating with the sinusoids, vessels of the stalk were also anastomosing directly with veins in the surrounding fibrous tissue, and thus with neighbouring dural sinuses.

In one critical case, however, the pars tuberalis had been so severely damaged that it was neither possible to recognize cells which could be designated as tuberalis cells, nor the primary loops of the portal vessels. In another ferret, paper, new bone and fibrous tissue intervened between the pituitary gland and the part of the brain anterior to the base of the stalk, there being no trace of any vascular connexion between the two. Both these animals reacted to light by becoming oestrous.

A detailed account of these experiments will be published elsewhere. They show that the gonads of the ferret will respond to additional light during the winter, when there appears to be no possibility of impulses emanating in the retina being transmitted via the hypothalamus to the pars distalis of the pituitary, either directly by a nervous pathway, or indirectly, through the pituitary-portal system of vessels. Our experiments do not give any indication of the way in which the response is mediated, and we are continuing our study of this essential problem.

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## Therapeutic Action of Glutathione and Mercaptoethylamine against a Lethal Dose of X-Rays

IT has been shown that the shielding of the liver *in situ* protects 73 per cent of a group of rats against a dose of X-rays which is 100 per cent lethal after fifteen days for the control animals[1]. E. S. G. Barron[2] showed that glutathione had a protective action in mice when injected before the lethal irradiation. Bacq and his co-workers[3] have shown that β-mercaptoethylamine protects mice against a lethal dose of X-rays when this compound is injected into the animals immediately before the total body irradiation. We have been able to confirm these results in rats[4]. On the other hand, the β-mercaptoethylamine is completely inactive when given even immediately after the exposure to a lethal dose.

The purpose of this short communication is to show the therapeutic action of reduced glutathione and of β-mercaptoethylamine against a lethal irradiation when the rats have the liver area shielded during the exposure. Six groups of twenty-four rats each have been irradiated over the entire body with a dose of 1·130 r. measured with the Victoreen X-ray condenser r.-meter. The apparatus used is a 250-kV. Maximar X-ray machine of the General Electric Co. The distance anticathode – animal is 55 cm., the voltage 180 kV., 15 m.amp., with no secondary filter. The first group of rats was irradiated over the entire body. A second group received the same dose, the liver area being shielded with a lead foil of 5 mm. thickness protecting an area of 5 cm. × 3 cm. corresponding to the liver region. A third group was irradiated as the second group (liver region protected); but the animals were injected immediately after the irradiation, 6 hr. and 12 hr. later, with an intraperitoneal dose of 7 mgm. of β-mercaptoethylamine. The fourth group was irradiated over the whole body like the first group but injected with β-mercaptoethylamine as the animals of the third group. The fifth group was irradiated as the second group (liver region protected), but the animals were injected intraperitoneally with 12 mgm. of reduced glutathione immediately after the irradiation, 6 hr. and 12 hr. later. The sixth group was irradiated over the whole body like the animals of the first group, but were injected with reduced glutathione as were the animals of the fifth group. The number of survivors is shown in the accompanying table.

This type of experiment was carried out twice with the same general results, and shows that reduced glutathione and β-mercaptoethylamine have a therapeutic action when injected into rats exposed to a lethal body-dose of X-rays if the liver area is shielded during the exposure.

| Group | I | II | III | IV | V | VI |
|---|---|---|---|---|---|---|
| Dose | 1,130 r. alone | 1,130 r. + lead shield on liver | 1,130 r. + lead shield on liver + 3 × 7 mgm. mercaptoethylamine | 1,130 r. + 3 × 7 mgm. mercaptoethylamine | 1,130 r. + lead shield on liver + 3 × 12 mgm. glutathione | 1,130 r. + glutathione |
| No. of animals | 24 | 24 | 24 | 24 | 24 | 24 |
| Days after X-rays | | | | | | |
| 7 | 4 | 16 | 20 | 3 | 24 | 1 |
| 14 | 0 | 8 | 18 | 0 | 18 | 0 |
| 21 | 0 | 7 | 15 | 0 | 17 | 0 |
| 30 | 0 | 5 | 14 | 0 | 11 | 0 |

We have repeated the experiment with rats having an equivalent area of the costal region protected during the irradiation. In such conditions β-mercaptoethylamine has practically no therapeutic action.

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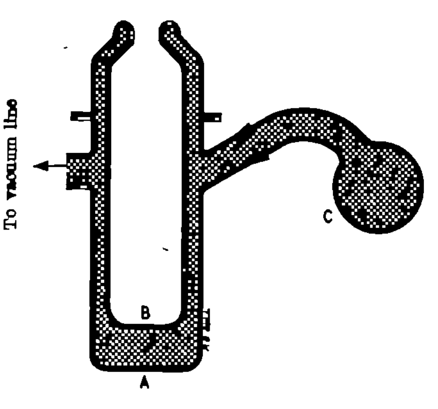
## A Simple Tissue Freeze-drying Apparatus using the Principle of Short-path Sublimation

WITH increasing recognition of the advantages of the freezing and drying of tissues for cytochemical studies, it is of interest to describe a cheap and efficient drying apparatus which has been in continuous use during the past two years.

The dryer works on the principle of short-path sublimation[1] and is constructed of 'Pyrex' glass. The quenched tissue is placed in the bottom of the drying chamber (*A*), which is immersed in an ethyl oxalate/solid carbon dioxide mixture giving a temperature of – 40° C. The top of the chamber is then placed in position and the system evacuated by a commercial diffusion pump and a rotary pump. The condensing finger is then filled with liquid air or nitrogen, which cools the condensing surface *B*, placed 3 cm. away from the tissues. The operating pressure is $10^{-4}$ to $10^{-5}$ mm. mercury, giving a mean free path for the water molecules of about 50 cm. This permits straight-path sublimation of the water molecules from the specimens to the condenser. At the end of the drying time, the drying chamber is slowly warmed by hot water to a temperature just above the melting point of the embedding wax used. The



previously degassed wax in $C$ is just melted and then poured on the tissue by rotating $C$ in its socket. After a short interval, the vacuum is released and the tissues blocked out.

In our original model the embedding wax was a lining to the bottom of the drying chamber during the drying cycle; but it acted as a thermal insulator between the bath and the tissues and also required a long time to melt when embedding.

Mouse tissues such as liver, kidney, gut, spleen and pancreas can be dried in seven hours at – 40° C.; but in our hands human tissue (post-mortem) requires twenty-four hours drying for the best results. This need for longer drying times may be due to post-mortem changes, and biopsy material may dry quicker. Fatty materials, such as some skins and also ovary, require a longer drying time. When it is necessary to dry overnight, the cold trap is filled with very finely powdered solid carbon dioxide and a little acetone added. In this way the trap remains cold for at least fourteen hours, whereas the usual acetone/carbon dioxide mush does not last as long. As a precaution against accidents, the apparatus is shielded in use by wire gauze. If short drying times are not essential, the diffusion pump may be dispensed with.

The main advantages of this dryer compared with other recently described designs[2] are its cheapness, robustness and simplicity.

We wish to thank Mr. V. C. Conlay for his helpful criticism.

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## The Ratio Molars/Premolars in Perissodactyls

IN the course of a study of the European *Hipparion*[1], it was found that the ratio of the length of the molar series to the length of the premolar series ($M/P$) is fairly constant within that genus. It ranges from 76·7 to 91 ($M/P \times 100$) in thirty-eight specimens of upper tooth-rows from Pikermi and Salonica, most values falling between 80 and 89. It appears to be independent of the length of the tooth-row.

From Osborn's review of the American Equidæ[2], approximate values of the index $M/P \times 100$ have been estimated for the principal members of that family. The first of them (***Mesohippus*** and ***Miohippus***) show some high indices (96–109); but, in those primitive types, if $P^1$ is included in the premolar series, the index falls to the range of values found in more advanced forms (about 78–90) or even lower. Thus, the ratio $M/P$ has tended to remain constant despite the loss of the first premolar; in other words, the series $P^2 + P^3 + P^4$ is playing in later forms the part of $P^1 + P^2 + P^3 + P^4$ in earlier forms (Fig. 1).

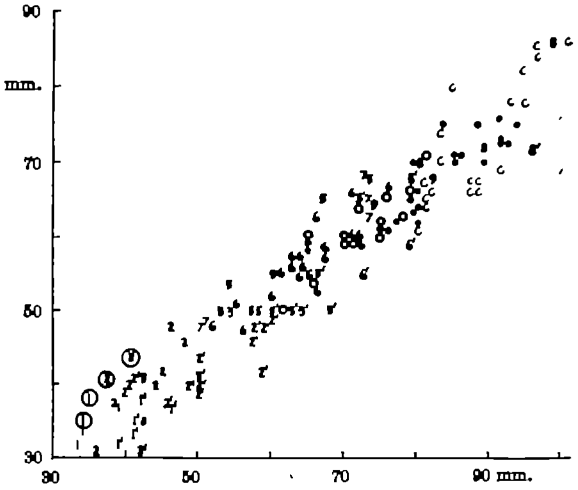

Fig. 1. Ratio molars/premolars in the Equidæ. Ordinate: molars; abscissa: premolars. 1, *Mesohippus*; 2, *Miohippus*; 3, *Kalobatippus*; 4, *Anchitherium*; 5, *Parahippus*; 6, *Merychippus*; 7, *Protohippus*; 8, *Pliohippus*; 9, *Hypohippus*; black dots, *Hipparion* from Pikermi; circles, *Hipparion* from other localities: $C$, *Equus caballus*; 1′, 2′, . . ., as above, but $P^1$ included

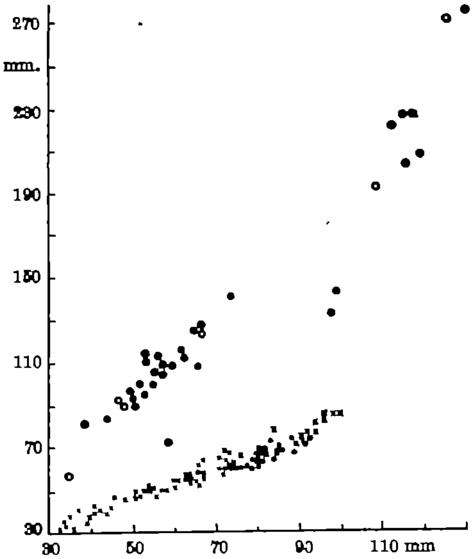

Fig. 2. The same ratio as in Fig. 1 in the Titanotheridæ (circles) and in the Equidæ. Black dots, *Hipparion*. Ordinate: molars; abscissa: premolars

That some individuals of ***Mesohippus*** and ***Miohippus*** have indices higher than 100 suggests that there may have been a trend which has been very soon abandoned by the Equidæ. This earlier trend may have been retained in other families of Perissodactyls. Indeed, in the Titanotheridæ, as described by Osborn[3], the evolution of the dentition has followed a course opposite to that seen in the Equidæ. The index $M/P \times 100$ is always greater than 100, and often reaches about 200. That the two families, at first near each other, have steadily diverged in the course of their respective evolutions, may be shown by plotting the lengths of the series as in Fig. 2.

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## Light Emission and Light Perception in Species of *Diadema*

That echinoderms are sensitive to light has been generally agreed, but the nature of their photoreceptors has been the subject of many conflicting statements, sometimes based wholly on inadequate evidence. This is especially so in the echinoids, one family of which, the Diadematidæ, possesses several members which are strikingly sensitive to light[1–6]. Light emission has also been attributed to the species of *Diadema*[1,7], but this has also been questioned[1] and, in the case of *Diadema setosum* (Leske), denied[5].

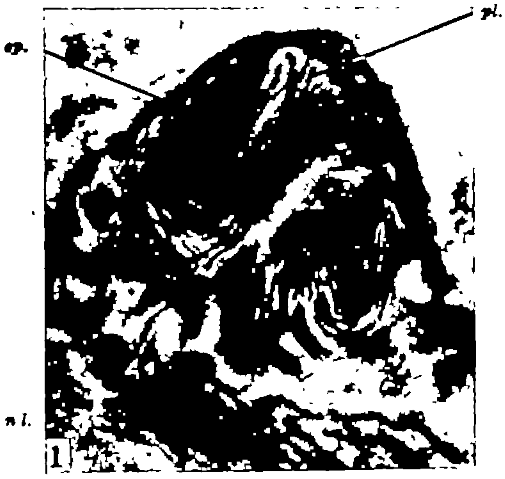
I have examined several hundred individuals of varying ages, of the allied species *Diadema antillarum* Philippi, at various times of the day and year, but I have never seen any signs of phosphorescence. There is a striking iridescence on the test, however, especially in young forms, appearing in bright light as thin lines[8–10] or spots of brilliant blue which correspond closely in distribution with the similar iridescent spots described in *D. setosum*[1,4], and with the areas that have been described as phosphorescent[7].

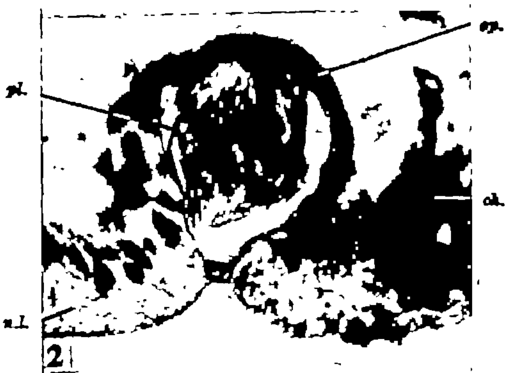
In sections through the test of *D. antillarum*, these areas are distinguished by the presence of the remarkable organs shown in Figs. 1 and 2. Each is composed of single or clustered units containing more-or-less regularly arranged plates (*pl.*) which at once recall those of iridophores[11]. It seems likely that the plates are responsible for the iridescence, which is probably intensified by the dispersion of melanin in the superjacent processes of melanophores (*ch.*).

The blue spots in *D. setosum*, however, have been described as eyes[1,4,5], and to them has been attributed the sensitivity to light. Sarasin, F., and Sarasin, P., have described and figured highly differentiated compound photoreceptors, each unit with cornea, lens and retina[4]. Their ideas have been widely accepted and their figures appear in standard zoological textbooks, despite some hesitancy as to their accuracy[1,12].

In *D. antillarum*, which is extremely sensitive to light[6], I can find nothing corresponding to a lens or a retina in these structures, which are much more reminiscent of clusters of iridophores than of eyes, a suggestion that agrees well with the iridescence observed in the areas where they are located.

Experimental evidence as to the relative sensitivity to light of various parts of the surface gives no support to the idea that these structures are eyes; for, using the production of the spine reflex[6] as an index of sensitivity toward changes in intensity of illumination, it is found that, on obliterating minute light spots projected on to various parts of the surface, the whole surface of the test (including the swollen spine bases) is sensitive to such changes, but the parts bearing the blue lines or spots are much the least sensitive[6]. If, therefore, these are photoreceptors, they are clearly not significantly involved as such in the animal's most striking and characteristic response to light.





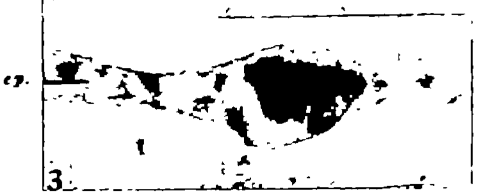


Fig. 1. Vertical section through a cluster of iridophores from a young *Diadema antillarum* (ambital diameter of test, 1·3 cm.), fixed Bouin, stained by Masson's method for the argentaffine reaction, counterstained Mallory's triple stain. Approx. × 500

Fig. 2. Vertical section through a single iridophore of the same individual showing the accompanying melanophore (*ch.*), the contents of which can be seen to have been partly discharged by the action of the fixative. Fixation and staining as above. Approx. × 500

Fig. 3. Vertical section through a developing iridophore from the interambulacrum of a very young *Diadema antillarum* (diameter of test at ambitus, 2·5 mm.). Compare with foregoing and note absence of a recognizable superficial nerve layer. Fixed Bouin, stained Delafield's hæmatoxylin and eosin. Approx. × 500

*ch.*, melanophore; *ep.*, epidermal layer covering test; *n.l.*, superficial nerve layer beneath epidermis; *pl.*, plate-like structure within iridophore

Fully in agreement with this is the recent discovery that a very young form (diameter of test 2·5 mm.), in which the iridescent areas were few and very imperfectly formed (Fig. 3), showed a clear response to shading on the part of the spines, pedicellariæ and suckered tube feet; though it must be admitted that the spine jerks were feeble and lacked the co-ordination characteristic of older forms. Moreover, so far as ordinary histological methods (fixation in Bouin's fluid followed by staining in hæmatoxylin and eosin) may be considered of value, they fail to reveal any direct connexion between many of these organs and the nervous system, for the superficial nerve layer (*n.l.*) so readily demonstrable immediately beneath them in older forms by a similar technique is apparently incomplete and missing from considerable areas of the interambulacra (Fig. 3) which bear these structures. It is highly significant that the absence of special nerves to the organs, in older individuals of *D. setosum*, has been mentioned by authors who regarded them as eyes[4].

For the present, therefore, I find no good reason for regarding these structures in *D. antillarum* as eyes, and in view of the obvious close relationship between *D. antillarum* and *D. setosum*, the matter clearly requires re-investigation in the latter form.

It is suggested that the organs in *D. antillarum* are iridophores, and reflect light on to the neighbouring areas which are more sensitive to changes in light intensity. This function would be especially useful in the deep recesses between the spine bases, and it is here that large masses of them are found. The iridophores would be effective only when the melanin in the chromatophores (which always accompany the iridophores (*ch.*, Fig. 2)) is largely concentrated; for when fully dispersed, the iridophores are covered. This would perhaps, in part, account for the fact that the animal becomes more sensitive to shading as the light fades, for it is then that the melanin becomes concentrated[10]. If the spine reflex is regarded as part of the general defensive reaction set off by the shadow of a potential enemy falling on the light-sensitive surface, the significance of increased sensitivity in fading light becomes obvious.

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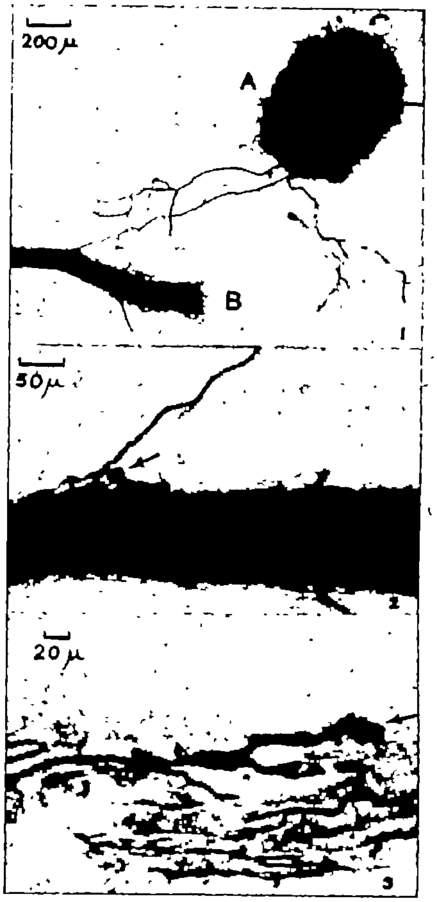
## Fructifications associated with Mycorrhizal Strawberry Roots

ROOT infections by vesicular-arbuscular mycorrhizal fungi have been reported in many plants for more than half a century. With the exception of one unconfirmed report, reproductive stages of these fungi have not been described[1]. Numerous attempts to isolate the fungus from infected tissue have been unsuccessful, and mycelial transplants unattached to a piece of infected plant tissue have never survived[2]. Butler[3] pointed out the close relationship of the vesicular-arbuscular mycorrhizal fungi to the Endogonaceae, and concurred with Peyronel's view that they are probably members of this family.

In 1951, fructifications of the Endogone type were found attached to mycorrhizal strawberry roots grown in pots. The presence of hyphal connexions between these fructifications and the mycorrhizal fungus inside the strawberry roots has been clearly established (Figs. 1–3). The fructifications appear as light-brown spherical bodies, up to 1 mm. in diameter. They consist of a loose weft of hyphæ containing usually two to six, but sometimes up to thirty-two small spores, 92–197 µ in diameter. The spores are distributed at random inside the weft. Mature spores are yellow to brown, with a thick endospore and a thin exospore wall. This, according to Kanouse[4], is a characteristic of the Endogonaceæ.



(1) Hyphal connexion between fructification (*A*) and strawberry root (*B*).
(2) Enlargement of connecting hypha at point of entry into root.
(3) Longitudinal section of the same root showing connecting hypha at point of entry, and its continuity with the mycorrhizal fungus inside the root. Arrows in (2) and (3) mark identical parts of the fungus

Inoculation experiments are in progress to synthesize mycorrhiza under controlled conditions, using the fruit bodies and sterilized spores excised from these to provide the fungus constituent. In these experiments some typical mycorrhizal infections have been obtained in strawberry seedlings grown in test-tubes in soil sterilized by autoclaving and with propylene dioxide. Attempts are also being made to germinate the excised spores on artificial media. The results of these experiments will be reported elsewhere.

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## Aggregation in Cellular Slime Moulds: *in vitro* Isolation of Acrasin

In *Dictyostelium* and *Polysphondylium*, members of the Acrasieæ, there is an aggregation stage in which previously independent amœboid cells stream towards certain cell clumps, which thus act as collecting centres, and there form communal fruiting bodies[1]. Communication between the centres and the reacting cells is through the external medium. Bonner[2] produced indirect evidence that a chemical diffused outwards from the centres, setting up a concentration gradient by which the separate cells oriented themselves; pointing out that isolation *in vitro* would be the final proof of the chemical's existence, he named it 'acrasin'.

Pfützner-Eckert[3] claimed that sensitive amœbæ of *D. mucoroides* would move towards a cell-free block of agar on which centres had rested. My own repeated attempts to get orientation to an artificial gradient set up by such an agar block, or by drops of water which had bathed centres and then been absorbed on agar or sucked up a capillary tube, were unsuccessful. Theoretical arguments and experimental observations both suggested that acrasin was short-lived, the active molecules probably having a mean life of a few minutes. If this were so, it would be necessary to renew the head of an artificial gradient at frequent intervals in order to demonstrate orientation. This was finally achieved by sandwiching amœbæ between an agar block and a glass slide; drop by drop, washings from living centres were then rapidly and continually transferred to the meniscus around the block, whence the acrasin they contained diffused into the interior. Chemotaxis now occurred, sensitive cells moving not towards a point, as in normal aggregation, but parallel to each other towards the nearest edge.

To study the stability of acrasin, the washings were kept for short periods before adding them to the meniscus: if kept 1 min., attraction was strong; if 5 min., weak; if 15 min., absent. The washings unavoidably contained a few loose cells from the centres, and there was scarcely sufficient time to remove them by centrifuging; but the fact that the reacting amœbæ, unless they had formed an autonomous organization, became disoriented immediately I stopped adding washings to the meniscus made it unlikely that loose cells which had been carried over were playing any part in setting up the gradient. It was later found that if the washings were frozen within a few seconds of collection their activity was retained indefinitely, though lost as rapidly as before when they were returned to room temperature. No viable cells survived severe freezing.

A test for the presence of acrasin and a means of preserving it made possible a wide variety of experiments. Studies were made of conditions under which acrasin was secreted; the changes in sensitivity of reacting amœbæ; and the rate of decay of acrasin at different temperatures. No evidence could be obtained that acrasin was stored in centres.

As two mixed species of *Dictyostelium* form joint aggregations, whereas when *Dictyostelium* is grown with *Polysphondylium* each genus forms its own[4], it might be expected that acrasin would be genus-specific. I examined *D. discoideum*, *D. mucoroides*, *D. giganteum*, *D. purpureum* and *P. violaceum*. *Dictyostelium* amœbæ of any species responded, as expected, to washings obtained from any *Dictyostelium* centre; but they also oriented themselves to washings from *P.* centres. This seemed to indicate that acrasin was not specific; but further work showed that specific *Polysphondylium*- and *Dictyostelium*-acrasins, which oriented the corresponding cells, did in fact exist. Young *P.* centres and streams made only *P*-acrasin and attracted only *P.* cells. At a certain stage of development, *P.* centres began to make *D*-acrasin too and then attracted both *P.* and *D.* cells; for technical reasons, only centres of this later stage could be bathed to yield acrasin solution, and this oriented both cell types. *D.* centres did not attract *P.* cells, except old ones at short range; probably *D.* centres made only *D*-acrasin, which had a weak effect on specially sensitive *P.* cells. The behaviour of *P.* centres was remarkable, for as they began to make *D*-acrasin their production of *P*-acrasin fell off; that is, they manufactured a foreign chemical, to which most *P.* cells were chemotactically insensitive, apparently at the expense of their own. It may be that *D*-acrasin takes some other role, as yet unknown, in both genera; whatever the explanation, the distribution of sensitivities and powers of synthesis suggest that *Polysphondylium* evolved from *Dictyostelium*; this is consistent with the morphological evidence.

Sussman and Noël[5], and Sussman[6], have shown that initiation of aggregation is a special process, and this confirms my own views based on quite different evidence. Once it is recognized that different acrasins are made at different stages of development, the possibility must be considered that some initiation factors are further slight modifications of the basic acrasin molecule.

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## Intolerance of Dizygotic Twin Lambs to Skin Homografts

It has been shown that homografts exchanged between dizygous cattle twins may often survive indefinitely in spite of the fact that grafts exchanged between full siblings other than twins, or between calves and dam, have not been found to survive more than twenty days after transplantation[1,2]. This anomalous tolerance on the part of dizygous cattle twins is thought to have the same origin as their conformity of red-cell agglutination types[3,4], namely, the confluence of their fœtal circulations. The purpose of the present inquiry was to determine whether dizygous sheep twins are also tolerant to grafts of each other's skin.

The same methods were used as have been described for cattle[2]. Pinch grafts were taken from the shaved dorsal surface of the ear and fitted into recesses cut to receive them in a shaved area of the animal's side, just below the withers. The grafts were covered with tulle gras, a layer of sterile gauze and a pad of cotton wool. These dressings were held in place by a 'Lastonet' bandage which completely surrounded the animal. The bandage was secured by rubber latex solution ('Copydex') and Michel suture clips. With cattle, a hessian covering is used for protecting the bandage;

but this was not thought necessary with sheep as their wool seemed to provide sufficient protection. At each operation site, a subcutaneous injection of 2–3 c.c. of 2 per cent ethocaine hydrochloride was given as an anaesthetic.

Two Scottish blackface ewes with twin lambs by a Cheviot ram or rams were available. The ewes were unrelated; but it is possible that all four lambs were half-sibs. The ewes were both about six years old. Ewe 27, dam of lambs ♀2*K*9 and ♂2*K*8, weighed 112 lb. and had lambed on March 29, 1952; ewe 129, dam of lambs ♀2*K*4 and ♀2*K*5, weighed 104 lb. and had lambed on March 26, 1952. All skin interchanges were made on April 30, 1952, when the lambs were about five weeks old.

Four grafts were put on to each animal in a square, thus:

| | |
|---|---|
| 1 | 2 |
| 3 | 4 |

On lambs, position No. 1 was occupied by an autograft, No. 2 by skin from an unrelated ewe, No. 3 by skin exchanged between dam and offspring, and No. 4 by skin exchanged between full-sib twins. On ewes, the arrangement was the same, except that position No. 4 was occupied by skin from the second lamb. The grafts on ewe 27 and her lambs behaved as shown in Table 1. The graft from the unrelated ewe 129 on to lamb 2*K*8 was lost by faulty healing, and the resulting scab obscured the fate of the neighbouring autograft.

Table 1

| Recipients | Donors | | | |
|---|---|---|---|---|
| | Ewe 27 | Lamb 2*K*9 | Lamb 2*K*8 | Unrelated ewe 129 |
| Ewe 27 | + | − | − | − |
| Lamb 2*K*9 | − | + | − | − |
| Lamb 2*K*8 | − | − | ? | lost |

+ indicates survival and − indicates a breakdown in 7–14 days

The parallel series of grafts on ewe 129 and her lambs gave the results shown in Table 2.

Table 2

| Recipients | Donors | | | |
|---|---|---|---|---|
| | Ewe 129 | Lamb 2*K*4 | Lamb 2*K*5 | Unrelated ewe 27 |
| Ewe 129 | Bandage slipped and all grafts lost | | | |
| Lamb 2*K*4 | − | + | − | − |
| Lamb 2*K*5 | − | − | + | − |

Of the six independent autografts, all, except the two lost for technical reasons, survived. At the end of a month they were perfectly established and healthy. That on ewe 27 was particularly well defined, as it consisted of black ear skin and carried a good crop of hair easily distinguishable from wool. The remaining live autografts on the lambs consisted of white ear skin which was less conspicuous but carried white hair instead of wool and were readily differentiated from the scars left by the neighbouring homografts. All homografts broke down rapidly, and fourteen days after the operation only dry scabs remained. It has been assumed that the like-sexed pair is dizygous. This is justified by the established rarity of one-egg twins[5].

These observations make it improbable that, in sheep, homografts between dizygous twins will survive transplantation. Accordingly, skin interchange could be used as a highly critical test for monozygotic twinning in sheep. The intolerance to homografts shown by two-egg sheep twins contrasts with the tolerance shown by two-egg cattle twins, a difference which is no doubt associated with the fact that freemartins occur in cattle but not in sheep.

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## Alteration of *p*H in the Sheep's Oviduct

During previous work on the oviduct of the sheep, evidence was obtained which suggested that a change of *p*H might be associated with the cyclical changes of mucin secretion[1] in this duct. In a further investigation the *p*H of the oviducts of seventy sheep, recovered at slaughter from the abattoir, was determined by using Lovibond's comparator. This material covered all stages of the oestrous cycle.

The oviducts were examined within 45–60 min. after death. One oviduct of each animal was washed out with 1 c.c. of double-distilled water, then a further amount of double-distilled water was added to the washing to bring the total amount of liquid to 10 c.c. The first ten oviducts showed a *p*H with the universal indicator between 6 and 7; therefore in all further work bromthymol blue (*p*H 6–7·6) and methyl red (*p*H 4·2–6·3) indicators were employed.

The investigations showed that the *p*H of the oviduct undergoes cyclical change which seems to correspond to the sexual cycle. Where the specimen was clearly in the di-oestrous stage, a *p*H of 6–6·4 was found, in pro-oestrus the *p*H rose to 6·4–6·6 and in oestrus and met-oestrus the *p*H ranged from 6·8 to 7·0. The phase of the cycle was determined by macroscopical examination of the ovary, and in the majority of specimens the follicle or corpus luteum permitted an accurate estimation to be made. In doubtful cases, however, it was found that the *p*H of the oviduct was more reliable than the naked eye diagnosis.

After standing for about two hours, it was found that the *p*H of the specimen fell to 6·2 regardless of the phase of the cycle and the temperature of the refrigerator.

The question arises whether this *p*H has any connexion with the conditioning factor[2] which enables the spermatozoa to penetrate the zona pellucida.

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## The Shark, *Isurus oxyrinchus*, in South African Waters

The isurid shark, *Isurus oxyrinchus* Rafinesque, 1810, although most closely related to the Indo-Pacific *I. glaucus* Müller and Henle, 1841, is apparently constantly and clearly differentiated in certain features, notably the height of the dorsal fin and the relative length of the head from snout tip to pectoral origin. Primarily of tropical and subtropical oceanic waters, this species has hitherto been known from a wide range in the Atlantic both east and west. It is extremely virile and vigorous, and is a game fish of repute much sought after by anglers.

Although known in mid-Atlantic at St. Helena, there has hitherto been no positive coastal record from West Africa south of about 12° N. The discovery of a specimen of undoubted *I. oxyrinchus* Rafinesque, off Algoa Bay (about lat. 34° S., long. 26° E.), is therefore of considerable interest. This is obviously a young specimen (see Figs. 1 and 2) which, taken on a line, gave the angler a spectacular fight.

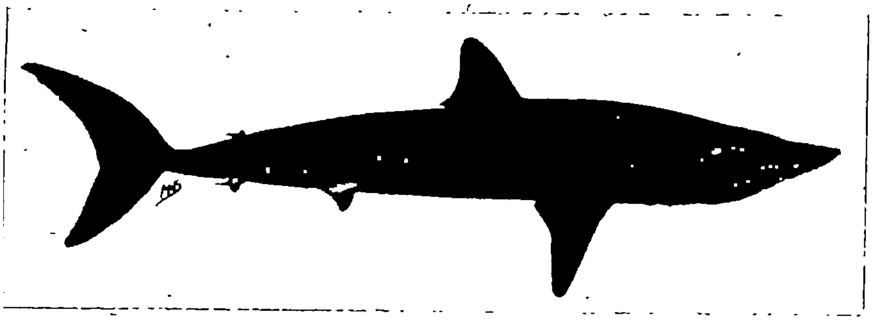

Fig. 1. *Isurus oxyrinchus* Rafinesque, 1810, ♂, 1,130 mm. total length, taken in Algoa Bay, South Africa

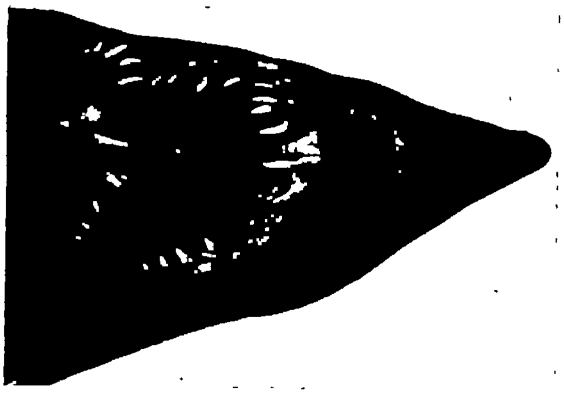

Fig. 2

The specimen is a young male, total length 1,130 mm. The following are percentages of total ength: body to upper caudal pit, 80·0; depth of ody at dorsal origin, 16·4; distance from snout tip o (1) first gill slit, 20·4; (2) pectoral origin, 25·6; 3) first dorsal origin, 38·0; (4) pelvic origin, 56·0; 5) second dorsal origin, 70·3; (6) anal origin, 72·2; 7) line connecting nostrils, 5·1; (8) front of mouth, ·55. The internarial distance, 3·9; diameter of eye, ·6; the interorbital, 6·0; width of mouth (equals eight), 7·6; height of first dorsal, 8·85; its base, ·42; distance from hind margin of eye to fourth ill slit, 17·5.

There are thirteen teeth on each side of each jaw, the third upper smaller, the front two on each side longer and more slender than all others. The body is coloured steel-blue above, white below. Weight 25 lb.

From information since received, it seems that this species may be not uncommon in South African waters.

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## Effect of Galvanized Iron on Some Tree Seedlings

It has become usual in Australian forest nurseries to grow tree seedlings in lacquered tin-plate tubes about 6 in. high and 1–1½ in. diameter, which contain sufficient soil for up to two seasons' growth before final planting. A shortage of tin-plate over recent years caused a change to the cheaper and more readily available galvanized iron.

Most varieties appeared unaffected by the change, but some species showed a yellowing of the foliage, stunting of growth and in some cases the death of the seedling after six months or more. Typical species affected are *Acacia spectabilis*, *Callitris cupressiformis*, *Casuarina suberosa*, *Eucalyptus grandis* and *Melaleuca hypericifolia*. For affected species, root growth was normal until the roots reached the tube, when further growth ceased, followed by progressive dying back of the roots until only those running straight downwards remained alive. A similar, but slower, process was seen with the roots of species which appear unaffected above ground, such as *Acacia decurrens*, *Casuarina cunninghamii*, *Eucalyptus saligna*, *Melaleuca bracteata* and *Tristania conferta*. Affected seedlings transplanted in time may recover, and there is some evidence that excessive watering may aggravate the trouble. Rusty tin-plate tubes or uncoated steel tubes, whether rusty or not, are satisfactory.

There have been reports that soils with high zinc contents have given rise to a similar chlorosis with other plants; zinc absorbed by the plant fixes available iron in the tissues so that it is no longer available for biochemical processes. A similar mechanism probably holds for chlorosis in galvanized iron seedling tubes.

In view of the convenience of galvanized sheet or wire as plant containers or protectors, this adverse effect is not so well known as it should be, particularly as there may be some effect not visible above ground. It has also been found that to dip the tubes in bitumen, as a convenient way of covering the zinc, is likely to kill the seedlings in tubes so treated. Experiments being carried out will be published elsewhere later.

We acknowledge the assistance of officers of the New South Wales Forestry Department in providing information and of Mr. E. J. Mansfield in particular, who directed attention to the effect.

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## Effects of DDT and BHC on Soil Arthropods

UNDESIRABLE changes in the composition of animal communities after applications of insecticides have become increasingly common phenomena since the widespread use of the more persistent chlorinated hydrocarbons[1]. With the view of throwing further light on this problem, the insecticidal treatment of soil was considered to be a convenient experimental technique, as special attention could be paid to the effects of the insecticides on the dominant soil arthropods, namely, Collembola and Acari.

Replicated plots were treated with (1) 2 oz. per sq. yd. of 2 per cent DDT (75–80 per cent *p,p′* isomer); (2) 2 oz. per sq. yd. of 2 per cent BHC (13 per cent γ isomer); and (3) a combination of these. The insecticides were incorporated to a depth of 9 in., and after treatment the plots were resown with perennial rye grass (*L. perenne*). Samples were taken periodically to a depth of 6 in. and the arthropods extracted with an apparatus similar to that described by Salt and Hollick[2].

The census of total Collembola taken seven months after treatment is of special interest. Treatment totals and the standard error of their differences (all expressed as a percentage of the control population) were:

| DDT | BHC | DDT plus BHC | 0 | S E.* |
|---|---|---|---|---|
| 118 | 76·1 | 106 | 100 | 6 38 |

* 9 d.f., $t = 2{\cdot}26$, $p = 0{\cdot}05$; $t = 3\ 25$, $p = 0\ 01$

A significant increase and a significant decrease in the population of Collembola occurred in the plots treated with DDT and BHC, respectively. The population of the plots receiving both insecticides, however, did not differ significantly from that of the control, but was significantly higher than the population of the plots receiving BHC alone.

In previous investigations, phenomena of this kind have been explained on the basis of predator – prey interaction, and it is probable that the latter may provide an explanation for the results of the present investigation. On the other hand, the results may be wholly or partly explained by the reduction of competition for a common food supply. More conclusive evidence on these points is being sought, and it is hoped to publish a detailed account of the investigation in the near future.

It was also noted that in two of the plots treated with DDT the dominant species included *Tullbergia crassicuspis* Gisin, a species hitherto unrecorded for Britain.

The advice given by Dr. D. S. MacLagan and Mr. M. V. Brian is gratefully acknowledged, and thanks are also due to Miss T. Clay, who identified *T. crassicuspis*.

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## Investigation of Nuclear Motion by Electron Diffraction

IT has long been known that the amplitude of nuclear vibrations in free molecules could be studied by electron diffraction if sufficiently accurate intensity measurements were made. Several years ago, Karle and Karle[1] developed the first successful experimental procedure for investigating nuclear motion. Since that time results for a number of molecules have been obtained, both by the Karles and by this laboratory. It is hoped that such information will prove useful in studies of potential fields of molecules, and will also serve to help in the interpretation of diffraction patterns of more complicated molecules with similar interatomic linkages.

In a recent communication in *Nature*, Schomaker and Glauber[2] discussed for the first time the effect of the variation with scattering angle of the phase shift of electron waves scattered by atoms. In particular, they showed that conventional procedures which neglect phase shift on scattering in the interpretation of electron diffraction data may incorrectly deduce an unsymmetrical structure for a symmetrical gas molecule containing a heavy atom.

We should like to point out that atomic phase shifts must be taken into consideration in the calculation of vibrational amplitudes also, even for light atoms. No values in the literature are corrected for this source of error. According to Schomaker and Glauber, the effect upon the molecular intensity is a factor of the form $\cos s\delta$, where $s\delta = |\eta_i(\vartheta) - \eta_j(\vartheta)|$, the phase difference introduced by the scattering processes at the atoms $i$ and $j$.

We note that, if the atoms are light, that is, if $\delta$ is small, Fourier analysis of the molecular diffraction terms for non-rigid molecules including the phase shift factor,

$$|f_i(\vartheta)|\ |f_j(\vartheta)| \cos s\delta \int_0^\infty P_{ij}(r)\ \frac{\sin sr}{sr}\ dr,$$

will lead to an apparent distribution function of the form $\exp\{-(r-r_e)^2/2(\overline{l^2}_{ij}+\delta^2)\}$ for the separation of nuclei $i$ and $j$, rather than the true $P_{ij}(r)$ of the form $\exp\{-(r-r_e)^2/2\,\overline{l^2}_{ij}\}$. The real vibrational amplitude $(\overline{l^2}_{ij})^{1/2}$ can be obtained from the apparent amplitude $(\overline{l^2}_{ij}+\delta^2)^{1/2}$ if $\delta$ is known. Schomaker and Glauber considered the case for $s\delta$ larger than $\pi/2$, in which the apparent distribution splits into two peaks separated by $2\delta$.

The atomic pairs treated by Schomaker and Glauber each contain a fairly heavy atom, and for these pairs $\delta$ is approximately equal to $1{\cdot}8 \times 10^{-3}\,\Delta Z_{ij}$ for 40-kV. electrons. A rough calculation for argon at this laboratory indicates that the formula $\eta(\vartheta)/s \sim 2 \times 10^{-3} Z$ also holds for lighter atoms. If only small differences in atomic number are involved, the apparent amplitude of motion has a relative error of $\sim 2 \times 10^{-4}\,\overline{\Delta Z^2}/l^2_{ij}$. We find then, for example, that the error for a C—F bond is negligible, and the error for a C—Cl bond is about 10 per cent. If $\Delta Z$ is much greater than 10, any information about the associated interatomic spacing which is derived from the shape of the distribution function (such as amplitudes of vibration or restricted rotation or, in extreme cases, type of symmetry) must be regarded with caution unless careful corrections have been made.

Further details and experimental results will be published later.

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## Difference between the Density Distribution of Neutrons and Protons in Atomic Nuclei

IN a former communication[1] I calculated the energy and distribution of nucleon density of atomic nuclei by Ritz's method in the first approximation, assuming Yukawa forces between the nucleons. In the energy expression of the nucleus, in addition to the exchange energy and kinetic zero-point Fermi energy of the nucleons, we have also taken into account the kinetic energy correction of Weizsäcker, the electrostatic Coulomb energy of protons and the Coulomb exchange energy of protons arising from the Coulomb interaction of protons. In the first approximation for the neutron density $\rho_n$ and the proton density $\rho_p$, functions of Gaussian type have been set up in the following form:

$$\rho_n(r) = \rho_{n_0} \exp(-a^2r^2/r_0^2), \qquad (1)$$
$$\rho_p(r) = \rho_{p_0} \exp(-a^2r^2/r_0^2), \qquad (2)$$

where $r$ is the distance from the centre of the nucleus, $r_0$ is the Compton wave-length of the $\pi$-mesons divided by $2\pi$, $\rho_{n_0}$ and $\rho_{p_0}$ are normalizing factors and $a$ denotes a variational parameter to be determined from the minimization of the energy.

As a second approximation of Ritz's method, the expressions (1) and (2) have been multiplied by the factor $1 + b(r/r_0)^2$, where $b$ denotes a further variational parameter. By varying the two parameters $a$ and $b$ independently of each other, the energy and the density distribution of the nucleons have been calculated in the second approximation. Thus we have obtained a small energy gain increasing with the mass number, which, however, even for the heaviest nuclei, is smaller than ½ per cent. The change in the nucleon density is also very slight, and except for the outermost boundary areas of the nucleus, only amounts to a few per cent. Thus, in the second approximation the density distribution practically remains a function of the Gaussian type for the heaviest nuclei also. In almost all work on this subject a Gaussian density distribution has been assumed for light nuclei only; for heavy nuclei, however, in the inner parts of the nucleus a constant nucleon density has been assumed, which rapidly decreases on the boundary of the nucleus. Although our variational densities in the second approximation are sufficiently general to represent such a distribution, in spite of this the nucleon distribution we obtain from the minimization of the energy is a Gaussian-type function also for the heaviest nuclei.

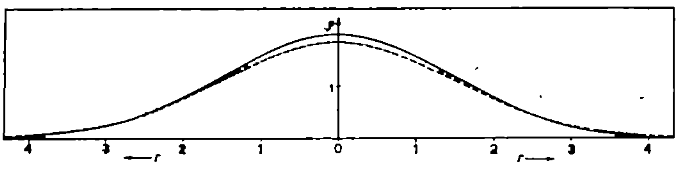

Fig. 1. Neutron density $\rho_n$ (———) and proton density $\rho_p$ (- - - - -) in the nucleus $A = 200$, $N = Z = A/2$. $r$ in $r_0$ units, $\rho_n$ and $\rho_p$ in $1/r_0^3$ units

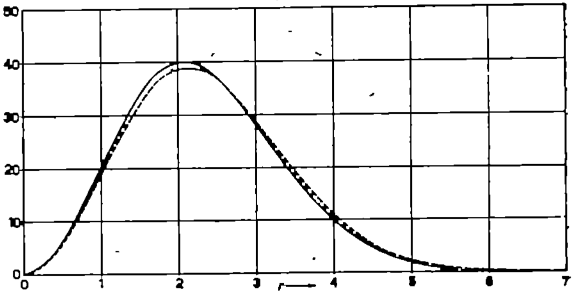

Fig. 2. Radial neutron density $D_n$ (———) and radial proton density $D_p$ (- - - - -) in the nucleus $A = 200$, $N = Z = A/2$. $r$ in $r_0$ units, $D_n$ and $D_p$ in $1/r_0$ units

In all these calculations the variations of the neutron and proton density have not been carried out independently of each other. Except for the normalization factors, which are in general different, both density functions have been assumed to be equal, both of them containing the same variational parameters. As the next step of Ritz's method, both the neutron and proton density have been varied independently of each other. Thus we have obtained a further slight energy gain increasing with the mass number, and being also for the heaviest nuclei smaller than 1 per cent. Between the neutron and proton density a comparatively small difference results. As was to be expected, due to the Coulomb repulsion, the protons are pushed somewhat towards the boundary of the nucleus. The curves of the neutron and proton density, as well as those of the radial densities $D_n = 4\pi r^2\rho_n$ and $D_p = 4\pi r^2\rho_p$, are represented in Figs. 1 and 2 respectively, the difference between the two density functions being more distinctly shown in the latter. As can be seen in Fig. 1, the density functions are still of the Gaussian type. Accordingly, nothing suggests in our case the tendency to form a hole in the centre of the nucleus, resulting from the Coulomb repulsion of protons, as found by Feenberg[2].

The density distributions of the nucleons determined in this way can be used to calculate various nuclear properties and constants. Thus they have been applied to calculate the angular momentum distribution of nucleons. We have obtained for the neutron and proton numbers, at which an *s*-, *p*-, *d*-, *f*-, *g*-, *h*-, *i*-, . . . neutron or proton appears in the nucleus for the first time: 1, 2, 8, 20, 42, 74, 119, . . . . These numbers are in good agreement with the corresponding neutron and proton numbers 1, 3, 9, 21, 41, 71, 113, . . . obtained from the wave-mechanical shell model[3].

A more detailed account of these calculations will be given in the *Acta Physica Hungarica*.

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## Wave Hypothesis of Moving Irregularities in the Ionosphere

THE existence of moving irregularities in ionospheric regions has been demonstrated by a number of workers using a wide variety of radio techniques[1], and information regarding their properties is accumulating rapidly. The motions are frequently described in terms of 'winds'; but, as has been repeatedly stressed, the observations need not imply any large-scale movement of the atmosphere. Indeed a number of fairly general considerations can be advanced in support of an alternative view, that a propagated wave-like disturbance is the cause. At the suggestion of Mr. J. A. Ratcliffe, I have begun a theoretical examination of the magneto-hydrodynamic effects involved in such an interpretation.

It is found that travelling atmospheric disturbances, governed by pressure oscillations and gravitational forces, will be accompanied by electromagnetic oscillations which can, under special resonant conditions, become large. The corresponding amplification of the associated electron motions would render such disturbances particularly susceptible to detection by radio methods. Gravity tends to confine the movement of these disturbances to the horizontal plane, though a vertical component is introduced by the effects of cross-conductivities and temperature inhomogeneities. If these, and similar complications, are neglected, it is found that conditions are particularly favourable for disturbances of quasi-period

$$\tau \sim 2\pi \sqrt{2/\gamma(\gamma - 1)}\, C/g, \qquad (1)$$

and group speed

$$V_G \sim C \sqrt{(\gamma - 1)/2\gamma}, \qquad (2)$$

in which $\gamma$ is the ratio of specific heats, $C$ the speed of sound, and $g$ the acceleration due to gravity. No preferred directions of travel relative to the earth's magnetic field appear at this stage, but they can be introduced, in some circumstances, by taking detailed account of electron motions and cross-conductivity effects.

It is natural to associate these resonant oscillations with the large-scale $F_2$-region disturbances observed by Munro[2], in which the numerical density of electrons may change by as much as 25 per cent. They appear to have a fundamental motion in the horizontal plane, with a secondary vertical component superimposed, in agreement with the theoretical predictions. Again, the larger amplitudes and shorter fractional durations (relative to $\tau$), associated by Munro with longer periods, receive plausible explanation in terms of varying resonance conditions.

If typical values for these disturbances, say, $\tau \sim 25$ min. and $V_G \sim 7$ km./min., are inserted directly in (1) and (2), the estimates $\gamma \sim 1 \cdot 1$ and $C \sim 35$ km./min. result. The corresponding temperature ($\sim 1{,}000°$ K.) is in good agreement with other estimates for this region, but the specific heat ratio is appreciably lower than one would expect from the usual considerations. Martyn[3], however, was led to a similar result when considering the bounding of ionospheric disturbances, and he pointed out that low values of $\gamma$ might well occur in regions where ionization was taking place. In any event, (1) and (2) do not take into account a number of factors which will be operative in practice, and so should only be considered as order-of-magnitude relations; as such, they appear to be quite satisfactory.

Favourable conditions are also obtained when

$$\tau \sim 2\pi \sqrt{2/\gamma}\, C/g, \quad V_G \sim C/\sqrt{2\gamma}, \qquad (3)$$

but these values do not appear to correspond to any disturbances so far reported.

No detailed analysis of the higher-frequency radio-star and $E$-region fluctuations has been undertaken as yet; but they appear amenable to a wave interpretation, and many of their properties can be profitably discussed on this basis.

In view of its potentialities and initial successes, the wave hypothesis might well be kept in mind when further analyses of the experimental data are undertaken.

This investigation, which is continuing, is supported by the National Research Council of Canada through a special scholarship. Full details are to be published at a later date.

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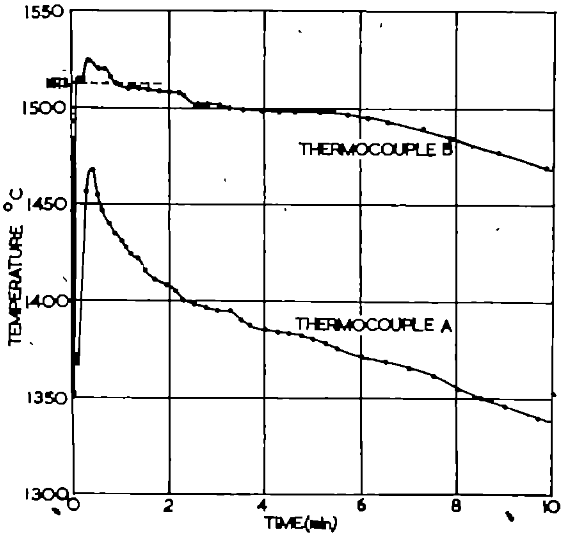
## Measurement of Temperatures of Metal/Mould Interfaces

MANY workers have attempted to observe metal/mould interface temperatures in metal castings by means of thermocouples with sheathed hot-junctions. However, since the temperature gradient in the refractory sheath is high, such measurements are liable to considerable error. We have therefore made measurements on an experimental steel casting with an unsheathed platinum / platinum - 13 per cent rhodium hot junction, the metal of the casting being used as intermediate metal; the two wires were simply pushed through the mould wall some 0·3 cm. apart. The technique has the following advantages: (i) it eliminates errors due to the temperature gradient across the sheath; (ii) it minimizes thermal lag; (iii) it ensures accurate location of the hot junction at the metal/mould interface, since the hot junction is formed at the points where the molten metal comes into contact with the thermocouple wires.



The temperatures recorded at the interface in the base of a 280-lb. low-carbon steel casting during the first 10 min. after pouring are shown in the accompanying graph, where the 'intermediate metal' thermocouple (*B*) is compared with a conventional thermocouple (*A*) of which the sheathed butt-welded hot junction lay in the plane of the metal/mould interface. The metal liquidus temperature of 1,518° C., shown on the graph, was determined in an independent laboratory experiment. The comparison shows that the initial chilling and subsequent remelting of the first metal to be poured are clearly recorded by *B*, but not recorded at all by *A*, owing to the temperature gradient in its sheath and its marked thermal lag. Also the temperatures recorded by *A* throughout are much lower than those of *B* because of the temperature-gradient error. Calibration of *B* before and after the experiment showed that errors due to contamination were negligible.

The method may have wider application than the one described. A detailed account of the use of the thermocouple will be published elsewhere.

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## Oat Lipase and Tributyrin

OAT lipase is located in the outer pericarp layers of the groat and can be removed by wet-brushing[1]. Using this technique with 20 gm. of groats per 100 ml. distilled water, a suspension is obtained which contains c. 98 per cent of the total active lipase. From such extracts oat lipase has been purified approximately 1,700-fold on a dry weight basis compared with the original activity in oatmeal.

The lipase activity has been measured by two methods: (*a*) a 'dough' method using olive oil as substrate[2]; (*b*) a manometric method[3] using tributyrin as substrate in a bicarbonate – carbon dioxide buffer system at $pH$ 7·4. Although the substrates are not interchangeable, that is, the lipase will not hydrolyse tributyrin in the 'dough' method nor olive oil in the manometric method, the same enzyme is thought to be responsible for both activities, since the ratio of the activities against the two substrates remains the same during the various stages in the purification of the enzyme.

The difficulties of differentiating lipase and esterase activities have been discussed by Desnuelle *et al.*[4], and it is generally considered that tributyrin hydrolysis is effected by a true lipase; in the case of milk, the tributyrinase and lipase activities have been definitely correlated[5].

In the course of a study of the kinetics of the purified enzyme using the manometric method with tributyrin at low substrate concentrations and $pH$ 7·4, the reaction was observed to cease when only a third of the total possible carbon dioxide had been evolved. This suggested that the purified lipase was only splitting off one butyric acid radical, leaving a dibutyrin as a reaction product. Krebs's pots were set up and the product of reaction (*X*) was isolated as a faintly yellow oil, boiling point 185–7°/26 mm., giving a negative periodate-fuchsin reaction; analysis gave C 56·71 per cent, H 8·52 per cent and saponification value 478 (calculated for dibutyrin, 56·86 per cent, 8·68 per cent and 483, respectively).

This suggests that the hydrolysis of the triglyceride by the purified lipase involves the splitting off of only one fatty acid radical and not a complete hydrolysis to glycerol and free fatty acid. Further evidence supporting this interpretation of the mode of action has been obtained by testing the activity of the purified lipase against the other compounds of glycerol and butyric acid. α-Monobutyrin was prepared by the method of Schuette and Hale[6], β-monobutyrin by the method of Daubert[7], and the two dibutyrins were prepared from the corresponding dibromhydrins by heating in sealed tubes with sodium *n*-butyrate as described by Guth[8]. The accompanying table gives the analytical data for these compounds.

These four compounds, together with *X* and tributyrin, were set up at 37° in manometers against a freshly prepared, purified lipase (3·3 mgm. substrate per flask, 0·0148 *M* sodium bicarbonate $pH$ 7·4, total vol. 3 ml., gas phase 5 per cent carbon dioxide/95 per cent nitrogen) together with appropriate boiled enzyme blanks. Lipolysis was only observed with tributyrin, the reaction being complete after 45 min. when one-third of the total possible carbon dioxide had been evolved. Thus under these conditions lipase is unable to hydrolyse either the di- or mono-butyrins, and attacks tributyrin by removing one fatty acid chain only. From the boiling point of *X* it would appear probable that the β-linkage is the one specifically hydrolysed and that *X* is in fact αγ-dibutyrin.

A high production of diglyceride has been observed with certain preparations of pancreatic lipase[4,9], and Frazer (see ref. 9) has suggested that more than one enzyme may be involved in the complete hydrolysis of a triglyceride. This, however, appears to be the first direct demonstration, with a lipase preparation acting upon a triglyceride, that only one fatty acid radical is specifically split off.

| | Boiling point | % Carbon | | % Hydrogen | | Sap. value | |
|---|---|---|---|---|---|---|---|
| | | Found | Calc. | Found | Calc. | Found | Calc. |
| α-Monobutyrin | 140–2°/5 mm. | 51·46 | 51·83 | 8·87 | 8·70 | 349 | 346 |
| β-Monobutyrin | 141–3°/5 mm. | 51·71 | 51·83 | 8·73 | 8·70 | 343 | 346 |
| αβ-Dibutyrin | 169–72°/20 mm. | 56·78 | 56·86 | 8·73 | 8·68 | 481 | 483 |
| αγ-Dibutyrin | 177–9°/20 mm. | 56·88 | 56·86 | 8·76 | 8·68 | 479 | 483 |

Full details of this work will be published elsewhere.

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## A New Spraying Agent for Paper Chromatography of Carbohydrates and Polyols

While investigating the chromatographic separation of sugars upon filter paper impregnated with sodium borate buffer (0·05 *N* borax, *p*H 9·18) it was found that the carbohydrates showed up prominently on spraying with 80 per cent aqueous ethanol containing either 1 mgm./ml. of phenolphthalein or phenol red just made alkaline with sodium hydroxide. Phenolphthalein gave rise to white spots on a purple background and was rather more effective than phenol red, which gave yellow spots on a purple background.

It was considered that the change in *p*H consequent upon the formation of carbohydrate–borate complexes might be used directly. Preliminary studies led to the development of a spraying reagent consisting of 1 part 0·05 *N* sodium borate (*p*H 9·18), 2 parts phenol red (2 mgm./ml. in ethanol made just alkaline with sodium hydroxide) and 7 parts methanol. The reagent could also be made up in ethanol. This, however, caused some precipitation of borate, which might lead to variability of performance, although the ethanolic reagent has given uniformly good results in our hands. Phenolphthalein was an inferior substitute for phenol red, as the reagent had to be adjusted to such a *p*H that it just coloured the paper. This proved awkward and, since the indicator did not always spread evenly, owing apparently to adsorption on the paper, phenolphthalein is not recommended.

Although we have experienced no trouble from this cause, it should be noted that acidic or basic substances able to move in the solvents used might interfere. These could be removed by ion exchange resins. The method has, however, proved more satisfactory than the use of ammoniacal silver nitrate. Methanolic phenol red – borate gave good definition with 25–50 μgm. dihydroxyacetone, arabinose, xylose, fructose, glucose, lactose, mannose, sucrose, maltose, cellobiose, raffinose and a number of polyols.

Ascending chromatography on Whatman No. 4 paper was carried out for 15 hr. using developing solvents similar to those described by Jeanes, Wise and Dimler[1]. The distances moved by glucose were about 9·5 cm. in solvent *B* and 4·5 cm. in solvent *F*. Typical *Rg* values are quoted in the accompanying table for some polyols.

The method may also be of value when it is necessary to determine the position of sugars by a technique that leaves them unchanged, so as to make possible leaching out the spots for micro-determinations.

$$Rg = \frac{\text{distance moved by substance}}{\text{distance moved by glucose}}$$

| Solvent | *B* *n*-Butanol : pyridine : water = 3 : 2 : 1·5 | *F* *n*-Butanol : pyridine : water = 4 : 1 : 1 |
|---|---|---|
| Dihydroxyacetone | 1·84 | 3·38 |
| Glycerol | 1·61 | 2·58 |
| Erythritol | 1·35 | 1·85 |
| Mannitol | 0·91 | 0·92 |
| Sorbitol | 0·92 | 0·87 |
| *i*-Inositol | 0·39 | 0·19 |

Reference has been made by Bradfield and Flood[2] in a communication entitled "Soluble Carbohydrates of Fruit Plants" to the use of borate buffer containing bromcresol purple for similar purposes to the above.

I acknowledge with thanks the technical assistance of Mrs. D. Goodinson.

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## Serological Activity of Globulin Fractions of Anti-*D* Sera separated by Paper Electrophoresis

It seems that the existence of blocking, incomplete (non-blocking) and complete (saline) antibodies is generally accepted; but up to now little work has been done to widen our knowledge about serological activity of different fractions of anti-*Rh* sera containing those kinds of antibodies.

After preliminary examination of many immune sera, three anti-*D* sera were chosen. All these sera are very close to each other from the point of quantitative serological reaction, but at the same time they show marked differences in respect of the qualitative behaviour of anti-*D* antibody in carrying out various serological tests. The sera used are: No. 1286, containing blocking antibody (blocking titre 1/16, trypsin titre 1/32, albumin titre 1/16, saline titre negative, indirect *AHG* titre 1/128); No. 23530 with incomplete (non-blocking) antibody (blocking titre negative, trypsin titre 1/64, albumin titre 1/16, saline titre negative, indirect *AHG* titre 1/256); and No. 11871 with saline antibody (blocking titre negative, trypsin titre 1/64, albumin titre 1/64, saline titre 1/16, indirect *AHG* titre 1/128).

Electrophoresis on filter-paper strips (Whatman No. 2, 37 cm. × 5 cm.) was carried out to isolate $\alpha_1$-, $\alpha_2$-, β- and γ-globulin. The apparatus described by Flynn and de Mayo[1] was used with barbitone buffer *p*H 8·6; potential 350 V., for 3 hr., current 0·4 m.amp./cm. width.

In all experiments seven strips were used for each serum to be investigated; 0·03–0·04 ml. of serum was placed on each strip in a straight line 4 cm. long by means of a capillary glass pencil. After each run the strips, still wet, were cut into two parts and one of 37 cm. × 1·5 cm. was dried and stained with a solution of 1 per cent bromphenol blue in 95 per cent ethyl alcohol saturated with mercuric chloride. The strips were then washed in running tap water. The coloured strips were used for detecting the exact position of the different globulin fractions on the uncoloured parts of the strips. Each unstained strip was cut into fractions and the different globulins immersed in 1 ml. of saline (for each fraction) and eluted for 16 hr. at + 4° C. The filter paper was removed from the eluate by centrifugation and the eluates were examined, using blocking, trypsin, papain, albumin

| Test | No. 1286 | | | | No. 23530 | | | | No. 11871 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $\alpha_1$ | $\alpha_2$ | $\beta$ | $\gamma$ | $\alpha_1$ | $\alpha_2$ | $\beta$ | $\gamma$ | $\alpha_1$ | $\alpha_2$ | $\beta$ | $\gamma$ |
| Blocking | − | − | − | + | − | − | − | − | − | − | − | − |
| Trypsin | − | − | − | v | − | − | − | ++ | − | − | − | v |
| Papain | − | − | − | ++ | − | − | − | ++ | − | − | − | v |
| Albumin | − | − | − | w | − | − | − | w | − | − | − | w |
| Saline | − | − | − | − | − | − | − | − | − | − | − | + |
| Indirect *AHG* | − | − | − | ++ | − | − | − | ++ | − | − | − | + |
| Titre of $\gamma$-eluate | blocking 1/2;<br>ind. *AHG* 1/32 | | | | ind. *AHG* 1/64 | | | | saline 1/4;<br>ind. *AHG* 1/16 | | | |

All controls were normal. v, Visible clumps; ++, large clumps visible in microscopic field; +, smaller clumps; w, microscopically weak reaction; −, no agglutination

saline and indirect anti-human-globulin tests. In all experiments the same $OR_1r$ and $Orr$ normal, trypsinized and papainized red cells were used. The results are tabulated herewith.

It is obvious from these results that the blocking, incomplete (non-blocking) and complete (saline) antibodies belong to the γ-globulin fraction of anti-*D* sera. Anti-*D* activity was not found in any other fraction.

We could not confirm the observation of Cann *et al.*[2] that other globulin fractions contain also *Rh* antibodies. It seems to us that it is rather difficult to obtain a clear conclusion from the results obtained by those authors. This discrepancy between the results of Cann and co-workers and our results is probably due to the fact that a better separation of globulin fractions is possible by means of paper electrophoresis than by the electrophoresis convection method.

Serological examinations of different fractions, using different tests, show that the albumin method gives the weakest reactions, whereas the indirect anti-human-globulin test and the tests with trypsinized and papainized red cells give very clear reactions. It is to be noted that some samples of eluates from the γ-globulin fraction of serum No. 1286 show a very weak blocking effect in spite of a satisfactory titre obtained with the indirect *AHG* test.

The use of the paper electrophoresis method for investigating an anti-*D* serum is very simple and gives accurate results. The method can probably be used for immune sera which contain two or more antibodies with different serological specificity. The method is especially convenient for the examination of very rare antisera, since a quantity of about 0·25 ml. is enough to obtain an eluate with good serological activity. The main disadvantage of the paper electrophoresis method is that it is practically impossible to obtain an eluate with the same concentration of antibody as in the original sample of the serum used.

We thank Dr. J. J. van Loghem, director of the Central Laboratory for Blood Transfusion in Amsterdam, for his advice and help. One of us (B. D. J.) holds a fellowship of the World Health Organization.

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## A Simple Method for the Preparation of Crystalline Potato Phosphorylase and Q-Enzyme

IN the purification of potato phosphorylase[1] by ethanol precipitation[2], it has been found that conditions established for a particular variety of potato, harvested at a particular time of the year, are not generally applicable to other potatoes, even though these may contain as much enzyme. This is because the solubility of the enzyme is affected by its association with other constituents, the nature and quantity of which vary with the type of potato and the season. Since, in spite of this association, the enzyme is always able to react with its substrate, it was thought that the formation of the enzyme substrate complex might be utilized to free the enzyme from these other complexing molecules. Preliminary experiments in which the precipitation of phosphorylase was carried out in the presence of glucose-1-phosphate did not, however, show any appreciable change in the solubility of the enzyme. These experiments were not pursued further after it had been found that the presence of the co-substrate, amylose, results in a strong and selective precipitation of phosphorylase at a concentration of ethanol at which the enzyme is otherwise soluble[3], and in at least a thousandfold purification of the enzyme with respect to protein. The phosphorylase is accompanied in the precipitate by the *Q*-enzyme of the potato[3]. The enzymes are readily extracted from the precipitate and can then be precipitated from solution with ammonium sulphate in crystalline form.

The exact conditions of the preparation do not seem to be critical, and crystalline enzymes have been obtained from four varieties of potato for which the ordinary ethanol precipitation was ineffectual. The following has proved to be a convenient procedure. Freeze-dried potato juice is reconstituted with distilled water and brought at 0° to 11 per cent ethanol concentration with 50 per cent ethanol–citrate reagent[4] (0·282 ml./ml. juice). The precipitate, which contains amylose precipitant, is discarded. A suspension of wrinkled pea amylose[5] in water (0·2 gm./ml.) is boiled for about three minutes, and cooled to 0°. The supernatant liquid is poured into this suspension (2 ml. supernatant/1 ml. suspension) and the mixture brought to 11 per cent ethanol by adding 50 per cent ethanol–citrate reagent (0·094 ml./ml. mixture). After stirring for 10 min. the mixture is centrifuged and the precipitate washed five times, each time with seven times its volume of 11 per cent ethanol containing 0·01 *M*-citrate *p*H 6·0, all these operations being performed at 0°. The precipitate is then extracted twice for 15-min. periods with stirring with three times its volume of 0·05 *M*-citrate *p*H 6·0. The extract is brought to a concentration of 30 per cent w/v ammonium sulphate by adding the appropriate volume of 50 per cent w/v ammonium sulphate (ammonia to *p*H 7·0), and left 1 hr. at 0°. The precipitate, after centrifugation, is extracted with 19 per cent ammonium sulphate solution (0·2 ml./ml. of original juice), to give a solution I and a residue II. Crystalline phosphorylase is precipitated from solution I when this is brought at 0° to 25 per cent w/v ammonium sulphate. Crystalline *Q*-enzyme is obtained by dissolving residue II in 0·05 *M*-citrate *p*H 6·0 (0·2 ml./ml. of original juice) and bringing the solution to 17 per cent w/v ammonium sulphate *p*H 7. The enzymes can be recrystallized from the appropriate ammonium sulphate solutions.

The amount of amylose required per unit volume of juice (for example, 13 per cent w/v above) depends on the previous history of the amylose, and particularly on the extent to which it has retrograded during preparation. The pea amylose used was a rather insoluble alcohol-dried sample. Potato amylose and potato whole starch also adsorb the enzymes under the conditions described; but the use of whole starch is not advocated owing to the complications introduced by its content of amylopectin. A non-retrograded, undried sample of potato amylose was found to adsorb 50 per cent of the phosphorylase of the potato juice when added to the extent of only 3 per cent w/v of the juice. Moreover, the whole of the *Q*-enzyme was adsorbed by 0·15 per cent of this amylose, enabling the *Q*-enzyme to be removed from the phosphorylase at this stage if desired.

Part of the adsorbed *Q*-enzyme is firmly bound to the amylose and cannot be removed with salt solution. It can only be removed by washing the precipitate with starch solution. This suggests that there is a general attraction of the amylose chains for the *Q*-enzyme molecule (presumably through secondary valency forces) leading to a complex which is easily dissociated in salt solution, and that in addition there are a number of sites at which the full enzyme-substrate complex is formed. From these sites the enzyme can be removed only by presenting the substrate in the dissolved form.

It will be noticed that the method of preparation above resembles that used by Schwimmer and Balls[6], who obtained α-amylase from barley by adsorption of the amylase on starch grains from alcoholic solution, and by Hobson, Whelan and Peat[7], who removed *Q*-enzyme irreversibly on potato starch in the preparation of *R*-enzyme.

We wish to thank Prof. H. W. Melville and Prof. M. Stacey for their interest in this work. One of us (H. B.) is indebted to the Department of Scientific and Industrial Research for a maintenance grant.

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## A Method of Embedding Brittle Specimens of Wood for Sectioning

GREAT difficulty was encountered in cutting sections from the brittle and often partly carbonized wooden remains found on the sites of Roman and ancient British settlements. The impact of the razor caused instantaneous fragmentation of the sections, and identification became very difficult. A simple embedding material was sought which would penetrate the specimen without difficulty, and which could be cut easily and would prevent the resulting section from crumbling.

A proprietary brand of a polyvinyl lactophenol mixture (that is, polyvinyl alcohol in lactic acid and phenol) was used at first, as it was known that this substance had proved satisfactory in the mounting of entomological specimens without the necessity of previous dehydration. The procedure adopted was as follows. Cubes of the brittle wood are cut in the usual way, with a tangential, a radial and a transverse face; they are then immersed in the polyvinyl lactophenol mixture and warmed gently for half an hour. After removal from the liquid, the cubes were allowed to drain and cool for 24 hr. (It will be found that the cubes are now darker in colour and of a rubbery consistency.) The cubes can then be sectioned with a sharp razor, and the sections mounted directly on to a slide, using the embedding agent as a mounting medium.

The resulting preparation possesses the added advantage of being 'cleared' by the polyvinyl lactophenol. The cell walls, which may be blackened and beginning to undergo carbonization, are rendered clear and translucent, enabling details of structure to be easily observed.

The method has proved to be a quick, easy and efficient one, but possesses certain aspects where care has to be taken. Due to the rubbery nature of the material, sections have to be cut with a sharp razor or else the cube will bend under the impact of the blade. Staining is somewhat difficult, because many dyes tend to diffuse from the sections into the mounting medium[1]. It has proved possible to stick the section to a slide, wash off the polyvinyl lactophenol in hot water, and then to stain, clear and mount up in canada balsam in the usual way, but this technique still requires to be perfected. Some preparations of polyvinyl lactophenol (for example, the proprietary one already mentioned) cause a slight shrinkage to the tissues on drying. Other preparations dry more slowly and so require a longer period at the second and third stages outlined above (for example, Salmon's type *M.A.*1 [2]).

Subsequent search through the literature has shown that this method is not new. Lubkin and Carsten[3] have used a polyvinyl alcohol – glycerine mixture for embedding and sectioning medical pathological material, such as heart, lungs, liver and spleen. Gray and Wess[4] advocate a polyvinyl alcohol – glycerine – lactic acid – acetone mixture for mounting entomological specimens, which has a slightly lower refractive index, but which Brown[5] claims overcomes the tendency to shrink and sets harder than other preparations. These preparations and others are being tested and may well eliminate some of the difficulties in the technique mentioned. Even with these disadvantages, the ease and quickness of embedding and mounting the material should commend itself as a useful method, especially where speed in identification of specimens is an important consideration.

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## FORTHCOMING EVENTS

### Wednesday, June 3—Friday, June 5

OIL AND COLOUR CHEMISTS' ASSOCIATION (at Eastbourne).—Biennial Conference.

### Thursday, June 4

BRITISH PSYCHOLOGICAL SOCIETY, INDUSTRIAL SECTION (in Room 105, London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 1 p.m.—Mr. H. W. Thiele: "A Study of the Occupational Achievements of a Group of Adults Educated at certain Schools for the Blind".

CHEMICAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 7.30 p.m.—Meeting to commemorate the Present-day Aspects of the Work of Sir William Ramsay.

### Friday, June 5

PRESENTATION OF TECHNICAL INFORMATION, DISCUSSION GROUP (in the Anatomy Theatre, University College, Gower Street, London, W.C.1), at 6 p.m.—Dr. P. M. Woodward: "Information Theory".

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 9 p.m.—Dr. M. F. Perutz: "Glaciers".

### Saturday, June 6

BRITISH PSYCHOLOGICAL SOCIETY (in the Psychology Department, University College, Gower Street, London, W.C.1), at 2.30 p.m.—Mr. H. M. B. Hurwitz: "Frustration in Learning, an Account of some Experiments".

NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS (at Neville Hall, Newcastle-upon-Tyne), at 2.30 p.m.—Mr. A. B. Dawson: "Methane Emission".

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## APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

ASSISTANT (Grade B) IN MATHEMATICS, and an ASSISTANT (Grade B) IN PHYSICS—The Principal, Derby Technical College, Normanton Road, Derby (June 6).

HEAD OF THE CHEMISTRY DEPARTMENT—The Principal, North Staffordshire Technical College, Stoke-on-Trent (June 6).

LECTURER or ASSISTANT LECTURER IN GEOGRAPHY—The Registrar, University College, Leicester (June 6).

PHYSICAL CHEMIST (with good honours degree, and thoroughly interested in the theory and experimental techniques associated with corrosion research) IN THE BOILER CORROSION RESEARCH LABORATORY, St. John's Wood, London—The Director of Establishments, British Electricity Authority, Winsley Street, London, W.1, quoting A.E.379 (June 8).

SENIOR ASSISTANT ENGINEER (turbines) for general investigations into turbine design problems including the effect of cycle conditions on performance, the preparation of specifications and the critical assessment of the technical features and performance of particular designs, IN THE GENERATION DESIGN BRANCH, Headquarters—The Director of Establishments, British Electricity Authority, Winsley Street, London, W.1, quoting T/381 (June 8)

ASSISTANT LECTURER IN THE DEPARTMENT OF AGRICULTURE (Crop Husbandry)—The Registrar, University College of Wales, Aberystwyth (June 10).

WELLCOME RESEARCH FELLOW for research in connexion with veterinary science or practice—The Scientific Director, Animal Health Trust, 232–235 Abbey House, Victoria Street, London, S.W.1 (June 10).

SENIOR LECTURER IN MECHANICAL ENGINEERING, LECTURERS (2) IN MECHANICAL ENGINEERING, a LECTURER IN PHYSICS, a LECTURER IN RADAR AND TELECOMMUNICATIONS, and DEMONSTRATORS IN MECHANICAL AND ELECTRICAL ENGINEERING, at the Royal Military College of Science, Shrivenham—The Civil Service Commission, Scientific Branch, Trinidad House, Old Burlington Street, London, W.1, quoting S.4211/53 (June 12).

DESIGN ENGINEERS to assist on design problems of control and nstrumentation for new types of reactors (Ref. D.186/53A), an ENGINEER (mechanical) to work on mechanical design and specification of new types of reactors (Ref. C.252/53A), and ENGINEERS (electrical) to assist design, planning, construction of electric plant and services for large new project (Ref. D.187/53A); in the Ministry of Supply at Harwell—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting the appropriate Ref. No. (June 13).

PRINCIPAL SCIENTIFIC OFFICER (with University degree with first- or second-class honours in mathematics or physics or an equivalent qualification, and at least three years postgraduate or other approved xperience in astrophysics, preferably with some experience in line ntensity spectrophotometry) at the Royal Observatory, Edinburgh—he Establishment Officer, Scottish Home Department, Room 364, St. Andrew's House, Edinburgh 1 (June 15).

SHELL SCHOLARSHIPS IN CHEMICAL ENGINEERING—The Registrar, mperial College of Science and Technology, South Kensington, London, S.W.7 (June 16)

GUIDE-LECTURERS (2) (with university honours degree; experience in lecturing or teaching essential, and a sound knowledge of French and at least one other European language desirable) at the British Museum, Bloomsbury—The Secretary, Civil Service Commission, Burlington Gardens, London, W.1, quoting 4208/53 (June 18).

LECTURER IN MATHEMATICS (with special qualifications in applied mathematics)—The Registrar, The University, Manchester 13 (June 20).

NUFFIELD FELLOWSHIPS (2) IN THE DEPARTMENT OF PHYSICS in connexion with research on the structure of crystalline proteins—The Secretary, Birkbeck College, Malet Street, London, W.C.1 (June 20).

UNIVERSITY DEMONSTRATOR IN ORGANIC CHEMISTRY—Dr. F. B. Kipping, Chemical Laboratory, The University, Cambridge (June 20).

CHAIR OF BOTANY at the Imperial College of Science and Technology—The Academic Registrar, University of London, Senate House, London, W.C.1 (June 22).

CHAIR OF CHEMISTRY in the Durham Division of the University of Durham—The Registrar, University Office, 46 North Bailey, Durham (June 22).

CHAIR of ELECTRICAL ENGINEERING at the Imperial College of Science and Technology—The Academic Registrar, University of London. Senate House, London, W.C.1 (June 23).

ASSISTANT EXAMINERS (3) (with such training in chemistry and physics as will enable them to make tests to detect faults in paper, stationers' sundries, etc., supplied for the Public Service) IN H.M. STATIONERY OFFICE—The Secretary, Civil Service Commission, 6 Burlington Gardens, London, W.1, quoting 205/53 (June 25).

APPLIED MATHEMATICIAN (preferably with experience in the application of statistical methods or in modern computational methods) in the National Physical Laboratory, Pretoria—The South African Scientific Liaison Officer, Africa House, Kingsway, London, W.C.2 (Pretoria, June 27).

RESEARCH OFFICER (with sufficient background and research experience in colorimetry and/or photometry) IN THE OPTICS SECTION of the National Physical Laboratory, Pretoria—The South African Scientific Liaison Officer, Africa House, Kingsway, London, W.C.2 (Pretoria, June 27).

ASSISTANT (Experimental Officer grade) IN THE PATHOLOGY DEPARTMENT, to work on selection and indexing of fruit stocks for virus infection, and assistance with experimental work on plant virus diseases—The Secretary, Scottish Horticultural Research Institute, Mylnefield, Invergowrie, Dundee (June 30).

ASSISTANT LECTURER or LECTURER (preferably with experience in cytogenetics) IN THE DEPARTMENT OF BOTANY—The Registrar, The University, Liverpool (June 30).

ASSISTANT EDUCATIONAL PSYCHOLOGIST (woman) (with honours or research degree in psychology, and experience in teaching) to the Child Guidance Clinic and Bristol Schools—The Chief Education Officer, Council House, College Green, Bristol 1.

ASSISTANT LECTURER (with honours degree in geology, and preferably some research experience in stratigraphy and palæontology) IN GEOLOGY—The Secretary, University College, Gower Street, London, W.C.1.

ASSISTANT LECTURER (with good honours degree) IN PHYSICS—The Secretary, St. Mary's Hospital Medical School, Paddington, London, W.2.

ASSISTANT SUPERINTENDENT (Senior Scientific Officer grade) (professional/academic qualifications and administrative ability essential; thorough knowledge of the use and testing of textile and related materials used on railways required) IN THE TEXTILES DIVISION of the Research Department, Derby—The Director of Research, Railway Executive, 222 Marylebone Road, London, N.W.1.

CURATOR (with university degree in anthropology or archæology) OF THE ZANZIBAR MUSEUM—The Director of Recruitment (Colonial Service), Colonial Office, Great Smith Street, London, S.W.1, quoting CDE.167/1C/01.

DEMONSTRATOR IN BOTANY, and a DEMONSTRATOR IN ZOOLOGY (with good honours degree in botany, agricultural botany, or zoology) IN THE DEPARTMENT OF BIOLOGICAL SCIENCE—The Registrar, Wye College, Ashford, Kent.

LECTURER IN ELECTRICAL ENGINEERING (with honours degree in electrical engineering, and some practical experience)—The Professor of Electrical Engineering, Imperial College of Science and Technology, Exhibition Road, London, S.W.7.

LECTURER IN ELECTRICAL ENGINEERING (electronics) (with honours degree in physics or electrical engineering, and experience in airborne radio and radar systems, servomechanisms, or electronic techniques in measurement and control) to cover fundamental electronic circuits, including pulse circuits and their application to the measurement of non-electrical quantities—The Recorder, College of Aeronautics, Cranfield, Bletchley, Bucks.

LECTURERS and ASSISTANT LECTURERS IN (*a*) APPLIED MECHANICS, (*b*) HEAT ENGINES, and (*c*) ENGINEERING DRAWING, IN THE DEPARTMENT OF CIVIL AND MECHANICAL ENGINEERING—The Secretary, Royal Technical College, Glasgow.

REGIONAL TRIALS OFFICER (with degree in botany or agriculture or equivalent qualification, and practical experience in crop production) for work possibly at Newcastle—The Secretary, National Institute of Agricultural Botany, Huntingdon Road, Cambridge

RESEARCH STUDENT (with some biochemical experience, and preferably with a knowledge of tissue slice techniques) IN THE CANCER RESEARCH DEPARTMENT, to work on problems concerning the mechanism of enzyme synthesis—The Secretary, London Hospital Medical College, Turner Street, London, E.1.

SCIENTIFIC OFFICER (Grade 1) and a SCIENTIFIC OFFICER (Grade 2) to work on behalf of the British Transport Commission on problems of friction and adhesion, at the Mechanical Engineering Research Organization, East Kilbride—The Director of Research, Railway Executive, 222 Marylebone Road, London, N.W.1.

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## REPORTS and other PUBLICATIONS

*(not included in the monthly Books Supplement)*

### Great Britain and Ireland

Report to the Boiler Availability Committee by the Burton Investigation Group on the Relationship between the Chlorine Content of the Coal Burned and the Availability of a Stoker Fired Boiler at the Burton Generating Station of the British Electricity Authority East Midlands Division. (Bulletin MC/233. Technical Paper No. 3.) Pp. 51. Second Interim Report on External Deposits and Corrosion in Boiler Plant, 1946–1951. (Bulletin MC/234.) Pp. 31. Summaries of Published Papers. (Bulletin MC/235.) Pp. 24. Bibliography of

Papers relating to the External Fouling and Corrosion of Boiler Plant, 1940–1951. (Bulletin MC/236.) Pp. 27. (London: Boiler Availability Committee, 1953.) [263

Memoirs of the Geological Survey of Great Britain. The Mesozoic Ironstones of England—The Liassic Ironstones. By T. H. Whitehead, W. Anderson, Dr. Vernon Wilson and Dr. D. A. Wray; with Contributions on Petrography, by Dr. K. C. Dunham. Pp. viii+211+8 plates. (London: H.M. Stationery Office, 1952.) 25s. net. [303

Royal Institute of International Affairs. Information Papers No. 18: World Production of Raw Materials. New and revised edition. Pp. viii+104. (London and New York: Royal Institute of International Affairs, 1953.) 7s. 6d. net. [313

Library Association: Reference and Special Libraries Section (South Eastern Group). Library Resources in the Greater London Area, No. 2: Photographic Literature; a Symposium. Pp. 20. (West Wickham: Miss O. T. Smith, Hon. Secretary, 230 Queensway, 1953.) 2s. 9d.; to Members, 2s. [313

Lundy Field Society. Sixth Annual Report, 1952. Pp. 62+2 plates. (Exeter: Dr. A. Harvey, Secretary, University College, 1953.) 2s. 6d. [14

Chelsea Polytechnic. Fifty-seventh Annual Report, Session 1951–52. Pp. 32. (London: Chelsea Polytechnic, 1953.) [14

Photography and the Amateur Astronomer. By Dr. Gerald Merton. (B.A.A. Reprint No. 1.) Pp. 24+7 plates. (Hounslow: British Astronomical Association, 1953.) 1s. [84

The Production of Barley for Malting. (Monographs on Malt and Malt Products.) Pp. 28. (Bedford: Muntona, Ltd.; Ipswich: Edward Fison, Ltd., 1953.) [84

Department of Scientific and Industrial Research: Food Investigation. Special Report No. 58: Whalemeat; Production and Preservation. By Dr. J. G. Sharp and Dr. B. B. Marsh. Pp. vi+48+4 plates. 2s. 6d. net. Special Report No. 59: Whalemeat; Bacteriology and Hygiene. By R. H. M. Robinson, Dr. M. Ingram, Dr. R. A. M. Case, Dr. J. G. Benstead; with Appendix by Dr. H. E. Daniels. Pp. vi+56. 2s. net. (London: H.M. Stationery Office, 1953.) [84

Anti-Locust Memoir 5: Seasonal Breeding and Migrations of the Desert Locust (*Schistocerca gregaria* Forskål) in South-Western Asia. By J. Fortescue-Foulkes. Pp. 36. (London: Anti-Locust Research Centre, c/o British Museum (Natural History), 1953.) 10s. [84

Transactions of the Royal Society of Edinburgh. Vol. 62, Part 2, No. 12: The Monomyarian Condition in the Lamellibranchia. By C. M. Yonge. Pp. 443–478. (Edinburgh and London: Oliver and Boyd, Ltd., 1953.) 9s. [84

Thirty-second Annual Report of the E.R.A. for the period ended 31st December, 1952. Pp. 162. (Leatherhead: British Electrical and Allied Industries Research Association, 1953.) [94

Philosophical Transactions of the Royal Society of London. Series A: Mathematical and Physical Sciences. No. 903, Vol. 245: Mass Transport in Water Waves. By M. S. Longuet-Higgins. Pp. 535–581. (London: Cambridge University Press, 1953.) 11s. [94

Commonwealth Bureau of Horticulture and Plantation Crops Technical Communication No. 23: Field Experimentation with Fruit Trees and other Perennial Plants. By S. C. Pearce. Pp. x+131. (Farnham Royal: Commonwealth Agricultural Bureaux, 1953.) 10s. [94

University of Cambridge. Report of the Observatories Syndicate for the Year ending 1952 September 30. Pp. 4. (Cambridge: The University, 1953.) [204

Wye College: Department of Hop Research. Annual Report, 1952. Pp. 70. (Wye: Wye College, 1953.) 4s. [204

British Iron and Steel Research Association. Annual Report, 1952. Pp. 128. (London: British Iron and Steel Research Association, 1953.) [204

Transactions of the Royal Society of Edinburgh. Vol. 62, Part 2, No. 11: Serpentine Lavas—The Ankara Mélange and the Anatolian Thrust. By Sir E. B. Bailey and Prof. W. J. McCallien. Pp. 403–442+8 plates. (Edinburgh and London: Oliver and Boyd, Ltd., 1953.) 17s. 6d. [204

## Other Countries

Carnegie Institution of Washington. Year Book No. 51, July 1, 1951–June 30, 1952; with Administrative Reports through December 12, 1952. Pp. xxxv+286. (Washington, D.C.: Carnegie Institution, 1952.) 1 dollar. [313

Ministry for Foreign Affairs of the Polish People's Republic. Documents on the Hostile Policy of the United States Government towards People's Poland. Pp. xii+246+8 plates. (Warsaw: Ministry for Foreign Affairs of the Polish People's Republic, 1953.) [14

East African Industrial Research Board. Technical Pamphlet No. 16: Clays, Red and Black, and Nairobi Building Stone; an Attempt to use them for the Manufacture of Bricks and Tiles. By W. Colet Birch. Pp. 22. (Nairobi: Government Printer, 1953.) 1s. 6d. [14

Smithsonian Miscellaneous Collections. Vol. 121, No. 3: A Revision of the Colombian Species of Monnina (Polygalaceae). By Ramón Ferreyra. (Publication 4100.) Pp. v+59. (Washington, D.C.: Smithsonian Institution, 1953.) [14

Department of Transport: Meteorological Division. Summaries of Radiosonde Observations in Southern Canada, Stations South of Latitude 55° N., June 1941–December 1949. Pp. 149. (Toronto: Department of Transport, n.d.). 1 dollar. [14

United States Department of Agriculture. Farmers' Bulletin No. 1945: The Pea Aphid on Peas and Methods for its Control. By J. E. Dudley, Jr., and T. E. Bronson. Pp. ii+13. 5 cents. Farmers' Bulletin No. 1971: The Pea Weevil and Methods for its Control. By T. A. Brindley, J. C. Chamberlin and Ralph Schopp. Revised edition. Pp. ii+24. 15 cents. Circular No. 906: Improvements in the Control of Ribes by Chemical and Mechanical Methods. By H. R. Offord, V. D. Moss, W. V. Benedict, H. E. Swanson and A. London. Pp. 72+9 plates. 35 cents. Technical Bulletin No. 1036: Parasites of the Lima-Bean Pod Borer in Europe. By Henry L. Parker. Pp. 28. 15 cents. Technical Bulletin No. 1039: Effect of Winter Cover Crops on Wireworm Injury to the Dry Lima Bean Crop. By M. W. Stone. Pp. 20. 10 cents. Technical Bulletin No. 1047: Effect of Soil Treatments with DDT, Benzene Hexachloride and Toxaphene on Tobacco, Cotton and Cowpeas. By Norman Allen and Floyd F. Bondy, J. F. Bullock and R. E. Hall. Pp. 22. 15 cents. Technical Bulletin No. 1052: Classification of the Ortheziidae; Supplement to Classification of Scale Insects of the Subfamily Ortheziinae. By Harold Morrison. Pp. 80. 30 cents. (Washington, D.C.: Government Printing Office, 1951–1952.) [14

Bulletin of the World Health Organization. Supplement 7: Guide for National Studies of Nursing Resources. By Margaret G. Arnstein. Pp. 36. (Geneva: World Health Organization; London: H.M. Stationery Office, 1953.) 0.75 Swiss francs; 1s.; 20 cents. [14

Mededelingen van de Koninklijke Vlaamse Academie voor Wetenschappen, Klasse der Wetenschappen. Jaargang 14, Nr. 12: Het probleem der bevruchting in de loop der tijden. Door Dr. A. Schierbeek. Pp. 30. (Brussel: Koninklijke Vlaamse Academie voor Wetenschappen, 1952.) [14

Publications of the Kapteyn Astronomical Laboratory at Groningen. No. 55: An Investigation on the Eclipsing Binaries brighter than Photographic Magnitude 8.50 at Maximum. By L. Plaut. Pp. iii+62. (Groningen: Verenogde Drukkerijen Hoitsema N.V., 1953.) [14

United States Department of Agriculture. Miscellaneous Publication No. 273: Insect Enemies of Western Forests. By F. P. Keen. Revised edition. Pp. 280. (Washington, D.C.: Government Printing Office, 1952.) 1 dollar. [14

Scientific Institutions and Scientists in Latin-America. Cuba, Vol. 1. Pp. iv+96. (Montevideo: Unesco Centro de Cooperacion Cientifica para America Latina, 1953.) [14

Carnegie Institution of Washington. Annual Report of the Director of the Department of Terrestrial Magnetism. (Reprinted from Carnegie Institution of Washington Year Book No. 51.) Pp. 65–98. (Washington, D.C.: Carnegie Institution, 1952.) [14

Annals of the New York Academy of Sciences. Vol. 56, Article 2: Comparative Conditioned Neuroses. By Edward J. Kempf and 16 other Authors. Pp. 141–379. (New York: New York Academy of Sciences, 1953.) 3.50 dollars. [14

State of California: Department of Fish and Game. Forty-second Biennial Report of the Department of Fish and Game for the Years 1950–1952. Pp. 187. (San Francisco: Department of Fish and Game, 1953.) [14

Smithsonian Miscellaneous Collections. Vol. 121, No. 1: Geology of the San Jon Site, Eastern New Mexico. By Sheldon Judson. (Publication 4098.) Pp. v+70+5 plates. Vol. 121, No. 13: Regarding Washington, D.C., Precipitation and Temperature, 1952 and 1953. By C. G. Abbot. (Publication 4130.) Pp. ii+7. (Washington, D.C. Smithsonian Institution, 1953.) [14

Bulletin of the American Museum of Natural History. Vol. 100 Article 3: Avian Systematics and Evolution in the Gulf of Guinea: the J. G. Correia Collection. By Dean Amadon. Pp. 393–452+4 plates. 1 dollar. Vol. 100, Article 4. A Generic Revision of Flycatchers of the Tribe Muscicapini. By Charles Vaurie. Pp. 453–538. 1 dollar. (New York: American Museum of Natural History, 1953.) [14

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# THE ROCKEFELLER FOUNDATION

THE Rockefeller Foundation was established in 1913; it was named after its founder, John D. Rockefeller, and although the Laura Spelman Rockefeller Memorial was combined with it in 1929, the original name was retained. Its purpose is quite simply "to promote the well-being of mankind throughout the world". An account of its activities has been prepared by Dr. Raymond B. Fosdick*, whose annual reports as president of the Foundation for more than a decade have become well known to scientific workers and others. Now he has written more particularly for the layman; he tells the story of the Foundation's achievements in the field of public health, starting with the control of hookworm, and broadening out to deal with malaria, typhus, tuberculosis and yellow fever, its contribution to medical education first in China and the United States and eventually over all the world, and the way these activities have led the Foundation to support a wide programme of medical research, and ultimately research in the social sciences and the natural sciences.

Quite apart from its value as a connected account of the development of the Rockefeller Foundation, the book could scarcely be bettered as an exposition of the contribution which science can make towards human welfare, and of the vital importance of adequate support for fundamental scientific research. These alone are sufficient reasons for welcoming the book at the present time; but there are others also why the volume is timely. The policy behind its fellowship programme of seeking solely to place the chosen Fellow in the institution where he could obtain the best possible training in the work for which he showed definite promise, no matter where the institution was located, provides a striking vindication of Mill's principle that "what the improvement of mankind and of all their works most imperatively demands is variety, not uniformity". The results of that policy refute the conception of uniformity or levelling down that finds expression, for example, in the comprehensive school. Moreover, the success of the fellowship programme, and the fruitfulness of even the limited movement of scholars across international frontiers which it has been able to foster, give plain warning of the dangers to mankind as well as to scientific advance inherent in all those tendencies which, especially during the past decade, have discouraged or prohibited scientific intercourse and the exchange of ideas.

Perhaps the main interest and chief importance of the book at the present time, at any rate, for scientific men, lie in the last two chapters. There Dr. Fosdick outlines the evolution of the principles and practices with which the Foundation now works, and finally attempts to estimate the place and significance of such a private—and voluntary—institution in the world to-day. Both chapters are as relevant to problems facing us in Britain as they are to the American scene which Dr. Fosdick possibly has first in mind.

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* The Story of the Rockefeller Foundation. By Raymond B. Fosdick. Pp. 352. (London: Odhams Press, Ltd., 1952.) 25s. net.

Nor is it only to the administrator of research funds, either public or private, that the first of these chapters is of interest. Next to the importance of giving the public regularly sufficient information about a private foundation, or other voluntary body, so as to secure public confidence in, and understanding of, its purposes and work, Dr. Fosdick stresses the importance of elasticity. Enlarging on this and the undesirability of the grants of a foundation being tied up to rigid and unchangeable purposes, he shows that the trustees of the Foundation, following out Mr. Rockefeller's own ideas and distrust of the dead hand, have evolved a philosophy which avoids a danger, to which Lord Beveridge directed attention in his report on voluntary action and which Lord Nathan's committee is at present considering.

Dr. Fosdick describes the provisions regarding grants which the trustees have adopted to free the future so far as possible from frozen endowments. With this healthy scepticism of the ability of one generation to foresee the needs and requirements of the next, there goes much common sense that finds expression in other principles that have not always been given proper attention in the administration of grants. "Money", wrote Mr. Rockefeller nearly fifty years ago, "is a feeble offering without the study behind it which will make its expenditure effective"; and Dr. Fosdick emphasizes the dependence of any success in the Foundation's work on careful study and investigation as a basis for judgment. Once, however, grants are made to responsible groups or institutions, no degree of control over the operation of the grants has been or should be exercised by the Foundation.

Another danger to which Dr. Fosdick directs attention is the tendency to exalt the machinery of organization above the purpose for which the organization was created. The Foundation has indeed always placed much emphasis on the need for constant self-examination and adaptability to changing conditions. Departure from this principle, in fact, threatens the ability of the voluntary body to fulfil its prime and, as Lord Beveridge pointed out, indispensable function in the world of to-day—that of providing the growing-points of society, where there is freedom to experiment in ways that would not justify the commitment of public resources, or where such resources could not be deployed with the necessary freedom. The Rockefeller Foundation has, in fact, consistently recognized that its proper objective is to prime the pump, not to act as a permanent reservoir. With rare exceptions it has sought, in undertaking a new line of work, to begin in a small way and progress by trial and error to larger ends.

Manifestly the Rockefeller Foundation has been guided by essentially the same principles as the Nuffield Foundation and the Carnegie United Kingdom Trust, though its international preoccupations have rightly led the trustees to eschew some of the more local needs and problems that the other two bodies have been able to handle without risk of frittering away reserves on the trivial. The very success of such institutions in securing officers and trustees of the requisite quality, and the vindication of their policy of seeking first and foremost the most promising and most able men—of backing talent or brains, as Wickliffe Rose put it—contrasts sharply with some of the egalitarian tendencies of to-day. The question of the future of such foundations is inevitably raised by such a contrast, and all the more because the two main conclusions which Dr. Fosdick draws from his long experience strongly support the individualist point of view. The private foundation, writes Dr. Fosdick, should be a pioneering institution rather than a regular source of support for tried and established activities; it should work on the frontiers of knowledge and experience, rather than in the more settled areas behind. Moreover, promising men and creative ideas are the fundamentals; they are far more important than money, and the best that a foundation can hope to do is to put its support in the right place at the right time. Its utmost success lies in expediting the development of ideas which, without help, might be retarded.

The experience of the Rockefeller Foundation thus fully confirms that of the Nuffield Foundation and the Carnegie Trust, and endorses Lord Beveridge's argument as to the importance of voluntary action in the world of to-day if the opportunity for blazing new trails and for pioneering and creative experiments is to continue. Inevitably the question will be asked as to whether such bodies will be able or allowed to continue to function. Dr. Fosdick notes that, in its modern sense, the Foundation is an Americar phenomenon of the twentieth century. Only sever such foundations were established in the Uniteo States during the nineteenth century, wherea during the first decade of the twentieth a dozer new foundations were established, some twenty-twc in the second decade, and about ten a year sinc 1920.

Conditions in Great Britain are overweighte against the creation of any new trusts to-day, an recent reports point to the drying up of traditiona sources of income. The capacity of such bodies, a least in Britain, to continue operation in the ways i which they have been accustomed in the past, an on the principles which are so strikingly endorsed b Dr. Fosdick, is already seriously endangered; if the continue at all, their choice of objectives may be le adventurous and more difficult. Considerable as a the other merits of Dr. Fosdick's book, its greate service may well be its demonstration of the value the contribution which the voluntary body can mak to scientific advance and to social welfare in th world of to-day. It will remind us of the loss whic must follow if we fail to find effective measures f ensuring that opportunities and resources remain the disposal of the talented investigator or th creative minority to pursue their ideas untrammell by constraint of authority, orthodoxy or topic oth than their sense of duty to the community.

# TAXONOMY OF THE YEASTS

The Yeasts, a Taxonomic Study

By J. Lodder and N. J. W. Kreger-van Rij. Pp. xi+713. (Amsterdam: North Holland Publishing Company, 1952.) 130s.

THIS book, which is a successor to Stelling-Dekker's well-known "Die Sporogenen Hefen" (1931), to Lodder's "Die Anaskosporogenen Hefen I" (1934), and to Didden and Lodder's "Die Anaskosporogenen Hefen II" (1942), is based upon such a considerable intellectual effort and such an enormous amount of experimental work that it can truly be regarded as the 'Bible' of the yeast investigator. Few groups of organisms are so difficult to arrange into a reliable system of classification as the yeasts.

The authors have attempted in a most rational manner to overcome these difficulties, and, although this has necessitated considerable rearrangements in yeast taxonomy, compelling one to become accustomed to new names for previously well-established species, there is no doubt that their efforts, in general, have been successful. The basis for this study has been a thorough investigation of the extensive yeast collection of the Centraalbureau voor Schimmelcultures in Delft.

Morphological characters are employed in the book as the basis for the primary sub-divisions, and it is obvious that such characters, which may be observed without resorting to physiological tests, are of importance and are the most convenient and practical to employ. The yeasts as a whole are first divided into two large families and one small one—the ascosporogenous yeasts (Endomycetaceæ), the anascosporogenous yeasts which produce ballistospores on sterigmata (Sporobolomycetaceæ), and yeasts which produce neither ascospores nor ballistospores (Cryptococcaceæ). The further sub-division of these families into sub-families, genera and species is based upon morphological as well as physiological criteria. In all, approximately one hundred and eighty species and varieties are discussed. Whether the Sporobolomycetaceæ should actually have been included in this study is doubtful. This family, which comprises only a few species, all of which are unable to ferment, is treated in a special manner; in fact, the family name in the text does not appear as a page heading but has been replaced by "The Genera *Sporobolomyces* and *Bullera*".

It is not the place here to discuss the numerous examples of the grouping into a single species of forms which formerly were regarded as distinct species, nor to discuss the many instances of re-grouping within the genera. The authors have taken cognizance of the recent investigations showing that both *Zygosaccharomyces* and *Saccharomyces* diploidize in a similar manner and are therefore nearly indistinguishable, with the result that the only difference between them is that those types originally described as *Zygosaccharomyces* often remain haploid for a longer period of time than the others. With justification, the authors have placed all species of *Zygosaccharomyces* in the genus *Saccharomyces*.

The ability of each species described to ferment a series of sugars is listed, as well as the ability to assimilate the same sugars.

In Stelling-Dekker's book it is common to encounter species described under names which the author actually did not recognize. As an example, after the description of *Saccharomyces batatæ* Saito, it is stated that this form should be correctly classified under *S. cerevisiæ*. In Lodder and Kreger-van Rij's book, on the other hand, this yeast of Saito is discussed under the name which the authors accept: *S. cerevisiæ* var. *ellipsoideus*; this is obviously an improvement over the older work.

It is correctly stated on p. 45 that "two yeast strains which show the same sugar fermentation may not be genetically alike" and that the presence in a type of one or of several genes for the fermentation of a particular sugar "must inevitably be neglected in yeast taxonomy". The authors point out that the various constant morphological differences which are found must be considered to be of greater significance in classification.

The reliability of a taxonomic character such as pellicle formation, which is partly morphological and partly physiological, may be questioned. In the description of *Pichia* and of *Saccharomyces* on p. 54 and in the generic key on p. 78, the only significant difference between these two genera is the occurrence of pellicle formation in *Pichia* and its absence in *Saccharomyces*. However, we have found (through unpublished work performed by my former collaborator, O. Laustsen) that a *Hansenula* showing typical pellicle formation was able to segregate out from a single ascus two single-spore cultures with pellicle formation and two single-spore cultures without pellicle formation. All these four cultures were haploid. This fact indicates that pellicle formation is not a completely reliable systematic character. One may also question whether the generic character of *Hansenula* of nitrate assimilation is sufficiently important, in view of the fact that in many of the anascosporogenous yeasts both nitrate assimilating (N+) and non-nitrate assimilating (N−) species are found in the same genus.

It must be admitted that the difficulties encountered in erecting an acceptable system of yeast classification may justify the use of criteria which the systematist finds practical, even to the exclusion of a natural relationship and even if such a classification is not always completely logical. Of prime importance is whether the species can be identified by the system proposed, and in this respect the present work is certainly to be preferred to the earlier attempts.

It is inevitable that in such an extensive work errors will occur. With regard to minor errors, it can be noted that, on p. 333 as well as on other pages, "*Lypomyces*" is used instead of *Lipomyces*. In this connexion, it should be mentioned that, in the transfer of *Torula lipofera* to the genus *Lipomyces* (p. 335), the species should be called *Lipomyces lipofer* (not *lipoferus*, which is incorrect Latin). In the species index on p. 712 one finds "*Zygopichia*" as a heading for a long list of species. This should read "*Zygosaccharomyces*". It is incorrect to say that Lindegren (1949) "supposes that a dominant gene controls a high rate of enzyme production, whereas its recessive allele only is able to produce a very small amount of enzyme" (p. 46). This is the view held by Dr. Roberts and myself, proposed in 1948 in connexion with galactozymase, while Lindegren maintains that the recessive type, through mutation, may acquire the ability to synthesize the enzyme.

I am not in complete agreement with the statement that "If giant colonies are to be made the yeast is inoculated on malt gelatin in Petri dishes or Lindner flasks and observed after 4–8 weeks' incubation at 21° C.". I find that a lower temperature (15° C.)

produces a more characteristic surface appearance of the colonies, and that an incubation time of 3–4 weeks is quite sufficient. The authors have employed Einhorn tubes for their routine qualitative fermentation tests, although they consider Durham tubes more satisfactory. Actually, whether Einhorn or Durham tube is to be preferred depends upon the construction of the Einhorn. However, both tubes suffer the defect of allowing the carbon dioxide produced during fermentation to diffuse out of the sugar solution; this can, however, be overcome by employing mercury in the Einhorn. In our laboratory, we prefer the small Winge fermentometer, which is easy to use and inexpensive and which completely prevents gaseous diffusion.

These critical comments should, however, not detract from the merits of this imposing work, and there is good reason for congratulating the authors upon its completion. The book is provided with drawings which are a considerable improvement over those appearing in the earlier systematic works mentioned above. Nineteen new species and varieties have been erected and are described in Latin.

Øjvind Winge

# BRITISH PHARMACOPŒIA, 1953

### British Pharmacopœia 1953

Published under the direction of the General Medical Council. Official from 1 September 1953. Pp. xxiv+894. (London: Pharmaceutical Press, 1953.) 50s. net.

THE eighth "British Pharmacopœia", which becomes official on September 1, 1953, follows its predecessor after an interval of only five years. The Pharmacopœia Commission is to be congratulated on this acceleration of its output, which cuts down the time for this important standard work to get out of date. Much has happened during the past five years and many new drugs now appear for the first time, including aureomycin, cyanocobalamin, decamethonium, dibutylphthalate, ethyl*bis*coumacetate, folic acid, methadone, sodium aminosalicylate, troxidone and fifty-four other substances or preparations. There are also fifty-two new monographs which appeared in the addendum published in 1951 and now appear for the first time in the "Pharmacopœia" itself. The preparation of so much new matter is itself a formidable task; but the Commission has done much more than this. The number of old monographs ejected is even greater than the number of new monographs admitted. The Commission has shut its mind against sentiment and thrown out such old favourites as grey powder, Blaud's pill, squill, iodoform and aromatic spirit of ammonia. Some drugs, such as amidopyrin and diamorphine and sulphonal, are now thought too dangerous for general use, though some doctors still believe in them. Certain drugs of comparatively recent origin, such as acriflavine and dicoumarol and thiouracil, have been replaced by better drugs in the same class. The only remaining lozenge contains nothing but penicillin and sugar. As these examples will show, the Commission has spared no effort to ensure that the new book shall be efficient rather than picturesque and shall contain all essential drugs and nothing more.

The form of the book is more attractive than ever before. Latin has been deposed from pride of place, and the main title of each drug is given in English. The alphabetical arrangement has been improved, so that tincture of digitalis comes close to digitalis instead of being segregated with the other tinctures. Doses are given in the metric system, and the other weights and measures still used by old-fashioned doctors sometimes appear in brackets.

There is an interesting innovation in Appendix 15. Biological assays were first officially discussed in the 1932 "Pharmacopœia", and since then new methods of assay have been introduced from time to time, with various different recommendations for the design of the experiment. Some of the older ones were rather crude, and some of the newer ones were rather difficult to understand without much mathematical training. All such assays are based on the same general principles, and the Commission has prepared a section dealing with the design and accuracy of biological assays in general. It has thus been possible to eliminate repetition in the description of the separate assays and to introduce a simplified method of calculation which gives results accurate enough for all practical purposes. The methods now recommended are described in about a dozen pages with six examples of actual calculations, a table of *t*, a table of probits and a table of weights for probits. These methods of calculation do not include all the refinements recommended by some authorities, but they also do not include the inaccurate and unsatisfactory approximations recommended by other authorities; thus they should be found satisfactory for routine assays.

The new "Pharmacopœia", like all its predecessors, represents a great advance; but in this case the advance has been achieved in a very short time.

J. H. Gaddum

# SCIENCE IN PROGRESS

### Science in Progress

By Bradley M. Patten, George W. Corner, Arnold Gesell, H. J. Muller, T. M. Sonneborn, Ralph W. G. Wyckoff, Carl D. Anderson, Farrington Daniels, J. R. Dunning, Emil Artin, George Gaylord Simpson, Raymond M. Fuoss. Edited by George A. Baitsell. Seventh Series. Pp. xvii+512. (New Haven, Conn.: Yale University Press; London: Oxford University Press, 1951.) 40s. net.

THIS beautifully produced book is a worthy successor to the six former volumes in the series. Recent major contributions to many fields of science are described by the men who have been partly or wholly responsible for them. The new volume includes articles by two Nobel prize-winners and eight members of the United States National Academy of Sciences.

Dr. Bradley M. Patten writes of his research on the first heart-beats and the beginning of embryonic circulation in the developing chick; then follows a study of the action of ovarian hormones in the Rhesus monkey by Dr. George W. Corner, director of the Department of Embryology at the Carnegie Institution of Washington.

Dr. Arnold Gesell, who is known throughout the world for his work on the psychology of young children, presents a well-illustrated account of the psycho-physical development of the infant; analysis of cinema photographs of the child's reaction to its environment has been made possible by the use of a photographic dome for recording infant behaviour patterns. Then follows a long section by Dr. H. J Muller, of Indiana University, on radiation damage to the genetic material, in which much more research is called for on the long-term effects on tissue produced by frequent small doses of X-rays and other forms of radiation usually assumed to be safe.

The author of the next chapter, Prof. Tracy M. Sonneborn, professor of zoology in Indiana University, discovered a mating reaction associated with the conjugation of *Paramecium*, which culminated in the establishment of the concept of the plasmagene in cytoplasm, and he writes that "The ultimate task will be to reunite the nuclear and cytoplasmic components of the genetic system in an integrated, interreactional conception of the genetic system of the cell and the study of the function of each in the work of the whole". Dr. R. W. G. Wyckoff has a chapter on the structure of crystals, and his work is illustrated with some remarkable electron-microphotographs of virus crystals, in which the actual molecules may be seen. Carl D. Anderson, the discoverer of the positron, sums up the present position with regard to our knowledge of the elementary particles of physics, and Farrington Daniels, of the University of Wisconsin, reviews the possibilities of the future use of atomic and solar energy; no less than fifty fields of research in the utilization of the sun's energy are listed.

Pure mathematics has been given consideration in a section by Emil Artin, of Princeton University, in which the theory of braids is worked out by combining topology and the theory of groups. Finally, there are important chapters on the fauna of Latin America by George Gaylord Simpson, and on the physical chemistry of polymers by Raymond M. Fuoss. Each chapter is well documented.

W. L. SUMNER

# PROGRESS IN THE STUDY OF REAL CRYSTALS

Institut International de Physique Solvay
Neuvième Conseil de Physique tenu à l'Université Libre de Bruxelles, du 25 au 29 septembre 1951. L'État solide: Rapports et discussions. Pp. 577. (Bruxelles: R. Stoops, 1952.) 650 francs.

THE scientific committee of the Institut International de Physique Solvay convenes periodically a conference at which problems of some branch of physics are reviewed. The reader learns from the table of contents or from an aside on p. 167 that the main theme of this conference report on the solid state is that of imperfections and transformations, and principally the former. The book is a collection of papers, with discussions, and the majority deal specifically with studies of metals, although most problems treated have a wider application. Some of the papers review an aspect generally, but most describe particular developments with which the authors have been personally associated. Much of the subject-matter has, of course, been published already, and indeed, as is perhaps inevitable in a field in which such rapid developments are occurring, has also been discussed at recent conferences of similar scope. There is, however, some new work of interest to the specialist, and although its nature makes it rather disjointed, the book is to be recommended to a wider circle as an authoritative account of the state of development at September 1951 of he topics discussed.

The book begins with a fascinating paper by C. S. Smith describing the recent work on grain boundaries which has been stimulated by comparing the polycrystalline solid with a soap froth. There are three other papers concerned directly with grain boundaries and their properties. W. G. Burgers, discussing recrystallization, gives a comprehensive review of new data and ideas which have appeared since 1940 and includes a survey of new techniques for studying structural changes. G. W. Rathenau describes the application of one of these—electron emission microscopy—to the direct study of grain-boundary migration in metals at high temperatures. Calculations on the energy of grain boundaries using the dislocation model are reported by W. Shockley.

There are five papers about transformations. E. Rudberg reviews recent Swedish work, and this is supplemented later by a brief note from G. Borelius. Age-hardening and the order–disorder transformation are treated by W. Köster and A. Guinier, while C. Crussard describes his theory of the interference of thermal waves and its applications. Lattice vibrations are also discussed in J. Laval's detailed account of his theoretical work on the elastic properties of a perfect crystal in which the interatomic forces are not central.

The remaining papers are all concerned directly with the theory of dislocations. E. Orowan discusses the dynamics of slip and examines critically some of the fundamental hypotheses of this theory. There are articles by F. C. Frank on crystal growth, F. Seitz on the generation of vacancies by moving dislocations, and A. H. Cottrell on the yield-point in iron. N. F. Mott discusses current ideas on work-hardening, recovery and creep, and there is a short note from U. Dehlinger.

The dislocation theory has made great strides since the Second World War. At the time of the Bristol Conference in 1947, perhaps the most convincing parts of the theory were the explanations it afforded of the influence of traces of impurity on mechanical properties (atmosphere theory), and of the phenomenon of polygonization. Since that time the observation of spiral steps on the surfaces of growing crystals has provided direct evidence for the existence of dislocations. Also, the actual propagation of slip lines across the surface of a specimen has been studied with the high-speed camera. At the same time, it is now possible to understand how slow-moving dislocations can multiply. Already, important new evidence of the co-operative movement of dislocation arrays, predicted and referred to briefly in the paper of W. Shockley at this conference, is available in the experiments of Washburn and Parker, while the comparison of absolute grain-boundary energies for small angular disorientations with the predictions of the dislocation theory appears to make possible the first quantitative test of this theory. Much of the theory remains, however, frankly speculative, and, as E. Orowan emphasizes, the need for experimental support for its foundations is acute. There is some ground for confidence, however, that this will be increasingly forthcoming in the near future.

Despite its title, English-speaking readers will be glad to know that some three-quarters of the book is in their language. It is perhaps unkind to comment on the numerous errors of editing which result; but it is impossible to refrain from quoting the apposite heading of "Creed and Polygonisation".

B. A. BILBY

### Classical Mechanics

By Dr. D. E. Rutherford. (University Mathematical Texts.) Pp. viii+200. (Edinburgh and London: Oliver and Boyd, Ltd.; New York: Interscience Publishers, Inc., 1951.) 10*s*. 6*d*. net.

DR. D. E. RUTHERFORD'S aim is to provide a concise and unified account of classical theoretical mechanics from the beginning up to Hamilton's principle. There are five chapters, dealing respectively with kinematics, the nature of force, dynamics of a particle, dynamics of rigid bodies and generalized co-ordinates. A surprisingly large amount of information has been packed into a small space. For example, Chapter 4 contains not only the usual elementary theorems on rigid dynamics, and an account of Euler's equations and the top, but also some statics, including centre of gravity, Poinsot's central axis and virtual work. Chapter 5 includes Lagrange's equations, normal modes of oscillation, stability, Hamilton's equations and Hamilton's principle. There are examples for solution at the end of each chapter, the total number being 108, and an index.

There can be no doubt as to the value of the matter contained in the book; but it is rather puzzling to know for what type of student it is intended. The introduction points out that a knowledge of calculus, co-ordinate geometry, and vectors is required. It does not mention that p. 141 uses the notation and two theorems of matrix theory. Also there is no statement as to the previous knowledge of dynamics required; but it is obvious that a beginner will find great difficulty with some of the early pages—for example, p. 13 on moving axes. The introduction stresses that the book is arranged in logical order and not in order of increasing difficulty, and that "many readers may find it advisable, therefore, to read the various sections in an order other than that in which they are presented. Teachers will, no doubt, advise their students on this point according to the students' maturity". This last sentence transfers the task of presenting the subject in a form that can be easily assimilated from the author's to other shoulders.

H. T. H. PIAGGIO

### The Cold Working of Non-Ferrous Metals and Alloys

A Symposium on Metallurgical Aspects of the subject held in London on the occasion of the Annual General Meeting of the Institute, 14 March 1951. (Institute of Metals Monograph and Report Series, No. 12.) Pp. 207. (London: Institute of Metals, 1952.) 15*s*.

THE five papers which make up this symposium are reviews of particular aspects of cold-working, such as wire-drawing, cold-rolling and pressing. The practical techniques employed are examined in relation to the optimum process conditions for the more commonly used non-ferrous metals and alloys, with the fundamental aspects of cold-working reviewed in one general introductory paper. This may represent a just proportion in a work on applied metallurgy, but even in this paper the discussion is not extended to cover any detailed theory. The interpretation of cold-working phenomena in terms of dislocations, and the treatment given of deformation textures, are both so generalized that they give no more than a brief indication of current ideas. This is unavoidable in the space of the few pages devoted to these subjects, and the selection of the material, which must have been a difficult task, is, on the whole, well judged. The volume is clearly a most useful work for those actively connected with industrial processes which involve cold-working in any form. Most problems are touched upon, and where detail is inadequate the quoted references may be followed up. However, as the development and extension of such techniques depend upon a fuller understanding of the metallurgy and physics of the deformation mechanisms, a closer consideration of fundamentals would have widened its appeal.

A. J. KENNEDY

### Entwicklungsphysiologie

Von L. v. Ubisch. Pp. 85+16 plates. (Berlin: F. W. Peters, 1952.) n.p.

PROF. VON UBISCH has made important contributions to the experimental embryology of a wide variety of forms—echinoderms, ascidians, *Ascaris* and amphibians among them. He has, however, stood somewhat outside the major schools, such as the German, the Swedish and the Belgian, which have tended to dominate the subject in the past few decades, and his contributions have perhaps received rather less attention than was their due. It is therefore all the more gratifying to have from his pen a general treatment of the field. His little book is exceedingly short and is aimed at a student audience. Its brevity has enforced a most admirable clarity of theoretical outlook. Von Ubisch presents a very modern point of view: that the essential basis of differentiation is to be sought in the interaction between nuclei and locally differentiated cytoplasms, by which different sets of genes become activated or inhibited. In the space at his disposal the author can do little more than adumbrate this proposition and has had to forgo a discussion of much of the widely diversified evidence which bears on it, particularly from the side of genetics. However, little of major importance is omitted from his summary of the facts of experimental embryology, and his book is probably the best short and up-to-date account of it.

C. H. WADDINGTON

### Leibniz und das Reich der Gnade

Von Kurt Hildebrandt. Pp. viii+505. (Haag: Martinus Nijhoff, 1953.) 26.50 guilders.

CONTEMPORARY scholarship may perhaps be said to have 're-discovered' Leibniz; the stately volume here under review is not the only evidence of this trend in recent months, but it is a contribution of a somewhat special character, designed to set the great thinker at the centre of a specifically European philosophy, occidental in spirit and intended to be "understanded of the people". To this extent, it represents a return to the early Greek concept, when the love of wisdom was taught not so much as an academic subject, as a life to be lived. Thus, a not inappropriate rendering of the title of the present work might be "Leibniz and the Realm of Grace".

The first part is largely biographical, including the encounters with Locke and Newton. Next follows a typical *Systematik*, an assessment of the creative faculty in mankind, and the problem of good and evil. (The celebrated "Theodicy" comes in for attention earlier.) Finally, there is the inevitable discussion of action and re-action, including questions of belief and configuration. The latter should not be confused with the *Gestalt* of to-day; for Leibniz, 'shape' was more of an abstraction than it is to us. The book—a work of real distinction—concludes with a useful chronological table.

F. I. G. RAWLINS

## An Explaining and Pronouncing Dictionary of Scientific and Technical Words

10,000 Scientific and Technical Words in 50 Subjects explained as to a Person who has little or no Knowledge of the particular Subject. By Dr. W. E. Flood and Dr. Michael West. Pp. viii+397. (London, New York and Toronto: Longmans, Green and Co., Ltd., 1952.) 12*s.* 6*d.* net.

THIS is a very useful compact dictionary, and it will have a wide acceptance. In less than four hundred pages, ten thousand scientific and technical words in fifty subjects ranging from architecture to zoology are explained and given correct pronunciations. Like Larousse and Nuttall before them, but in a more generous and enlightened manner, the authors have supplied thirteen hundred pictures and diagrams to assist them in their explanations. A simple and effective method of cross-reference has been used in the book, and thus its value has been enhanced. The authors set themselves a number of working rules when they made their dictionary, and, by following these, their work has not degenerated into an unsatisfactory encyclopædia. Only a captious critic would find details which would evoke comment.

Why has oxygen not been given when nitrogen and hydrogen have? Why axolotl and not salamander, geriatrics and rheology but not cybernetics, harmonic but not consonance or temperament in their acoustic sense, coma with two meanings but without reference to lens aberrations? There is tawny port wine (which is important), but not polyploid, serology or the biological use of the word spindle. Very few of the explanations have suffered through the process of condensation, but some seem to need qualification; for example, "calciferol is found in yeast", "burn bones to make lime". There is a table which gives British and metric weights, measurements and temperatures, but atomic weights are not usually given. The most hypercritical reviewer would have to admit that in such a small but comprehensive volume some matters of choice must be left with the authors.

The book is excellent value for money and is attractively produced. It will be handy as a reference work for all intelligent citizens, even if their primary interest is not science. Many will be tempted to browse in it.
W. L. Sumner

## Tables of the Bessel Functions of the First Kind of Orders Seventy-nine through One Hundred and Thirty-five

By the Staff of the Computation Laboratory. (Annals of the Computation Laboratory of Harvard University, Vol. 14.) Pp. x+614. (Cambridge, Mass.: Harvard University Press; London: Oxford University Press, 1951.) 52*s.* net.

THE publication of this volume completes a project inaugurated in 1944 by the Computation Laboratory of Harvard University and continued since, at intervals, whenever the Laboratory's automatic computer was not engaged on work of higher priority. The results are given in a series of large volumes, of which this is the twelfth. Previous volumes in the series have been reviewed (*Nature*, 160, 772 (1947) and 163, 152 (1949)), and there is not much to add to what has already been said.

The original project was to tabulate the function $J_n(x)$, for positive integer $n$ up to 100 and for values of $x$ up to 100, to ten decimals, except that, for $n = 0(1)3$, values are given to eighteen decimals. For $x$ greater than 25, the tabular interval has so far been 0·01, but in the present volume it is increased to 0·05 at $n = 97$, and again to 0·1 at $n = 112$. It has been found possible to increase the range of $n$ up to 135, beyond which $J_n(x)$ is not significant to the tenth decimal at $x = 100$. The range of $x$ has been closed by the inclusion of a ten-decimal table of $J_n(100)$ up to $n = 135$, and a table of $J_n(n)$ for $n = 1(1)100$ is also given.

Dr. H. Aiken and his staff—and also the machine—are to be congratulated upon the completion of the great task which they set themselves, and the result is probably the most extensive piece of tabulation which has so far been attempted and brought to a successful conclusion.
W. G. Bickley

## Du Pont

The Autobiography of an American Enterprise. The Story of E. I. Du Pont de Nemours and Company published in commemoration of the 150th Anniversary of the Founding of the Company on July 19, 1802. Pp. vi+138. (New York: Charles Scribner's Sons, 1952.) n.p.

THIS handsome volume, richly illustrated partly in colour, traces the development of a famous American firm from its foundation in 1802 near Wilmington, Delaware, by a young refugee from France, Eleuthère Irénée du Pont, who had been a pupil of Lavoisier. Many of the illustrations connected with the early period are taken from the contemporary press and are of great interest in respect of such things as costume. The illustrations showing present-day conditions may seem at first sight too familiar to warrant inclusion; but in due time they also will come to be records of past days, equally interesting and valuable. The volume, which has drawn upon many sources, including the records of the firm, is one of the most interesting and attractive of its type which has come to the notice of the reviewer, and any library which looks to the future should make a point of including it.

## The Bay

By Gilbert C. Klingel. Pp. x+278. (London: Victor Gollancz, Ltd., 1952.) 12*s.* 6*d.* net.

THE bay of which Gilbert Klingel writes is the Chesapeake, stretching to the east of Maryland and Virginia, and so called after the American Indians who first peopled its shores. The coast is deeply indented with wide river mouths, long lagoons, estuaries, and thousands of small creeks, so that, it has been said, if the shore-line were straightened out it would stretch more than four thousand miles. For twenty years Klingel has watched the bay with the acute perceptions of an enthusiastic and experienced naturalist. In this book he describes the bay in many moods as well as the remarkable variety of its living forms. The latter he has studied above, on and below the surface of the bay; possibly his best descriptions are those of the living creatures which he met underwater. For Klingel is an experienced underwater observer and, whether in helmet, diving-suit or his curious home-made 'Bentharium', his close contacts with submarine life have produced descriptions of animal behaviour which put him in the top flight of writers on natural history. One of the best chapters is an account of happenings during a whole twenty-four hours spent in the heart of a swamp. The chapter on luminescence is equally good, while the author's description of his experience with the 'Bentharium' is one of exciting adventure.

# THE SUPERSONIC BANG

By G. M. LILLEY, R. WESTLEY, A. H. YATES and J. R. BUSING
Department of Aerodynamics, College of Aeronautics, Cranfield, Bucks

THE reason for the bang or bangs heard by ground observers after an aircraft has exceeded the speed of sound has been the subject of much speculation. In previous communications, Gold[1], Warren[2] and Rothwell[3] have based their explanations on Huygens's wavelet construction for a moving source which replaces the aircraft. They have shown that an observer will experience a bang if $-dr/dt = c$, where $r$ is the (scalar) distance between aircraft and observer, and $c$ is the speed of sound. This is simply the condition for the pulse waves emanating from successive elements of the supersonic flight path to form an envelope or wave front (Mach wave).

For a source moving in a straight line at a speed which increases and then decreases through the speed of sound, two curved wave fronts are formed, joined at their outer extremity by cusps (see Figs. 1–4 inclusive).

In the simple theory it is assumed that these waves, which eventually move ahead of the retarded source, cause bangs as they pass the observer. Although the calculated time interval between the two bangs, and the strength of the first wave front, have shown reasonable agreement with measured values obtained from a restricted series of flight experiments, the calculations to date do not predict a second wave front of comparable strength to the first. Experiments with aircraft in dives have shown, however, that the strength of each component of the double-bang is approximately equal. If instead of the Mach wave configuration the shock waves around an aircraft, in unsteady as well as steady flight, are considered, this discrepancy between theory and experiment does not arise.

Since it is only necessary to discuss the pattern of the shock wave at large distances from the aircraft, it is possible to replace the aircraft by an equivalent body of revolution. This avoids the complicated

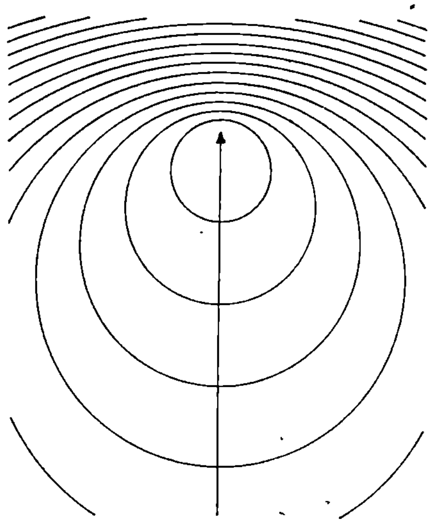

Fig. 1. Source moving along a straight line with constant subsonic speed, $M = 0 \cdot 8$

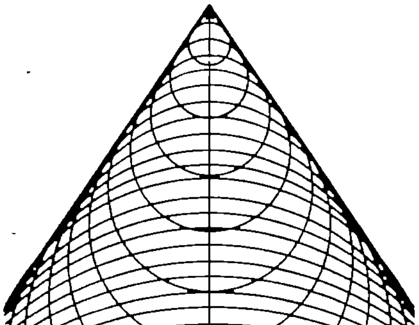

Fig. 2. Source moving along a straight line with constant supersonic speed, $M = 1 \cdot 6$

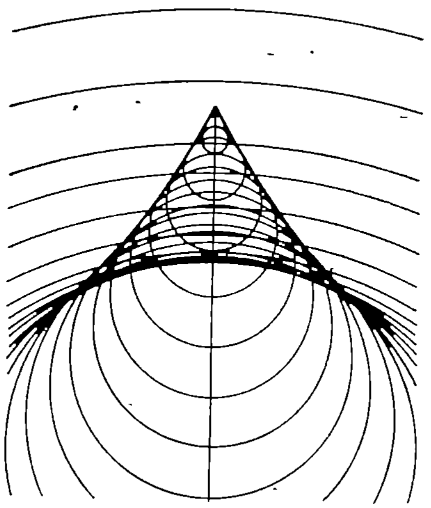

Fig. 3. Source accelerating along a straight line from subsonic to supersonic speed

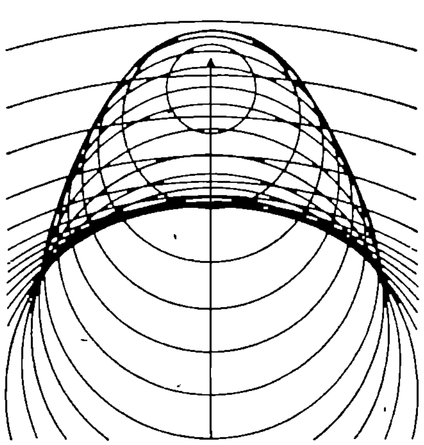

Fig. 4. Source accelerating along a straight line from subsonic to supersonic speed and then retarding to subsonic speed

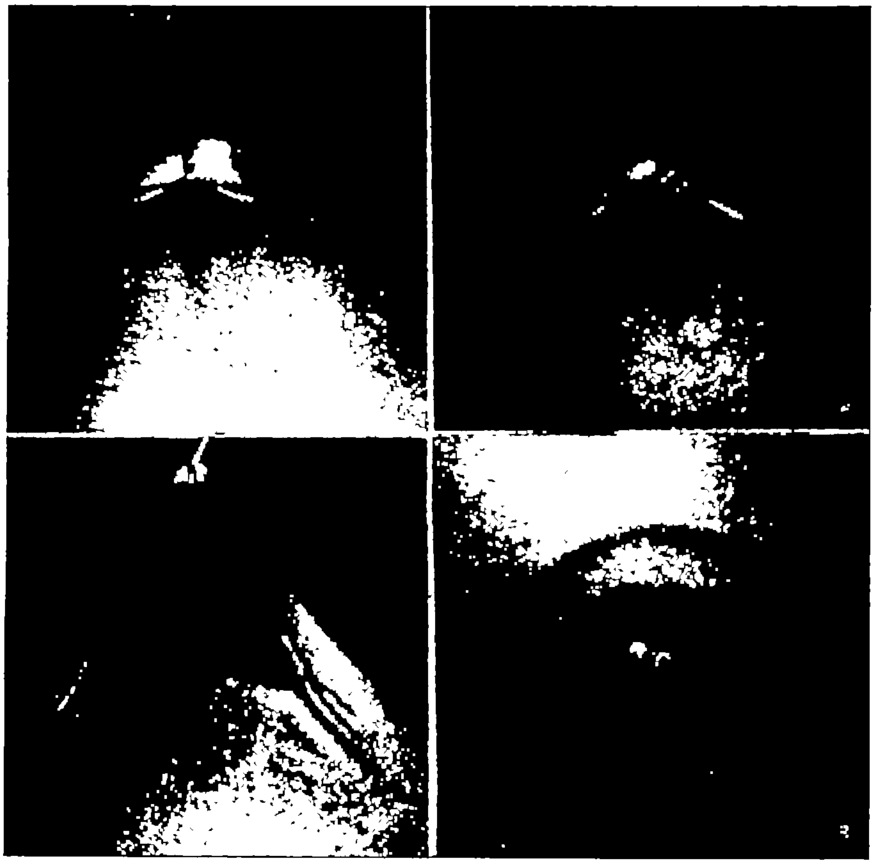

Fig. 5. Aerofoil accelerating (subsonic Mach No. ~ 0 95)

Fig. 6. Aerofoil accelerating (supersonic Mach No. ~ 1·1)

Fig. 7 Aerofoil at maximum speed (supersonic Mach. No. ~ 1 8)

Fig. 8. Aerofoil retarding (subsonic Mach No. ~ 0·6)

treatment of the multi-shock interaction close to the aircraft. Simple experiments[4] based on the hydraulic analogy technique, using towed models, have verified the shock-wave explanation of supersonic bangs (see Figs. 5–8).

## Shock-wave Configuration in Unsteady Flight

When a body is uniformly accelerated from rest up to high subsonic speeds below the critical Mach number (the Mach number of the body at which the local speed near the surface first reaches sonic speed), the flow pattern around the body at each instant will not be markedly different from that at the corresponding steady speed. At flight speeds above the critical Mach number, shock waves are formed around the body at the end of the local supersonic region. These shock waves move back towards the tail as the Mach number of the body is increased. At a sufficiently high subsonic Mach number, the tail shock becomes bifurcated with its rear member nearly normal to the wake (Fig. 5).

When the acceleration of the body is continued to supersonic speeds, a bow wave is formed just ahead of the body (Fig. 6). Unlike the front tail wave, it remains approximately normal, near the body, at least over a finite range of supersonic speeds. It becomes attached to the nose, if sharp, above a certain supersonic Mach number, which is a function of the nose angle (Fig. 7). The extent of the bow wave and its distance from the nose is a function of the body geometry, the body speed and acceleration, as well as the complete time-history of the motion. Thus the bow wave can only attain its steady state configuration after an infinite time. Away from the body axis the interaction of the expansion waves (which are necessary to accelerate the flow between the bow and tail waves) with the bow wave reduces its inclination relative to the flight path. It can be seen, therefore, that marked differences occur between the formation of the bow and tail waves. In the latter case, the wave is concave forwards, close to the body (Fig. 5), and the formation of its rear member is therefore analogous to that of the Mach waves associated with an accelerated point source (Fig. 3). The bow wave is, however, convex forwards (Fig. 6), and a simple qualitative analysis will show that the flow inhibits the formation of cusps at its outer extremity. Thus for a body accelerated from subsonic to supersonic speeds, the shock formation consists of a bow wave ahead of, or attached to, the nose, and separated from the front tail wave by a system of expansion waves, plus a rear transverse wave joined to the front tail wave at its outer extremity.

When the body is retarded and its speed falls below the critical Mach number, the bow wave will have travelled far ahead of the nose, since it detaches itself from the body when its speed is just above sonic. The front tail wave will travel slowly towards the nose, and in doing so becomes approximately normal to the surface. Its shape changes and it becomes convex to the direction of the motion. It moves ahead of the body when the speed of the latter falls below the critical Mach number. The rear tail wave moves towards the body, overtakes it, and finally it also moves ahead of the body (Fig. 8). Thus the shock wave formation ahead of a body, retarded from supersonic motion of finite duration to subsonic, is a bow wave separated from the front tail wave by a system of expansion waves, and trailing farther behind a rear transverse wave joined to the front tail wave at its outer extremity. The two members of the tail wave tend to coalesce after a finite time. Thus at a large distance ahead of a body executing this simple manœuvre, we shall have either two or three shock waves each travelling at approximately the speed of sound. The first two waves will have similar strengths, whereas the third wave, if it has not overtaken the front tail wave, will be considerably weaker.

The distance apart of the shock waves can be calculated approximately as follows. The distance between the bow and the front tail wave is equal to the speed of sound multiplied by the time for the body to slow down from sonic speed to just below its critical Mach number. The distance between the bow wave and the rear tail wave depends on the time-history of the accelerated and then retarded motion of the body. When this is known, the calculation can be completed, since it has been shown that the rear tail wave is left behind in the wake of the body at the commencement of the supersonic motion, while the bow wave separates from the body at the conclusion of the supersonic motion. In addition, as a first approximation, it may be assumed that the free shock waves are moving normal to themselves at the speed of sound. The spread of the shock waves after a given time can be found approximately from the corresponding Huygens wave diagrams for the motion of a point source which replaces the body.

In the case of steady motion at supersonic speeds, the bow and tail shock waves are of infinite extent, except where they are reflected from solid surfaces. The rear tail wave is now infinitely far behind the body and hence is not observed.

### Noise from High-speed Aircraft

In the case of jet-propelled aircraft travelling at high subsonic speeds, the main noise is due to the turbulent motion created by the jet. At supersonic body speeds, the sensation of noise caused by shock waves, even when they are weak, is very much greater than that due to other sources, although the duration of the noise is very short. For a body flying at constant supersonic speed at a fixed altitude, the bow and tail shock waves will sweep over the ground, and these and their reflexions will be heard by observers as separate bangs, only if their time interval is greater than about 0·02 sec. For a body executing a high-speed dive, during which the speed increases and then decreases through sonic speed, ground observers may hear one, two or three bangs depending upon their location and the time-history of the motion. In the cases where more complicated manœuvres are executed, simple analysis will determine the number of bangs to be expected.

In the discussion above, the refraction of the shock waves through a non-uniform atmosphere has not been considered. This will not invalidate the above results; but it should be noted that for certain manœuvres the shock waves produced around the body at altitude will not penetrate to the ground.

[1] Gold, T., *Nature*, 170, 808 (1952).

[2] Warren, C. H. E., *Nature*, 171, 215 (1953).

[3] Rothwell, P., *Nature*, 171, 216 (1953).

[4] Lilley, G. M., and others, College of Aeronautics Report 71 (1953).

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## HEALTH OF THE SCHOOL CHILD[*]

THE report of the Chief Medical Officer of the Ministry of Education for the years 1950 and 1951 shows that the mortality-rate of children aged 5–14 years is still falling. Of the 3,341 children who died in 1950, 851 met their deaths through accidents—about half of them motor accidents. 294 children died of tuberculosis compared with 937 in 1938, 207 of cancer and 153 of poliomyelitis. Deaths from diphtheria continued to fall: 16 children died in 1950 compared with 1,733 in 1938. The general health of the children continues to improve.

There has been a remarkable reduction in skin disease among children. During 1947–51 the number of children with scabies, impetigo and ringworm of scalp has fallen from 108,000 to 34,000. Acute rheumatism is being reduced, and although more than 4,000 children a year suffer from this disease, this is less than a third of the number ten years ago.

Cleanliness of school children is also improving. "Even so," states the report, "it is inexcusable that 347,544 children (6%) were found verminous in 1951. Parents of consistently verminous children must have very little self-respect." A persistent campaign is being waged against this problem; but success in preventing repeated re-infestation depends upon the measures taken to deal with possible verminous conditions in other members of the family—in particular, the pre-school child and the young adult. In one area, methods of treatment include an offer of DDT hair-cream to the parent.

Nearly 4¼ million children were examined or re-examined during 1951 by school medical officers. 157,566 children were found to have defects in vision and a further 37,499 children required treatment for squint compared with 31,189 in 1949. Nearly three children in every thousand required treatment for defective hearing, and nearly five in every thousand were recommended to be kept under observation. More attention is now being paid to the ascertainment of deafness in children as it is considered vital to treat them early in school-life.

The report includes a highly critical survey of open-air schools by four medical officers of the Ministry. In their account of premises they state: "There are in this country some first class open-air schools which have been designed to give the children full benefit from fresh-air and sunlight, but there are others which are merely ramshackle wooden huts, unpleasant to live in and ugly to look at. In some of the schools the walls were simply screens, made partly of wood and partly of canvas extending from the floor about 2–4 feet from the ceiling. The rooms were without any means of heating and were often without artificial light. In wet, windy weather, rain drove in between and above the curtains so that the floor and furniture were often wet. We saw children scraping frozen snow off the desks and chairs before they could be used. In cold weather the children sat at their desks wearing hats, caps, coats, scarves and gloves, and with blankets round their legs. As doctors, we cannot feel that refrigeration or dampness contributes to health and, therefore, we strongly condemn the 'bandstand' type of classroom. In one school on a wet day we saw the children lying on damp canvas stretchers in an unheated, open-fronted stone-floored shed, with the rain driving in at the front and leaking through the roof".

The report explains that a well-conducted open-air school is of great value for delicate children, and apart from its physical benefits, they usually find sheer pleasure in being out of doors; but they must be kept dry and reasonably warm. There is still a place for these schools, especially in industrial areas; but no expansion of existing provision is considered necessary. "With a rising standard of living, better housing, the provision of meals and milk in schools, and with a fuller appreciation in the ordinary schools of the varying needs of individual children, it may be that the need for special schools for 'delicate' children will diminish with the years."

[*] Health of the School Child. (H.M.S.O.) 5s. net.

# BIOSYNTHESIS OF PROTEINS*

By Dr. P. N. CAMPBELL and Dr. T. S. WORK
National Institute for Medical Research, Mill Hill, London, N.W.7

BIOCHEMICAL research has been concentrated until recently on the degradative rather than on the synthetic reactions of the living cell. This was the natural outcome of limitations imposed by technique. The products of degradation are small molecules amenable to investigation by the classical techniques of organic chemistry, whereas the products of synthesis are often of high molecular weight and of embarrassing complexity. The introduction of isotopic tracers, of chromatography and of high-speed centrifuges has made possible a reorientation of research. Among the many problems open to attack by these new methods, that of protein synthesis is among the most formidable and most important.

Proteins such as those of hair and skin cannot be said to have any definite molecular weight and they may well have no definite molecular structure, but the smaller water-soluble proteins when purified show many of the attributes of homogeneous molecular species. Thus, for example, it seems likely that all the insulin molecules produced by one animal are of identical structure. There is no indubitable proof of this view, but the recent determinations by Sanger and Porter[1] of protein end-groups, the work of Porter[2] and of Schroeder[3] on amino-acid sequences adjacent to the end-groups, and especially the recent work of Sanger[4] on the amino-acid sequences in insulin, all suggest that a single purified protein is a single molecular species.

It is known from the classical investigations of Nuttall[5] and others that the morphological differences between species are no more distinct than the serological differences between the proteins of those species. Thus, for example, purified duck ovalbumin can be distinguished from purified hen ovalbumin by immunological methods[6]. In the same way the serum globulins, the fibrinogens, the trypsins and the hæmoglobins of two closely related species may be indistinguishable by physical methods but serologically distinct. The work of Landsteiner[7] and others has suggested that immunological specificity is the reflexion of a specific chemical structure. Thus it is reasonable to suppose that each type of cell possesses enzymic mechanisms capable of exact control of the amino-acid composition and sequence of all its proteins. This conclusion is fortified by the recent investigations of Sanger[8], of Lens[9] and of Craig[10] on sheep, pig and bovine insulins. These proteins are indistinguishable by physical methods and are of equal biological potency but are chemically distinct. Apparently the pancreatic cells of each species control the exact reproduction of a complex polypeptide pattern characteristic of the species. For some proteins the specificity of structure appears to be controlled within even narrower limits than that of the species and is characteristic of the family, the specific immunological character of the protein then being inherited within the family. To understand the mechanism of protein synthesis is thus a step towards understanding the inheritance of character and the continuity of the species.

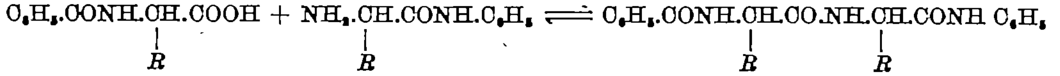
## Protein Turnover in the Adult Animal

In the early years of the present century much progress was made in the study of protein digestion. By 1920 it was generally accepted that ingested protein was degraded by proteolytic enzymes in the stomach and gut and that the nitrogen was absorbed as free amino-acids[11]. The work of Folin[12] indicated that in the adult the dietary amino-acids were rapidly oxidized, and thus most of the nitrogen was excreted as urea. It was assumed, therefore, that protein synthesis almost stopped when growth stopped. However, in 1935 Borsook and Keighley[13] presented evidence to suggest that there is a continuous and high rate of protein synthesis even in the adult animal. In 1939 this conclusion was supported by the results of Schoenheimer[14] on the distribution of isotopic nitrogen ($^{15}N$) after feeding $^{15}N$-glycine to rats. This work proved beyond doubt that there is, even in the adult animal, a constant and rapid turnover of many body proteins. Shemin and Rittenberg[15] later showed that the average life of rat liver protein was about seven days. Such rapid turnover is not, however, characteristic of all body proteins, since Neuberger and Slack[16] have recently shown that the rate of turnover of collagen in the adult rat is very low.

## Enzymic Synthesis of Protein *in vitro*

When proteolytic enzymes are allowed to act upon protein in dilute aqueous solution, there is rapid hydrolysis of peptide bonds and liberation of small peptides and amino-acids. However, so long ago as 1901, Sawjalow[17] showed that when a concentrated solution of peptone was treated with fresh gastric enzyme there was formation of a precipitate which appeared to be protein in nature. This material was given the name 'plastein'. Even to-day, plastein formation continues to excite considerable interest as the simplest example of protein synthesis (cf. Tauber[18]).

The work of Bergmann and his colleagues, especially Fruton, on synthesis of small peptides by proteolytic enzymes has done much to clarify the mechanism of plastein formation. It is fundamental to the definition of an enzyme that it should be able to catalyse a reaction in both directions. For example, in dilute aqueous solution papain catalyses the hydrolysis of casein; but if papain is incubated with a concentrated solution of benzoylleucine and leucine anilide, a peptide bond is formed between the two leucines and benzoylleucylleucine anilide is precipitated from the solution:



$$C_6H_5.CONH.\underset{R}{\underset{|}{CH}}.COOH + NH_2.\underset{R}{\underset{|}{CH}}.CONH.C_6H_5 \rightleftharpoons C_6H_5.CONH.\underset{R}{\underset{|}{CH}}.CO.NH.\underset{R}{\underset{|}{CH}}.CONH\,C_6H_5$$

Benzoylleucine and leucine anilide are readily soluble in water, but benzoylleucylleucine anilide is very sparingly soluble. Papain catalyses the reaction in both directions, but the very low solubility of benzoylleucylleucine anilide in water causes immediate precipitation of the peptide as formed and the reaction is forced from left to right (Bergmann and Fraenkel-Conrat[19]).

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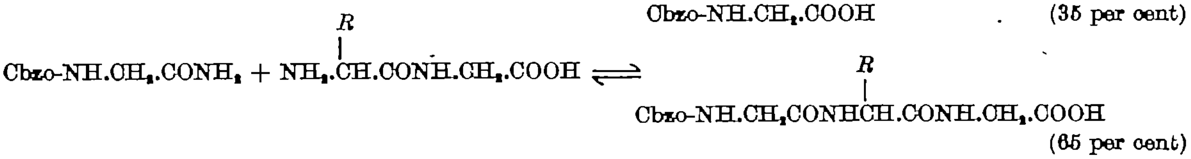
* Based on two lectures given by Dr. T. S. Work, honorary lecturer in pharmacology, at University College, London, on February 16 and 20.

During the past three years, Fruton[20] has shown that proteolytic enzymes also catalyse the exchange of one amino-acid for another within a peptide chain. Papain was incubated with carbobenzoxyglycine amide, leucylglycine and buffer. The enzyme catalysed the hydrolysis of the amide link in carbobenzoxyglycine amide, but not that of leucylglycine. When the reaction mixture was analysed it was found to contain 35 per cent carbobenzoxyglycine and 65 per cent carbobenzoxyglycylleucylglycine :



$$\text{Cbzo-NH.CH}_2\text{.CONH}_2 + \text{NH}_2.\overset{\overset{\textstyle R}{|}}{\text{C}}\text{H.CONH.CH}_2\text{.COOH} \rightleftharpoons \begin{array}{ll} \text{Cbzo-NH.CH}_2\text{.COOH} & \text{(35 per cent)} \\ \text{Cbzo-NH.CH}_2\text{CONH}\overset{\overset{\textstyle R}{|}}{\text{C}}\text{H.CONH.CH}_2\text{.COOH} & \text{(65 per cent)} \end{array}$$

The enzyme had thus catalysed not only hydrolysis but also exchange of a peptide for a simple amide nitrogen. This transpeptidation, as it has been called by Fruton[21], shows that a proteolytic enzyme such as papain can act to lengthen a peptide chain provided that the necessary energy is available in the form of a preformed amide or peptide bond.

It is now reasonably clear that in plastein formation the concentrated solution of low-molecular weight peptides undergoes partial hydrolysis and partial transpeptidation, so that during the rather random rearrangement which takes place some peptide chains grow at the expense of others and eventually are precipitated as protein-like material.

## Transpeptidation as a Mechanism for Protein Synthesis

It is known that all cells contain intracellular cathepsins, which are enzymes similar to papain, and it may reasonably be asked whether such enzymes could be responsible in part for protein synthesis. From our knowledge of the behaviour of proteases *in vitro* and from a knowledge of the thermodynamics of peptide-bond formation, it is possible to say at once that, if the intracellular cathepsins do take part in protein synthesis, they could only do so when provided with a supply of energy, probably in the form of a pool of preformed amide or peptide bonds. Study of amide-bond formation was initiated by the observation of Fuller[22] that sulphanilamide given by mouth is rapidly acetylated and excreted in the urine as acetylsulphanilamide. In 1945 Lipmann[23] found that a homogenate of pigeon liver could acetylate considerable quantities of sulphanilamide under aerobic conditions, but that anaerobically acetylation was slight unless adenosine triphosphate was added to the homogenate. In Lipmann's nomenclature, this suggested that energy for amide-bond formation was supplied by the energy-rich phosphate bonds of adenosine triphosphate. Borsook and Dubnoff[24] showed that adenosine triphosphate also stimulated formation of hippuric acid by guinea pig liver homogenates. Moreover, the formation of glutamine from glutamic acid by cell-free enzyme preparations was shown by Speck[25] and by Elliott[26] to require adenosine triphosphate. True peptide-bond formation as opposed to simple amide-bond formation has been studied by Bloch[27]. An extract was obtained from pigeon liver which catalysed the formation of glutathione from glutamylcysteine and glycine. For this condensation a supply of adenosine triphosphate was essential.

The exact mechanisms of these examples of amide- and peptide-bond formation are not understood, but it is clear that cells possess a variety of mechanisms for the conversion of phosphate-bond energy into amide or peptide bonds. Thus, from the thermodynamic point of view, there is no insuperable objection to supposing that protein synthesis takes place by transpeptidation catalysed by the intracellular cathepsins.

Attempts have been made during the past few years to obtain direct evidence for the conversion of simple amides and peptides into other peptides by transpeptidation. Waelsch[28] has shown that cell extracts can catalyse a reaction between glutamine and various amino-acids to give γ-glutamyl peptides. Hanes, Hird and Isherwood[29] have shown that kidney extracts catalyse formation of γ-glutamyl peptides from glutathione and various free amino-acids. In each case the product is a γ-peptide and not an α-peptide, and therefore the reactions are not quite satisfactory as examples of cellular transpeptidation from an amide-bond pool; but further work along the same lines may well reveal other examples of transpeptidation or other amide-bond pools.

## Objections to the Transpeptidation Theory

It should be clear from what has been said that there is much indirect evidence in favour of transpeptidation as a possible mechanism for protein synthesis. Evidence that a theory is possible should not be taken as proof that it is correct; there are various observations difficult to reconcile with a transpeptidation mechanism.

It is obvious that, if protein synthesis takes place by transpeptidation, there should be present in cells a great variety of intermediate peptides, and we should expect that cells would find no difficulty in using for synthesis peptides supplied in their nutrient medium. Many experiments suggest that this is not so; thus, for example, an animal can be maintained in positive nitrogen balance by intravenous infusion of suitable mixtures of amino-acids; when a partial hydrolysate of protein is used instead of amino-acids, the animal appears to be unable to use much of the peptide material and this is rapidly excreted in the urine[30].

A similar difficulty arises in the study of the nutritional requirements of micro-organisms. Many organisms show loss of ability to synthesize one or other of the twenty amino-acids, but organisms have not been found with absolute growth requirements for peptides. Moreover, when a peptide has been found to have growth-promoting properties, this has usually been shown to be due to hydrolysis of the peptide (see ref. 55). Against this must be set a recent observation of Marshall and Woods[31] that the inhibition of bacterial growth by 4-methyltryptophan can be reversed by tryptophan peptides in a non-competitive manner. They suggest that 4-methyltryptophan inhibits growth by virtue of its ability to inhibit synthesis of tryptophan peptides; thus a supply of peptide in the medium renders the organisms insensitive to 4-methyltryptophan. It must be remembered also that, although there is little direct evidence of the use of peptides by bacteria, it is seldom that these organisms reach their maximal rate of growth except in complex peptide media[32].

It has frequently been claimed that, if peptides played any prominent part in protein synthesis, it should be possible to find peptides in cell extracts. No significant quantity of any peptide other than glutathione has ever been isolated from such extracts, but the value of this as evidence is extremely doubtful. It may be that proteolytic enzymes have no function in protein synthesis; but it is accepted that they must be responsible for intracellular degradation of protein. This degradation must take place by a stepwise process with production of numerous peptides, so that failure to isolate peptides is of no significance except as a demonstration of the inadequacy of our techniques.

## Control of Specificity in Protein Synthesis: the Template Theory

Any scheme of protein synthesis must take into account immunological and chemical evidence that the proteins of each species appear to be unique and structurally distinct from those of other related species. To control synthesis in such a highly specific manner the transpeptidases would be required to show an extremely high degree of specificity. The work of the Bergmann school has shown that pepsin, trypsin, chymotrypsin and papain all have some specificity[33]. Each hydrolyses certain limited groups of peptides; but the recent results of Sanger[34] and of Desnuelle[35] suggest that proteases have different specificities when acting upon larger polypeptide chains. Their specificity in transpeptidation is still largely unknown.

If transpeptidation and coupling of many peptide units are the mechanism of protein synthesis, then many enzymes would be required for the synthesis of a single species-specific protein. These synthesizing enzymes would in their turn have to be synthesized by equally specific enzymes, so that we are faced with an infinitely receding series of enzymes controlling the synthesis of enzymes. However, the specificity of protein structure appears to be inherited within any one species, and the syntheses of proteins would appear, therefore, to be under genetic control.

So long ago as 1909, Bateson[36] suggested that there might be a connexion between genes and enzymes. The concept of the gene was originally a purely formal one, namely, that it is the ultimate unit of hereditary transmission; but in 1937 Haldane[37] suggested that genes had the dimensions of protein molecules. He pointed out that genes must be copied exactly in each succeeding generation and suggested that they behaved as master templates or moulds controlling the specificity of protein structure. This idea was extended still further by Beadle following his study with Tatum[38] of the effect of mutagenic agents on the bread mould, *Neurospora crassa*. After exposing a mould to X-rays, progeny could be isolated with changed nutritional requirements owing to inability to carry out one single step in the synthesis of an essential metabolite. The defect was inherited in a Mendelian pattern as though it were controlled by a single gene mutation, and was shown to be due to lack of a single enzyme. Beadle[39] suggested a one-to-one relationship between genes and enzymes. Since enzymes are proteins, it was a simple extension of this hypothesis to suggest that genes are master templates upon which proteins are synthesized, and that for each specific protein structure there is a template or gene.

Since the segregation of chromosomes during formation of the gamete cells exactly parallels the segregation of genes, it is reasonable to suppose that genes are located on the chromosomes. Both Brachet[40] and Caspersson[41] (using different methods) have shown that chromosomes contain much nucleoprotein and there appears to be good reason for supposing that the ultimate unit of self-reproduction, the gene, is composed either of nucleic acid or protein or an association of the two. Similarly, Stanley[42] has shown that the tobacco mosaic virus, another form of self-reproducing agent, is composed entirely of nucleic acid and protein. The same appears to be true of the bacterial viruses such as *Escherichia coli* phage[43]. Hershey and Chase[44] have labelled coli phage with radioactive phosphorus and sulphur and have shown that when the phage infects the bacterium only the radioactive phosphorus enters the cell and reappears in the phage progeny. Since phosphorus is associated with the nucleic acid fraction of the phage, it is reasonable to conclude that the nucleic acid fraction carries the inherited specificity of the virus. Emphasis on nucleic acid as the controlling factor in transmission of hereditary character and therefore of protein specificity has been increased by the demonstration that type transformation in bacteria can be brought about by cell extracts from other related bacteria and that the active factors in these extracts are nucleic acids[45]. The report of Binkley[45a] that cysteinylglycinase is a polynucleotide directly associates protein metabolism with enzymic activity in a polynucleotide.

In an attempt to take all these factors into account, Dounce[46] has recently outlined an ingenious theory of protein synthesis in which allowance is made for the close association between nucleic acids and inherited character. He suggests that nucleic acids function as templates in governing the order of arrangement of amino-acids in peptide chains as well as the order of nucleic acids in nucleic acid chains. It is supposed that the nucleic acid template is first phosphorylated to give a nucleic acid polyphosphate with a series of energy-rich phosphate bonds; this polyphosphate then reacts either with nucleoside or with amino-acids, thus giving either a double nucleic acid complex or a nucleic acid – amino-acid complex. Linear polymerization of the added nucleosides or amino-acids would then give either a complete replica of the original nucleic acid or a peptide chain, the specificity of which is dependent upon the nature of the original template of nucleic acid [see also p. 1027 of this issue].

This theory has several attractive features: it provides a mechanism for reproduction of the template or gene; it supplies an explanation of the genetic control of protein specificity by nucleic acid; it explains the failure to demonstrate any metabolic function for small peptides; and it provides a mechanism of energy supply for peptide bond formation. In spite of this, there are various facts which do not seem to fit any theory involving control of protein specificity by permanent nucleic acid templates acting as genes.

## Objections to the Template Theory

Caspersson[41] has suggested that protein synthesis takes place at the nuclear membrane; but there is now no doubt that much protein synthesis takes place in the cytoplasmic granules. London, Shemin and Rittenberg[47] have obtained synthesis of hæmoglobin in non-nucleated erythrocytes, and Brachet and Chantrenne[48] have shown that non-nucleated fragments of the marine alga *Acetabularia* can continue to synthesize protein for several weeks. Since proteins synthesized in the cytoplasm are undoubtedly species specific, the direct control of specificity of each protein by a nuclear gene acting as a template seems improbable.

The process of differentiation in higher organisms is also difficult to understand in terms of a controlling template in the nucleus. It would necessarily involve nuclear differentiation of the template, but this seems contrary to the assumption of a one-to-one relationship between templates and genes. There is, in fact, some recent work which suggests that nuclear differentiation does take place (Stern *et al.*[49]). Other apparent exceptions to the control of protein specificity by nuclear templates are adaptive enzyme formation in bacteria and antibody formation in animals. The adaptive enzyme is a new protein not only characteristic of the species but also characteristic of the substrate or inductor (Monod and Cohn[50]); while a new antibody is characteristic not only of the animal immunized but also of the antibody used for immunization.

It is frequently taken as proved that there is a direct correlation between nucleic acid synthesis and protein synthesis, but there is clear evidence that each can proceed in the absence of the other: according to Hokin[51], pancreatic slices can synthesize amylase without simultaneous synthesis of nucleic acid and indeed without turnover of nucleic acid phosphorus; according to Gale and Folkes[52] protein synthesis can be inhibited by antibiotics without simultaneous inhibition of nucleic acid synthesis.

The conception of the gene is essentially an abstract idea and it may be a mistake to try to clothe this idea in a coat of nucleic acid or protein. Perhaps the most striking of all immunological observations is the fact that, despite differentiation, an animal cannot usually be immunized against its own proteins. This would seem to support the idea that if we must have a gene it should have a negative rather than a positive function so far as protein synthesis is concerned. Expressed in terms of protein synthesis, this would mean not that all the proteins of an individual have some common structural pattern, but rather that they are alike in that they all lack some possible peptide sequence which other species have found it possible to synthesize.

## Experimental Approach to the Study of Protein Synthesis *in vivo*

The advent of isotopic tracers and of improved chromatographic methods for the separation of amino-acids and peptides has made possible a more direct approach to the problem. As a suitable system for the study of protein biosynthesis, we have chosen the lactating mammary gland. Numerous earlier attempts have been made to determine the nature of the precursors of milk protein. By measuring the difference in amino-acid content between arterial blood entering, and venous blood leaving, the gland, it was concluded that little more than one-third of the milk nitrogen was supplied as free amino-acids[53]. If this is so, the mammary gland must be capable of transforming blood protein into milk protein, and it therefore seems to us that the gland was a particularly suitable organ for the study of protein biosynthesis (Campbell and Work[54]).

In preliminary experiments lactating rabbits were injected with radioactive amino-acids and the distribution of radioactivity in the blood and milk proteins was followed for seven days. If milk protein is derived from blood protein by minor transpeptidations, the injected radioactive amino-acids would not reach equilibration with intermediary peptides. In this case the radioactivity curves for blood and milk proteins would be expected to be of similar shape. In fact, it was found that the two curves showed no similarity, and that after six hours the milk casein was ten times more radioactive than blood plasma protein. From this result it was clear that the milk was synthesized largely if not entirely from free amino-acids. Other experiments using labelled radioactive plasma suggest that little of the free amino-acid is supplied by breakdown of plasma protein. It was noticed, however, that the casein was always more radioactive than the whey protein, and it thus seemed possible that casein was synthesized entirely from free amino-acids but that whey protein synthesis was by transpeptidation[55]. Whey is, however, a complex mixture of different proteins, and it was equally possible that some whey proteins were synthesized entirely from amino-acids and others obtained directly from blood protein.

By injection of radioactive methionine into an immunized rabbit, Campbell, Humphrey and Work[56] have recently shown that there is indeed direct transfer of antibody globulin from blood to milk; it thus seemed likely that this transfer would explain the low radioactivity of whey as compared to casein. To check this point, a lactating goat was injected with a mixture of four radioactive amino-acids and the milk collected four hours later[57]. The whey proteins were fractionated by the usual methods, and a β-lactoglobulin fraction was obtained which was electrophoretically homogeneous at pH 8·4. The radioactive amino-acids were re-isolated from this protein and compared with the corresponding amino-acids isolated from the casein. Valine and lysine were of the same activity in both proteins, but glycine, serine and methionine were less active in β-lactoglobulin than in casein.

It can be demonstrated on theoretical grounds that if two milk proteins are being synthesized on templates and from the same radioactive amino-acid pool, then the radioactivities of the amino-acids in the two proteins should be equal. The difference found between goat casein and goat lactoglobulin therefore suggested that peptides did, in fact, occur as intermediates in protein synthesis.

## Distribution of Radioactivity at Different Points along a Peptide Chain

Let us suppose that protein is synthesized by stepwise coupling of many peptide units, some peptides being supplied by partial hydrolysis and transpeptidation of existing protein. After injection of radioactive valine, the protein formed would contain this amino-acid at various points along the polypeptide chain. At some points the valine would be derived from the pool of radioactive free valine, but at other points it would be derived from peptides containing valine which is not in equilibrium with the free valine. There could thus be considerable variation in the activity of valine occurring at different points along the chain. If, on the other hand, the protein were synthesized by a template mechanism using only free amino-acids, there would be no substantial difference in the radioactivity at different points along the chain.

Muir, Neuberger and Perrone[58] measured the radioactivity of the terminal valine of rat hæmoglobin after injection of radioactive valine and found no difference between the terminal valine and the mean value for the valine from the remainder of the molecule. This result would be consistent with a template mechanism for globin synthesis. Askonas, Campbell and Work have carried out partial acid hydrolysis of radioactive casein obtained in the goat experiment already described. Preliminary results indicate a variation in the radioactivity of the valine in two different purified valine peptides and thus in activity at different points along the protein chain. In view of the fact that the valine isolations have to be made on a microgram scale, these results should be accepted only with considerable reserve, particularly since two serine peptides isolated from the same hydrolysate contained serine not differing significantly in radioactivity from the mean value for all the serine residues.

While this investigation was in progress, Anfinsen and Steinberg[59] were working quite independently along closely similar lines. They used as their protein-synthesizing system an oviduct mince, which appears to be capable of synthesizing ovalbumin. Radioactive carbon dioxide and radioactive amino-acids were incubated with this mince, and the distribution of radioactivity in the resultant radioactive ovalbumin was determined. Evidence was found for considerable differences in specific activity of alanine at different points along the chain. Again the results should be accepted with reserve, owing to the microgram scale of the work. It should be observed also that these results were obtained with a tissue mince in which transpeptidation could easily have occurred as an artefact; thus, they do not necessarily prove that ovalbumin is synthesized by way of peptide intermediates *in vivo*.

It is apparent from what has been said that there are two main streams of thought on protein synthesis: one derived from the study of isolated enzyme systems and suggesting a stepwise coupling of many small peptide units; the other based on the study of genetic inheritance of protein specificity and preferring synthesis on templates, each template being specific for a single protein structure and probably identifiable with a gene. It is impossible with our present knowledge to choose between these two theories. It may be that choice is the wrong word and that eventually a synthesis of the two ideas will be found to fit the facts. In the meantime, t seems certain that, by the application of such methods as ion-exchange chromatography and isotopic tracer techniques, much more can be learnt about the biosynthesis of proteins. Gale[60] has shown that in esting cells of *Staph. aureus* penicillin inhibits turnover of glutamyl residues of cell protein, but that in growing cells protein synthesis is insensitive to penicillin. It would be unwise, therefore, to assume hat net protein synthesis is identical with protein urnover. If this is admitted, much of the apparent conflict between different types of evidence may well disappear.

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# NEWS and VIEWS

## Coronation Honours

The Coronation Honours list contains the following names of scientific men and others associated with scientific activities:

*Viscount:* Lord Woolton, recently Lord President of the Council.

*K.C.B.:* Sir John Cockcroft, chairman of the Defence Research Policy Committee and scientific adviser to the Minister of Defence, and director of the Atomic Energy Research Establishment.

*K.C.M.G.:* Sir James Hance, medical adviser and president of the Medical Board, Commonwealth Relations Office; Stephen E. V. Luke, comptroller for development and welfare in the West Indies and British co-chairman of the Caribbean Commission.

*K.B.E.:* Dr. John A. Carroll, deputy for research and development to the controller of the Navy and scientific adviser to the Board of Admiralty; Major-General Clive S. Steele, for services to engineering in Australia; Prof. Hugh S. Taylor, professor of chemistry and dean of the Graduate School at Princeton University.

*Knights:* Dr. Edward C. Bullard, director of the National Physical Laboratory; Sydney Camm, director and chief designer, Hawker Aircraft, Ltd.; Enoch B. Levy, formerly director of the Grassland Division, Department of Scientific and Industrial Research, New Zealand; George D. A. MacDougall, chief adviser, Statistical Branch, Office of the Paymaster General; Charles R. Morris, vice-chancellor of the University of Leeds; Thomas O. M. Sopwith, for services to aircraft production; Dr. Francis M. R. Walshe, president of the Royal Society of Medicine.

*C.B.:* R. Cockburn, scientific adviser to the Air Ministry; E. T. Jones, principal director scientific research (air), Ministry of Supply.

*C.M.G.:* J. Durward, deputy director, Meteorological Office, Air Ministry; Prof. G. Macdonald, professor of tropical hygiene, University of London, and director of the Ross Institute of Tropical Hygiene; G. W. Nye, deputy agricultural adviser to the Secretary of State for the Colonies; C. T. Saunders, deputy director of the Central Statistical Office, Cabinet Office.

*C.B.E.:* Prof. W. G. Barnard, professor of pathology in the University of London at St. Thomas's Hospital Medical School; F. S. Barton, principal director of electronic research and development, Ministry of Supply; A. G. Beattie, lately inspector-general of agriculture, Nigeria; A. D. J. Brennan, deputy chief veterinary officer, Ministry of Agriculture and Fisheries; R. L. Brooks, Colonial Forest Service, permanent secretary to the Ministry of Agriculture and Natural Resources, Gold Coast; J. N. Brown, assistant comptroller, Patent Office; R. W. Cheshire, deputy chief scientific officer, Admiralty; D. D. W. Cole, assistant controller (production), Atomic Energy Establishment, Risley, Ministry of Supply; W. J. Duncan, Mechan professor of aeronautics and fluid mechanics, University of Glasgow; A. Fage, superintendent of the Aerodynamics Division, National Physical Laboratory; J. E. Hurst, president of the British Cast Iron Research Association; R. G. Lloyd, secretary to the Royal Commission on Awards to Inventors; Dr. A. A. Miles, director of the Lister Institute of Preventive Medicine, London; A. McL. Mooney, deputy director of electrical engineering, Admiralty; D. A. Oliver, metals economy adviser, Ministry of Supply; F. Rayns, director of the Norfolk Agricultural Station at Sprowston, Norwich; F. H. Rowe, director-general, Commonwealth of Australia Department of Social Services; R. L. Scarlett, chairman of the Scottish Horticultural Advisory Committee; Lieut.-Commdr. P. M. Scott, director of the Severn Wildfowl Trust; P. M. Sherlock, vice-principal and director of extra-mural studies, University College of the West Indies; H. S. Young, deputy chief scientific officer, Ministry of Defence.

*I.S.O.:* F. R. Callaghan, secretary, Department of Scientific and Industrial Research, New Zealand; F. R. Ennos, senior principal scientific officer, Government Chemist's Department; W. R. Penhall, secretary of the Aborigines Protection Board, South Australia; E. F. Peck, Colonial Veterinary Service, director of agriculture and veterinary services, Somaliland.

## Prince Louis de Broglie, For.Mem.R.S.

Prince Louis de Broglie was one of the four recently elected foreign members of the Royal Society. We owe to him one of the fundamental ideas forming the basis of quantum theory, the universal connexion between particles and waves. This connexion was obtained by de Broglie in 1924, apparently by a process of pure reasoning from mathematical relations suggested by relativity, and was for a while unsupported by any evidence, except in the case of light-quanta. However, it stimulated Schrödinger to seek for an explanation of the stationary states of atoms as a resonance phenomenon and led him to his famous wave equation, which is the accurate extension to curved orbits of de Broglie's relations for a particle on a straight course. In 1927 came the direct verification of de Broglie's ideas by Davisson and Germer working with slow electrons, and by G. P. (now Sir George) Thomson working with fast electrons, and a new era began in our understanding of atomic processes. The precise relationship of the waves to the particles remains a subject of controversy; what is established is that one must carry out calculations to determine the motion of the waves and then interpret them in terms of probabilities for the particles.

## Geography at Leeds: Prof. A. V. Williamson

Another of the pioneers of university geography is retiring. It is much to be regretted that, for health reasons, Prof. A. V. Williamson is leaving the chair of geography in the University of Leeds, of which he was the first occupant. Trained in the school of geography in the University of Liverpool, he went to Leeds in 1922 as assistant lecturer when the department was small and struggling for adequate recognition. In 1927 he was given the title and status of lecturer as the department grew under his thoughtful guidance; and he became head of the department in 1928. His merits brought him the title of reader in 1933 and he was elected to the first chair of geography in 1944. By this time he had built up a large department which was continually outgrowing the accommodation available. Experience in the First World War widened his interests and directed particular attention to the East; but Prof. Williamson had no narrow outlook in his view of geography and no doctrines on the subject. Prof. Williamson also took a leading part in administration, taking his turn as dean of the Faculty of Arts and as a member of the Senate and Council. To the deliberations of these bodies he brought penetrating criticism, sometimes caustic, but always valuable. He will be much missed by students and staff alike.

## Linnean Society of London: Anniversary Meeting

At the anniversary meeting of the Linnean Society of London held on May 28, the Linnean Gold Medal was awarded to Prof. P. A. Buxton. The following were elected officers for the session 1953–54: *President:* Lieut.-Colonel R. B. Seymour Sewell; *Treasurer:* Colonel F. C. Stern; *Secretaries:* (Zoology) Dr. A. Tindell Hopwood, (Botany) Dr. George Taylor; *New Members of Council:* Mr. J. S. L. Gilmour, Prof. C. T. Ingold, Dr. L. Harrison Matthews, Dr. C. R. Metcalfe and Prof. E. Smith. Prof. Albert Dalcq, of Brussels, Prof. Alfred Sherwood Romer, of Boston, Mass., and Prof. Roger-Jean Heim, of Paris, were elected foreign members; and Robert Mackechnie and Douglas Miller Reid were elected associates *honoris causa*.

## Bibliography of Scientific Aspects of Atomic Energy

The two volumes of "An International Bibliography on Atomic Energy", published by the United Nations Atomic Energy Section of the Department of Security Council Affairs, deal respectively with political, economic and social aspects, and with scientific aspects. Vol. 1 was issued in 1949 and Supplement No. 1 to this volume in 1950 (see *Nature*, 167, 671; 1951). In 1948 and 1949, preliminary mimeographed editions of the component parts of Vol. 2 were issued and circulated among experts of various countries, and in 1951 the printed edition was published. This volume, which listed more than twenty-four thousand articles, books and pamphlets published in all parts of the world during 1925–49, is divided into five main sections: fundamental nuclear science; the physics and engineering of nuclear reactors; the biological and medical effects of high-energy radiations; isotopes in biology and medicine; and applications of radioactive tracers in non-biological sciences and technology. However, the flow of scientific papers on nuclear energy has continued unabated, and periodical supplements to Vol. 2 have accordingly been planned, the first of which has recently been published (pp. 326. New York: U.N. Atomic Energy Section, Department of Security Council Affairs; London: H.M.S.O., 1952. 3.25 dollars, 25*s.* or 14 Swiss francs). The five sections into which it is divided are the same as in the original volume; but the table of contents has been somewhat improved in accordance with suggestions received, and fresh sub-divisions have been introduced to take account of rapidly growing or new research topics. The contents consist of 8,231 items, each item containing the authors' names, the title of the article (with translation if the original is in Russian), abbreviated title of the journal, the volume and page numbers and the date, and two appendixes (one an author index and the other a list of the journals, with addresses, arranged alphabetically under the abbreviations used in the volume). The bibliography does not exclude reviews and general articles, and in this respect is superior to some abstracting journals; but the absence of translations of titles in foreign languages other than Russian will cause difficulty to many users and will hinder further reference to abstracts in abstracting journals.

## Institution of Professional Civil Servants

In his presidential address to the Institution of Professional Civil Servants at the annual delegate conference on May 18, Sir Richard Redmayne commented at some length on the position of the Department of Scientific and Industrial Research as indicated by that Department's recent annual report. The current estimates of the Department, he said, represent not a slight increase on the estimates for 1950–51, but a reduction of about ten per cent, and he urged that reductions in expenditure involving restriction of important and necessary work are not economy but waste. Sir Richard also referred to the Institution's intervention in the decision of the Ministry of Works to dismiss certain artist-craftsmen employed on the restoration of national art treasures, and the reversal of the decision after debate in the House of Lords. The annual report of the Institution's executive committee indicates its intention of seeking to improve the efficiency of the Civil Service by ensuring not only the proper employment of professional, scientific and technical officers, but also their full access to administrative posts on the bases envisaged in the Gardiner Committees' reports. It is also proposed to press (1) the claims for parity between the experimental and the scientific officer classes on one hand and the executive and administrative classes on the other; (ii) the technical grades salary claim deriving from the Gardiner report on the Works Group; and (iii) the salary scales for medical officers based on the Spens reports and the judgment of Mr. Justice Danckwerts.

## Pacific Science Council Secretariat: Report for 1951–52

A report on the work of the Pacific Science Council Secretariat, covering the period March 1951–December 1952 (Bulletin *PS*/52/9; pp. 28; from the B. P. Bishop Museum, Honolulu, 1952), lists the continuing and completed projects of the secretariat, the supplements to the *Information Bulletin* issued during 1951 and 1952, and of the standing committees of the Pacific Science Association. The executive secretary represented the secretariat at the Australian National University's jubilee seminar on "Social Processes in the Pacific", and afterwards visited Singapore, Java, New Caledonia and Fiji. Reference is made to the value of the secretariat's assistance programme for transient scientific workers. The monthly summary, due for release in mid-January 1953, completed one full year of operation of the Pacific Area Communicable Disease Information Service; plague, small-pox, epidemic typhus, cholera, yellow fever, relapsing fever, all of which have already been reported by cable on a world-wide basis by the United Nations World Health Organization, are omitted to avoid duplication. The summary covers the reported incidence of more than thirty other diseases selected on the advice of health officers in the Pacific. A Periodicals Exchange Centre, covering periodicals published between 1920 and 1945, has been established by the secretariat jointly with the Unesco Science Co-operation Offices for South East Asia and for East Asia. The publication of a survey of Pacific scientific expeditions and of a handbook on organizations engaged in scientific research on an international scale in the Pacific was under investigation, while the secretariat was also responsible for organizing the Hawaii symposium on scientific research in the Pacific (held during March 9–10,

1951) and for preparing and distributing the papers and publishing the resolutions of the symposium. The admission of the Pacific Science Association to consultative arrangements with Unesco was approved by the sixth session of the general conference of Unesco (June–July 1951).

## Museums and Education

In the January issue of the *Museums Journal*, Dr. D. A. Allan (of the Royal Scottish Museum, Edinburgh), who was director of the seminar on "Museums and Education" held at Brooklyn Museum, New York, during September 14–October 14, 1952, describes the work and activities of that important gathering. In all, there were thirty-eight members from twenty-four member countries, and the seminar was held under the auspices of the United Nations Educational, Scientific and Cultural Organization. It was agreed at the outset that museums have to save traditions and preach standards in a world where both are threatened. With labels and sympathetic guide-lecturers, there would appear to be no subject involving three dimensions that a museum cannot teach. Books and museum displays were regarded as complementary, but museums can make the great immediate appeal. Many speakers stressed that the development of the emotions is an important element in an individual's education and that here the art museum can achieve much by encouraging sensitivity, response and inspiration. From this the discussions emphasized, first, the value of atmosphere in the individual museum and, secondly, the value of a museum as a point of infection for its community. Museum services must be qualitative rather than quantitative, and warnings were expressed on the inadvisability of expert museum chiefs having to devote valuable time to obtaining financial support and the common fallacy that attendance figures reflect services given. The resolutions passed by the seminar stated the unanimous conviction of the value of museums and appealed for the fullest support for them as educational, cultural and recreational centres.

## Calendar Reform

At the first meeting of the British Section of the World Calendar Association (20 Buckingham Street, London, W.C.2), which was held in London on October 17, Sir Harold Spencer Jones, the Astronomer Royal, gave a lecture entitled "The Calendar, Past, Present and Future". He began by pointing out that the difficulties in devising a satisfactory calendar have been due to the incommensurability of the three natural periods of time, the day, the month and the year, and he followed with a short survey of the various calendars—Egyptian, Babylonian, Greek, Jewish, Roman, Gregorian and Mahommedan—giving a brief reference to the confusion introduced by these different systems. In general, Sir Harold favours the adoption of the world calendar, which has the merit of being simple, stable and perpetual (see *Nature*, 169, 961 and 1083; 1952). In this scheme, the year is divided into four equal quarters of ninety-one days, which would leave a day over in normal years and two days in leap years. Each quarter is divided into thirty-one, thirty and thirty days respectively, commencing with a Sunday and ending with a Saturday, and containing exactly thirteen weeks, the second and third months beginning on Wednesday and Friday, respectively. As there would be a day left over in normal years, this would follow December 30 and be named 'world day'; in leap years the other extra day would come in between the first and second halves of the year and be named 'leap day', and each of these days would be a world holiday. Religious objections which have been advanced against the scheme are not considered insuperable, and Sir Harold expressed the hope that the scheme, which is to be discussed by the United Nations Organization, will be seriously considered on its merits. He ended with an appeal for the widest measure of support for the world calendar, a reform which will only be possible if there is a vigorous campaign to expound its advantages to the ordinary man.

## Careers in the Petroleum Industry

A number of booklets dealing with careers and prospects for professional men in the Royal Dutch/Shell Group of Oil Companies have been published by the Shell Petroleum Co., Ltd. (St. Helen's Court, London, E.C.3), and they can be recommended particularly to parents, headmasters and potential candidates for appointments in this field. In one, "Careers in the Petroleum Chemical Industry" (pp. 22; 1952), the subject-matter is divided into two sections, general information and careers. The former gives details of the Group's organization and work, incidence of National Service, conditions of pay, promotion, service overseas and how to apply for employment. Under the section on careers is explained the growth of this modern phase of petroleum technology, the marketing of special products, and areas where chemical manufactures are concentrated, concluding with a brief description of research and development laboratories, the production of intermediates and marketing areas. Another brochure, "Careers in the Royal Dutch/Shell Group" (pp. 82; second edition, 1952), goes into the oil industry in more detail, embracing the range of different occupations in the industry as a whole and covering all initial information that anyone having this vocation in mind will benefit by careful perusal. These publications are lavishly illustrated in a manner that, combined with excellent texts, brings home to the reader in straightforward wording the vast ramifications of this industrial scene as it exists to-day all over the world; no less are the great opportunities awaiting those who lean either to administrative or, perchance, more adventurous activities at home or overseas.

## Guide to Chemicals used in Crop Protection

The number and variety of chemicals used in plant protection from insect pests, diseases and weeds has vastly increased during recent years. The nomenclature of the many compounds employed is most involved, and few would claim to be thoroughly conversant with them, while the rapidity with which progress in the subject continues renders it impossible for the text-book writer to keep abreast with the latest developments. Many will therefore welcome the issue by the Canadian Department of Agriculture of a publication entitled "Guide to the Chemicals used in Crop Protection", by H. Martin and J. R. W. Miles (pp. 236; from the Science Service Laboratory, University of Western Ontario, Sub Post Office, London, Ontario; 1952). This mimeographed publication gives a concise account of some 177 chemicals, including in each case their full structural formula, history, manufacture, properties (physical, chemical and biological), formulation and method of analysis. The arrangement is alphabetical and in loose-leaf form to facilitate addition or revision. An index is also provided so that reference can be made by means of the alternative name if the full one is unknown. The precautions needed in the use of the compounds are stated where applicable.

## Age and Evolution of the ζ Persei Group of *O*- and *B*-Type Stars

A PAPER on "The Age and Evolution of the ζ Persei Group of *O*- and *B*-Type Stars", by A. Blaauw, has been published in the *Bulletin of the Astronomical Institute of the Netherlands* (11, 433; 1952), and this follows up a previous publication (No. 363; 1944), in which the moving cluster of early-type stars including, among others, the bright stars ζ and ξ Persei, was described. Further studies, which are dealt with in the present paper, lead to some interesting conclusions with reference to the evolution of this group and to an estimate of the age of its members. The principal observational data concerning the stars of the group are contained in a table, and two figures show the adopted linear relation between the components of proper motion and the co-ordinates of the star. The slope of this relation is taken as a measure of the apparent expansion, and this relation should exist in the following circumstances: the present dimensions of the group are large compared with the dimensions at the time when the stars began their independent motions; and these motions started at the same time and have since been uniform. In the circumstances the linear relation is independent of the distribution of the sizes and of the directions of the velocities, and on the above two assumptions it was found that the time, which has elapsed since the beginning of the uniform motions is 1·3 million years. It is admitted that this seems surprisingly short when compared with the period of revolution of the stars in the solar neighbourhood around the galactic centre—about 220 million years—or with the current estimates of the age of the sun. It would be possible to allow a longer time, however, if the condensation of the interstellar material into stars took place already during the process of contraction of the original cloud, but the difference would amount to only a few hundreds of thousands of years, so the figures given above must be accepted as approximately correct. In addition, the presence of high-luminosity stars like ζ and ξ Persei points to a small maximum age which can be estimated on the assumption of radiation of energy in the past proceeding at the same rate as at present, the source of the energy being the transformation of hydrogen into helium. Maximum ages of 7·9 and 7·4 million years for ζ and ξ Persei, respectively, are thus found, but for various reasons the true ages may be much less. An interesting feature of the group is the presence of a very small cluster of faint stars immediately south of o Persei, and the photographically determined proper motions for this cluster are shown in a table.

## Latin American Course in Santiago on Electrophoresis

THE second of a series of international training courses, in collaboration with leading Latin American research institutions, in order to introduce and improve the use of modern techniques and methods in scientific research in Latin America, organized by the Unesco Science Co-operation Office for Latin America, was inaugurated in Santiago de Chile on April 20. The course, which was full-time and lasted for three weeks, dealt with electrophoresis and was attended by research workers from Argentine, Brazil, Chile, Colombia, Ecuador, Peru, Uruguay and Venezuela. The instructors for the course were drawn from the University of Chile with Prof. Dan H. Moore, head of the Laboratory of Electrophoresis of the College of Physicians and Surgeons, Columbia University, New York, as guest lecturer. The first of these courses dealt with the methodology of radioisotopes in biological research and was held in the Laboratory of Radioisotopes of the University of São Paulo, Brazil, during January 14–February 28 (see *Nature*, February 14, p. 289). The next two courses planned by the Unesco Office will deal respectively with electron microscopy and chromatography, and further information can be obtained from Centro de Cooperación Científica para América Latina de la Unesco, Bulevar Artigas 1320, Montevideo, Uruguay.

## Biology and Productivity of the Sea

A SYMPOSIUM on "The Biology and Productivity of the Sea" will be held, under the auspices of the Institute of Biology, in the rooms of the Royal Geographical Society during September 18–19. The subjects include zoology, botany, fisheries and oceanography, and papers will be contributed from the British Museum (Natural History); National Institute of Oceanography; Fisheries Laboratory, Lowestoft; Marine Laboratory, Aberdeen; Marine Laboratory, Plymouth; "Discovery" Investigations; Institute of Seaweed Research; Fisheries Experiment Station, Conway; Food and Agriculture Organization; Colonial Office. Other authors in Copenhagen, Malaya, Southampton and Cambridge are contributing. The chairmen of sessions are: Dr. E. Hindle, Prof. F. E. Fritsch, Dr. F. N. Woodward, Mr. F. S. Russell and Mr. H. J. Johns. Further information can be obtained from the General Secretary, Institute of Biology, Tavistock House South, Tavistock Square, London, W.C.1.

## Announcements

THE Albert Medal of the Royal Society of Arts for 1953 has been awarded to Dr. E. D. Adrian, Master of Trinity College, Cambridge, for his outstanding contributions to neuro-physiology. This Medal, which is the highest award in the gift of the Royal Society of Arts, was instituted in 1864 to commemorate the presidency of the Prince Consort during 1843–61, and is given annually for "distinguished merit in promoting Arts, Manufactures and Commerce".

THE following appointments have been made in the Queen's University of Belfast: Dr. I. T. A. C. Adamson, formerly of Princeton University, to a lectureship in pure mathematics; Dr. A. R. Pinder, of Magdalen College, Oxford, to a lectureship in organic chemistry.

THE Heineman Foundation for Research, Educational, Charitable and Scientific Purposes, Inc., is offering a prize of 5,000 dollars, known as the "Dannie Heineman Prize", to be awarded every three years to the author of an outstanding book or manuscript in the mathematical or physical sciences. The object of the prize is to encourage the writing of books on a high scientific level which open up important fields of research. Those wishing to compete for the prize should submit two copies of the book or manuscript in question to the Secretary of the Foundation, 50 Broadway, New York 4, N.Y., not later than December 31, 1955.

# ROCKETS

THE subject of rockets is one that has attracted considerable popular attention during the post-war years, but on which very little reliable technical information has been available. It was, therefore, an attractive and interesting topic for a discussion meeting on April 24 at the Society for Visiting Scientists. Introductory talks were given by the chairman, Prof. A. D. Baxter, Mr. I. Lubbock and Dr. A. C. Merrington, all of whom have had long experience in the rocket field, and afterwards a general discussion ranged over a wide variety of problems of scientific interest.

In opening the meeting, Prof. Baxter emphasized the propulsion side of the subject and reviewed the relationship of rocket propulsion to other forms of power plant. The major distinction is that the latter are air-swallowing; but the rocket motor is practically independent of the atmosphere. Consequently, the propelling force developed by piston engines, gas turbines and ram jets falls off as the altitude increases, whereas the rocket motor force actually increases slightly. At the same time, the dimensions of a rocket motor are very much less for the same thrust, and its compactness gives it advantages of low weight and air resistance. These are offset to some extent by the large consumption of propellant resulting from the need to carry its own oxidant. Such features make the rocket motor eminently suitable for short-duration propulsion at extreme speeds and altitudes; hence its role in aircraft, guided weapons and, in the future, space-craft. Because of the high fuel consumption, it is probable that new flight techniques will evolve as, for example, the use of a combined ballistic and extended glide path. These would introduce new problems—how to deal with the very high skin temperatures of the rocket at high speeds, the cabin air-conditioning for passengers, the physiological effects of prolonged accelerations and periods of weightlessness and so forth.

Mr. Lubbock, who followed, gave an account of the early methods of designing liquid propellant rocket motors, which were contrasted with those using solid propellants. The selection of an oxidant was made from the three best known: liquid oxygen, hydrogen peroxide and nitric acid. All three were used by the Germans during the Second World War and each has problems peculiar to itself. Liquid oxygen is attractive in many ways; but its low boiling point introduces engineering problems of storage and transfer to the combustion chamber. Conditions in the latter are much more severe than in other internal combustion engines—the gas pressure is at least 300 lb. per sq. in. and the temperature is of the order of 3,000° K., compared with the normal gas turbine maximum pressures and temperatures of approximately 80 lb. per sq. in. and 1,150° K. respectively. The thermodynamics of rocket combustion is therefore complicated by dissociation, and heat transfer calculations demand data well beyond the limits of experimental knowledge.

From this point, Dr. Merrington followed with an explanation of rocket motor testing and research procedure. Contrary to the usual ideas, he said, the greater part of the testing and development is done statically, and only in the later stages is it necessary to consider flight testing at one of the rocket ranges. As in most experimental work, some risk of component failure exists with new developments, and proper precautions have to be taken. The risks arise mainly from the concentrated potential energy of an unburnt propellant mixture. This energy is of the same order as in high explosives, and if its liberation is not controlled, explosion can occur. To reduce the consequences of this, static testing is carried out in reinforced concrete cells. Measurements of thrust, propellant flow-rate, and the associated liquid and gas pressures are made, but no satisfactory methods of measuring the high combustion temperatures have been devised. Because of the rapid rates of change in the quantities to be measured, especially during starting, electronic recording is frequently adopted. In flight, the operation of the motor is studied chiefly by telemetry, the main information required being obtained indirectly in the form of pressures recorded graphically.

In the discussion which followed, a variety of points were made and questions asked. There was a natural interest in any possible uses of rockets other than for warlike purposes. The best known has been the life-saving rocket, in operation for more than a hundred years, which carries a line from shore to ships in distress. Among others enumerated were the mail-carrying rocket which had been tried in places where the topographical features encouraged it, such as across mountain ranges or stretches of water, high-altitude sounding rockets for studying upper atmosphere conditions and, at the other end of the speed and height-scale, assisted take-off rockets for transport aircraft operating from short runways or in conditions where the main engines could not give sufficient thrust. Mention was also made of rocket techniques applied to the drilling of oil bore-holes, the shaping of metal articles, and the operation of wind tunnels; the last relies on the ejector pump action of the high-velocity rocket exhaust gases entraining air from the tunnel. Such a tunnel would be expensive to operate frequently, but would save capital outlay on conventional electric motors and fans if only required intermittently. The principle has been applied to boundary-layer suction from aircraft wings to improve lift during take-off and landing. Another case of intermittent use requiring short periods of high-pressure gas generation is in driving small gas turbines used as engine starters.

The noise emitted by rocket motors was discussed at some length. This noise is made up from two sources—combustion and exhaust jet. Combustion noise is common to all types of engine in greater or lesser degree, and its level is dependent upon variables such as mixture ratio and combustion chamber loading. No satisfactory explanations relating the observed results in different forms of engine has yet been offered. Exhaust noise is a function of the shear velocity gradient between the jet and the atmosphere. Attempts to reduce this usually cause a loss of thrust. In cases where burning of fuel continued in the exhaust jet after leaving the motor, the suppression of this after-burning has produced a noticeable reduction in noise-level. Finally, it was remarked that, in most cases, rocket noise would be only of very short duration before the source would reach a height at which it would not be a serious trouble to ground observers.

The reliability of rockets, bearing in mind the *V2* firing failures, was queried; but it was stated that there is no fundamental reason why they should not be perfectly safe, and a number of aircraft applications were quoted in support. The problem of jettisoning assisted take-off or booster rockets in flight without damage to the motors or the populace below was also considered. A suggestion that rocket motors might be used for assisting gliders to extreme heights so that observations of meteorological interest could be made without the corrections necessitated by the transient conditions inherent in the sounding rocket was considered impracticable. An alternative proposal was a balloon with some rocket thrust available for directional control. Among other facts brought out was that the present maximum altitude reached by a rocket is 240 miles.

The chairman summarized the discussion by stating that rocket motors could give advantages wherever simplicity is needed, wherever high energy for short periods is demanded and wherever other power plants could not operate because of lack of air. The meeting then concluded with a short colour film of some rocket motor tests, both in flight and on the ground.

# RADIOISOTOPE TECHNIQUES IN INDUSTRY

THE wide use of radioisotopes in medical research has received considerable publicity; but their field of application is by no means limited to medicine, and consultations between nuclear physicists conversant with radioisotopes, and workers in other branches of science and engineering soon reveal numerous important problems that can be tackled successfully by the use of these substances. The international conference on radioisotopes held during July 16–20, 1951, at Oxford, under the auspices of the Atomic Energy Research Establishment, Harwell, is an outstanding example of the value of such consultations. In all, ninety-eight papers were presented, grouped under the main headings of therapy and diagnosis, biochemistry, agriculture, and industrial and allied research applications, and divided into thirty separate sessions. The complete text of the proceedings of this isotopes techniques conference, including the chairmen's addresses, the papers presented and the discussions on them, is to be published in two volumes, the first of which, Vol. 2, covering Sessions 21–30 inclusive and devoted to industrial and allied research applications, has now appeared*.

For the first two Sessions, 21 and 22, dealing with general and metallurgical applications, Dr. B. Goldschmidt, of the Commissariat à l'Énergie Atomique, Paris, was in the chair, and in his opening remarks he expressed gratitude to Great Britain for the liberal policy adopted with regard to the release and distribution of radioisotopes for industrial purposes to foreign countries; in addition, he paid tribute to Dr. H. Seligman, the head of the Isotopes Division at Harwell, for initiating the conference. Of the seven papers presented in the two sessions, the two main ones were by Dr. Seligman on types of applications of radioisotopes, and by Dr. R. W. Cahn on radioisotopes applied to metallurgical research. Dr. Seligman briefly reviewed the various industrial applications, mentioning, in particular, gamma radiography, static eliminators and thickness gauges. He pointed out that tracers have not been used as extensively as they might have been, particularly in problems of process control. Dr. Cahn distinguished between what he called microscopic applications in metallurgy (such as tracer methods for the measurement of self-diffusion in metals, and autoradiography for the determination of tracer elements in alloy sections) and macroscopic applications, in which the normal experimental or industrial procedure is followed, but where, at some stage, tracer elements are introduced.

Session 23 was devoted to gamma radiography, and Mr. W. N. Blacklock, of the Ministry of Supply Aeronautical Inspection Directorate, who presided, referred to the prominent part taken by radiography in non-destructive testing. He stated that the present relatively inexpensive and abundant supply of radioisotopes largely eliminates the need for heavy and costly X-ray equipment for the testing of heavy metal components. Five papers dealt with gamma radiography tests of iron and steel castings and inspections of metal welds. These were preceded by an interesting short paper by Mr. W. S. Eastwood on the handling of radiographic sources, in which he mentioned that, in addition to radium and radon, only three radioisotopes—cobalt-60, tantalum-182 and iridium-192, all metals—are in current use. They are prepared by the Atomic Energy Research Establishment, Harwell, in the form of small cylinders of standard sizes. Shorter-lived isotopes are also obtainable; but these are irradiated to order at Harwell in the size required and to the necessary activity. With regard to transport of the strong sources, it has to be remembered that the limits of radiation at a package surface set by British Railways are even more stringent than those of airline companies, and thus radiographic sources are transported inland by motor-car and are sent to Continental users sometimes by sea.

Mr. B. Schuil, who spoke about radioisotopes in radiography and measurements of wall thickness, made an interesting reference to the psychological effect that radiographic control of welds has on welders who are working far away from their workshops. With radioisotopes, control and test of pipe welds are possible in the field even under the worst conditions, and it was found in Holland that when welders were aware that a radiographic inspection was in force the percentage of bad welds fell from 80 to 20 per cent. Finally, to wind up the Session, Dr. J. S. Blair described some of the safety precautions that are necessary when radioisotopes are handled.

In Session 24, on counting techniques, Dr. S. G. Cohen and Dr. D. Carmi described counters with thin plastic walls for the detection of X-rays, and Mr. H. Herne showed how, by the use of the commonly known, but not commonly employed, property of radioisotopes—namely, the random nature of the radioactive disintegrations themselves—the isotopes could be used in an analogue computer for stochastic problems. Mr. J. L. Putnam then discussed the very important but somewhat thorny problem of the absolute measurement of the activity of radioisotopes. He stressed the need for generally accepted standards of radioactivity and mentioned some of the intercomparison measurements and absolute measurements which are being made in

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* Ministry of Supply. Radioisotope Techniques: Proceedings of the Isotope Techniques Conference, Oxford, July 1951, sponsored by the Atomic Energy Research Establishment. Vol. 2: Industrial and Allied Research Applications. Pp. iv+177+33 plates. (London: H.M.S.O., 1952.) 25s. net.

Britain. (Some of the results of these measurements have since been published; see *Nature*, 170, 916; 1952.)

The study of solid reactions is probably one of the main applications for radioactive tracers in physical chemistry; and in Session 26, on chemical applications, the first paper, by Dr. R. Lindner, dealt with this subject. Another interesting paper in this Session, by members of the Kodak Research Laboratories, was on the determination of silver in photographic images using radioactive iodide (iodine-131). Where a large number of analyses is required, the radio-iodination method has a distinct advantage over the potentiometric method and is to be preferred where only a small image is available, as in X-ray crystallographic patterns, or when the optical density is low.

The remaining four Sessions (27–30) were devoted respectively to ion exchange, non-destructive testing, static elimination and radioactivation analysis. Mr. K. Fearnside, of Isotope Developments, Ltd., Aldermaston, described four instruments: the transmission beta-ray thickness gauge used in paper, plastic sheet and metal foil production; the reflexion beta-ray gauge for the measurement of the thickness of coatings and liquid films; the gamma-ray thickness gauge applied to thick or hot-rolled metal strip; and the package monitor used to check the contents of sealed packages as they leave the packaging machine. Mr. G. Syke dealt in more general terms with the problem of inspection and gauging with ionizing radiations. Fog-making on certain kinds of fabrics due to static electricity forming on the fibres can be prevented by dissipating the static when it occurs before it has time to become a nuisance. The static may be made to leak away either through the textile itself or through the surrounding air. Ionizing the air by means of a radioactive substance is a most successful method; and in his paper on radioactive static eliminators for the textile industry, Dr. P. S. H. Henry, of the Shirley Institute, discussed thoroughly the question of static on textiles and the relative merits of alpha- and beta-ray static eliminators. Finally, Mr. A. A. Smales gave some indications of the scope of radioactivation analysis, the essential basis of which is that an element is detected and determined by the formation of a radioactive nuclide which is then subjected to radioassay, and Prof. G. Chaudron described some work on the analysis of traces of sodium and copper in high-purity aluminium by pile activation.

## BREEDING-BACK OF THE TARPAN

BEFORE the existence of human culture a number of different kinds of wild horses existed in Europe and Asia. Of these only one is extant to-day. This one was discovered by the Russian Przewalski in the desert-like steppes of Zungaria in western Siberia. Like most steppe-dwelling animals, the Przewalski wild horse is red-brown in colouring and light underneath. As a legacy from its forbears it still carries zebra-like stripes at the backs of the legs which show up very clearly in the summer coat. The discovery of the last remaining species of wild horse was followed by the news that in the 1920's it had become extinct in the free state. To-day only a few are left scattered in various zoological gardens, and none is breeding except in the sixteen-head Munich herd. It is on this herd that the hopes of preserving the species must rest.

If the species is not preserved, apart from its own interest, one of the most interesting animals of to-day will have become extinct. One of the European wild horses, the mouse-grey, for which the Russian name of tarpan has been adopted, was, in historical times, still extant over large areas of Europe (*Oryx* (Journal of the Fauna Preservation Society), 1, No. 7; November 1952).

In the first half of the past century it was still numerous in the steppes of the Ukraine north of the Black Sea. In 1876 it became extinct, leaving few traces of its existence. The tarpan was different from the Przewalski wild horse not only in colouring but also in build. The Przewalski has strong thick bones and an almost disproportionately heavy skull with narrow forehead which, many investigators believe, is the reason why the heavy carthorses of to-day are descended from this type. The tarpan has much finer bones and a short light head and is probably the progenitor of swift riding horses.

Distinguished for his successful efforts in breeding back the wild aurochs, Heinz Heck, director of the Tierpark Hellabrunn, Munich, has also successfully bred-back the tarpan. Mares from Iceland and Gothland that were markedly like tarpans were crossed with a Przewalski stallion; the resultant crosses were mated with one another and, in 1933, from this stock emerged the first foal with a mouse-grey tarpan colouring. Other foals followed, and through resultant crossings there is to-day a considerable stock of back-bred tarpans in the Tierpark, Hellabrunn.

## MICROSCOPY OF PLANT ASHES

THE statement that a microscope magnifies four hundred times never quite conveys a true idea of the wealth of detail that can be seen at this magnification. Perhaps only when the incredibly small fragments of material on a cosh, the minute amounts of blood or hair and other such negligible 'small dust of the balance', appear as important items of evidence in criminal proceedings is it realized how valuable is this instrument in the examination of such unpromising material.

One would, however, be pardoned in assuming that even the microscopist would have to admit defeat when dealing with material that had been so thoroughly incinerated that only an ash remained. However, in 1920, the Austrian botanist Hans Molisch investigated the structures left after incinerating plant material and showed that the ash still retained definite structural features. Prof. Gosta Edman, now professor of botany and pharmacognosy in the Royal Pharmaceutical Institute, Stockholm, was then a pupil of Molisch and later set out to investigate these 'ash pictures' systematically and has since published numerous papers on the subject. Recently he was awarded the Hanbury Memorial Medal of the Pharmaceutical Society of Great Britain which, in conjunction with the Linnean and Chemical Societies, periodically makes the award for "high excellence in the prosecution or promotion of original research in the Natural History and Chemistry of Drugs". After receiving the medal, Prof. Edman gave an account of his work on ash pictures (*Pharm. J.*, 170, 189; 1953).

Naturally, a good proportion of the work has been concerned with powdered or broken vegetable drugs, and Prof. Edman claimed that his method of examination is sometimes more convenient than normal ones. The drug is strongly heated until the bulk of the tissues is completely burned away; the characteristic appearance of the mineral skeletons of the cell walls and the cell contents is then revealed. The method, however, has several other important applications, especially in criminal proceedings involving suspected arson. Further, the examination of prehistoric materials by this method has been of some assistance to archæologists. Thus, the examination of the charred vegetable matter in a Chinese clay-sheard, about five thousand years old, showed it to consist mainly of the remains of the leaf blades of *Oryza sativa*, the same plant used to-day for the production of rice. In the same way, fragments of cereals, medicinal herbs, etc., have been identified in the intestines of Egyptian mummies. Prof. Edman has also examined the ash pictures of about 375 related plant species in relation to their phylogeny and taxonomy and has published many original articles on this subject in the botanical literature. He concludes that extensive silicification of the cell wall is associated with primitive characters.

J. W. Fairbairn

# OBSERVATIONS AT THE ROYAL OBSERVATORY, GREENWICH

THE observations made at the Royal Observatory, Greenwich, during 1937 in astronomy, magnetism and meteorology, under the direction of Sir H. Spencer Jones, have been published in a single volume (pp. *A*62+*B*21+*C*200+*D*66+*E*46+40. London: H.M.S.O., 1951. £6 net), which is divided in five sections, *A–E*, as follows: meridian astronomy, equatorial observations, photo-heliographic observations, magnetic observations and meteorological observations.

The first section includes work on the transit circle and on the time service; in the former are the results of regular observations of the sun, moon, major planets and minor planets Juno, Ceres, Pallas and Vesta, and in the latter is given a short account of the new equipment and advances in the technique since the publication of the "Time Service Results" in 1936. The section on equatorial observations contains a table on the observations of double stars made at the Observatory which includes not only all pairs observed during 1937 but also all previously unpublished measures of earlier years. A systematic difference was found for close pairs between the results of the filar micrometer and of the comparison image micrometer (brought into use towards the end of 1937), and the table indicates which instrument was used.

The second section, on photo-heliographic observations, is by far the largest of the five sections. The positions and areas of sunspots and faculæ for each day during the year 1937 is the first of seven tables in this section, the photographs being taken at the Royal Observatories of Greenwich or of the Cape, and at the Kodaikanal Observatory (a negative transparency for November 3 was supplied by the Mt. Wilson Observatory to fill a gap in the series). The other tables are: a general catalogue of groups of sunspots for 1937; ledgers of areas and positions of groups of sunspots (recurrent groups and non-recurrent groups); total areas of sunspots and faculæ for each day; mean areas of sunspots and faculæ for each rotation and for the year; mean heliographic latitude of spots for each rotation and for the year; and observations of solar flocculi made with the spectrohelioscope.

The introduction to the section on magnetic observations describes the magnetic station at Abinger, with its instruments, methods of observation, magnetic reductions and arrangement of results; these results are listed in fifteen tables, and there are notes for each month of 1937 which briefly summarize the magnetic conditions exhibited by the traces of declination and horizontal and vertical intensity during the year. Finally, a description of the instruments and the meteorological reductions is given in the section on meteorological observations; several changes were made in the 1934 volume as regards the notation for clouds and weather, this being done to bring the symbols into general accordance with those in use at the British Meteorological Office.

All the above-mentioned work by the Royal Observatory, Greenwich, was continued during 1938, and an account of it has now been published; the volume is similar in all respects to that for 1937. Another series of Greenwich observations which has at last been published is Vol. 2 of "Observations of Colour Temperatures of Stars:- Relative Gradients" (pp. 115; London: H.M.S.O., 1952; 25*s*. net); this volume covers the years 1933–38 and is a sequel to the observations of 1926–32, published in Vol. 1.

# UNITED STATES NATIONAL ACADEMY OF SCIENCES

AT the annual general meeting of the National Academy of Sciences, held in Washington, D.C., during April 27–29, the following officers, new members and foreign associates were elected.

*Vice-President:* George W. Corner, director, Department of Embryology, Carnegie Institution of Washington, Baltimore, Maryland, for a four-year term.

*New Members of Council:* Edwin B. Wilson, professor of vital statistics, Harvard School of Public Health, Boston; and Hugh L. Dryden, National Advisory Committee for Aeronautics, Washington, D.C.

*New Members:* L. V. Ahlfors, professor of mathematics, Harvard University; P. Bailey, professor of neurology and neuro-surgery, University of Illinois School of Medicine; H. A. Barker, microbiologist, University of California, Berkeley; V. H. Benioff, professor of geophysics, California Institute of Technology; J. H. Bodine, professor of zoology, University of Iowa; L. Brillouin, director of electronics education, International Business Machines Corporation, New York; M. J. Buerger, professor of mineralogy and crystallography, Massachusetts Institute of Technology; H. E. Carter, professor of biochemistry, University of Illinois; D. M. Dennison, professor of physics, University of Michigan; J. P. Den Hartog, professor of mechanical engineering, Massachusetts Institute of Technology; J. W. M. DuMond, professor of physics, California Institute of Technology; C. Eckart, director of the Marine Physical Laboratory, University of California, San Diego;

R. Emerson, research professor in botany, University of Illinois; J. F. Enders, chief, Division of Infectious Diseases, Children's Hospital, Boston; P. J. Flory, professor of chemistry, Cornell University; G. Gamow, professor of theoretical physics, George Washington University, Washington, D.C.; V. Hamburger, professor of zoology, Washington University, St. Louis; C. E. Hille, professor of mathematics, Yale University; J. O. Hirschfelder, professor of chemistry, University of Wisconsin; J. G. Horsfall, director, Connecticut Agricultural Experiment Station, New Haven; E. H. Land, president, Polaroid Corporation, Cambridge, Mass.; D. P. C. Lloyd, member, Rockefeller Institute for Medical Research, New York; H. W. Nissen, associate director, Yerkes Laboratories of Primate Biology, Orange Park; D. Rittenberg, associate professor of biochemistry, Columbia University; J. F. Schairer, physical chemist, Geophysical Laboratory, Carnegie Institution, Washington, D.C.; T. Shedlovsky, member, Rockefeller Institute for Medical Research, New York; J. C. Street, professor of physics, Harvard University; M. Tishler, director, Development Research Department, Merck and Company, Inc., Rahway, N.J.; H. G. Wood, head of the Department of Biochemistry, Western Reserve University; and R. B. Woodward, professor of chemistry, Harvard University.

*Foreign Associates:* J. H. Oort, director, Leyden Observatory; and Wilder Penfield, professor of neurology and neurosurgery, McGill University, and director, Montreal Neurological Institute, Montreal.

# KOSSUTH PRIZES IN HUNGARY FOR 1953

WINNERS of the 1953 Kossuth Prizes in Hungary, which are given for outstanding work during the past year, have recently been announced. These Prizes carry monetary awards of various amounts (1,000 forints is approximately £3), and those given for scientific, technological or medical work include the following. A Prize of 50,000 forints to Frederick Riesz, president of the Mathematical Section of the Hungarian Academy of Sciences, for his book entitled "Lesson of Functional Analysis", written in conjunction with B. Nagy, in which theories are developed that are of great importance in the development of mathematics. Prizes of 20,000 forints to: B. Nagy, correspondent member of the Hungarian Academy of Sciences, for his part in the joint work with F. Riesz, mentioned above; F. Ratkovszky, for work on the electrification of the country and for making a 'diabolo-transformer'; K. Novobatzky, professor of theoretical physics in the University of Budapest, for research on the quantum theory; J. Egerváry, for work in applied mathematics on the theory of differential equations, particularly in the development of a method for computing the critical limit of rotations of rotors in turbo-generators; Z. Csűrös, academician, for results achieved in the study of heterogeneous catalysis; A. Ábrahám, correspondent member of the Academy, for research of the nerve tissues, based on the teachings of Pavlov; Z. Gyulai, correspondent member of the Academy, for research work on the boundary layers of crystals and solutions, and for the production of artificial quartz crystals; V. Keilwert, chemical engineer at the Láng engineering factory for directing the planning of the Debrecene penicillin factory; J. Proszt, professor in the Inorganic Chemistry Institute, for pioneering research in the preparation of organic silicon compounds; L. Kulin, specialist in children's diseases, for results achieved in curing tuberculosis in babies; G. Bárczi, director of the Budapest Therapeutical Teachers Training College, for results achieved in basing Hungarian medical teaching and education on the natural sciences and for applying Pavlovian theories; J. Kollonitsch, departmental head of the Medicine Industry Research Institute, for medical research and work in the pharmaceutical industry, particularly in the new preparation of 'Treomycin' for the treatment of whooping cough, typhoid and dysentery.

Prizes of 10,000 forints to: P. K. Károly, correspondent member of the Academy, for his text-book entitled "The Factory Science of Electrical Machines", and for research; L. Verebély, professor at the Technical University, for his handbook entitled "Transmission of Electrical Energy", and for work on electrification; J. Urbanek, director of the Central Research Laboratory of the Electrical Industry, for his text-book entitled "Introduction to the Technical Science of Theoretical Electricity" and for his new method of cooling turbo-generators by refrigeration; S. Müller, correspondent member of the Academy, for work in organic chemistry in connexion with the industrial production of synthetic materials; A. Romwalter, university professor, for research in coal chemistry; K. Rauss, professor at the Pécs Medical Science University, for research into children's diseases and dysentery inoculation; L. Fuchs, university dean, for work on the theory of structural algebra.

# HYDRATION OF METAL CATIONS

By DR. E. GLUECKAUF and G. P. KITT
Atomic Energy Research Establishment, Harwell, Berks

MEASUREMENTS have been made by the isopiestic method of the water content of hydrogen and metal polystyrene sulphonates at different water vapour pressures and at two different temperatures, using concentrated sulphuric acid solutions as vapour pressure standards. This permits of a calculation both of water-activities (see curves *A* and *B*) and of the differential heats of hydration $\bar{H}$ of the ions (curve *C*). The polystyrene sulphonates of monovalent ions show in this respect great similarity to the behaviour of strong 1 : 1 electrolytes such as, for example, lithium chloride or perchloric acid and, as has been shown previously[1,2], can be considered as concentrated solutions of electrolyte in their swelling water. Indeed, the trend of $\bar{H}$ for the hydrogen polystyrene sulphonate (curve *C*) is very similar to that of concentrated sulphuric acid[3] in the range where the latter may be regarded as a monovalent acid, $H \cdot SO_4H$ (see curve *D*). For a study of concentrated solutions the polystyrene sulphonates have a great advantage over most aqueous solutions: they can be concentrated without crystallization to any desired strength (100 molal and above) and thus provide information on the interaction of water with all kinds of ion at high concentrations which are normally attainable for acids only. The polystyrene sulphonate of very low cross-linkage (0·5 per cent divinyl benzene) was obtained by courtesy of Dr. K. W. Pepper, Chemical Research Laboratory (Department of Scientific and Industrial Research), Teddington.

Attempts to fit water-activity data of concentrated electrolyte solutions to a model have been made previously by R. H. Stokes and R. A. Robinson[4]. They found that the water 'adsorption isotherm' conforms to a Brunauer–Emmett–Teller type, and an indication was obtained that the hydrogen and lithium ions form a primary solvation shell of four firmly bound water molecules. Their evidence was based on experimental results for molecular water-to-ion ratios of $R > 3:1$ only, and thus could not give detailed information concerning the first three water molecules. Our experiments cover the cases of most monovalent cations for a range down to $R < 1:1$; in some cases hydration results go as low as $R < 0·5:1$. So far, the experimental results have been evaluated for the $H^+$-resin only.

Over this much wider range, the results do not follow a Brunauer–Emmett–Teller isotherm and have to be interpreted as successive addition reactions of the type:

$$\mathrm{H}\cdot(R) + \mathrm{H_2O} \rightleftharpoons [\mathrm{H}\cdot\mathrm{H_2O}]^+ + H_1$$
$$[\mathrm{H}\cdot\mathrm{H_2O}]^+ + \mathrm{H_2O} \rightleftharpoons [\mathrm{H}\cdot 2\mathrm{H_2O}]^+ + H_2,$$
$$\text{etc.},$$

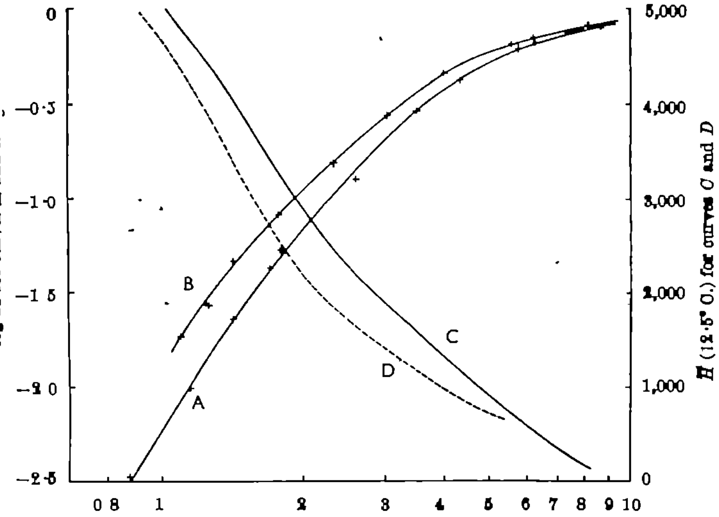
leading to mass law equations:

$$x_1 = K_1 \cdot a_w \cdot x_0$$
$$x_2 = K_2 \cdot a_w \cdot x_1,$$
$$\text{etc.},$$

where $x_0$, $x_1$, $x_2$, etc., are the mol-fractions of ionic species containing 0, 1, 2, etc., molecules of water of hydration, and $H_n$ are the heats of hydration.

The resulting isotherm has the form:

$$\frac{\text{mol H}_2\text{O}}{\text{mol ion}} = R = \frac{K_1 a_w + 2K_1K_2a^2_w + 3K_1K_2K_3a^3_w + \ldots}{1 + K_1a_w + K_1K_2a^2_w + K_1K_2K_3a^3_w + \ldots}$$



Water activities $a_w$ at 0° C. (curve *A*) and 25° C. (curve *B*) and differential heats of hydration $\bar{H}$ at 12·5° C. (curve *C*) as function of the ratio molar water to H-ion, *R*. For comparison, $\bar{H}$ for sulphuric acid solutions (curve *D*)

We obtain for successive water molecules the following values of $K_n$, $\Delta H_n$, $\Delta F_n$ and the entropy,

$$\Delta S_n = \frac{\Delta H_n}{T} + R \ln K_n.$$

CONSTANTS ($K_n$), HEATS OF HYDRATION ($\Delta H_n$), FREE ENERGIES ($\Delta F$) AND ENTROPIES ($\Delta S$) OF SUCCESSIVE HYDRATION STEPS

| $n$ | $K_n$ (273°) | $-\Delta H_n$(285°) $= H_n$ | $\frac{-\Delta F_n (273°)}{RT}$ | $-\Delta S_n$ |
|---|---|---|---|---|
| 1 | 1,050 | >6,000 | 6·96 | >7·0 |
| 2 | 26·0 | ~4,500 | 3·26 | 9·3 |
| 3 | 5·0 | 2,000 | 1·61 | 3·8 |
| 4 | 3·5 | 1,400 | 1·25 | 3·4 |
| 5 | 1·48 | 1,000 | 0·39 | 2·7 |
| 6 | 1·24 | 700 | 0·22 | 2·0 |
| 7 | 1·12 | 400 | 0·11 | 1·2 |
| 8 | 1·06 | 250 | 0·06 | 0·9 |
| 9 | 1·03 | 150 | 0·03 | 0·5 |
| 10 | 1·015 | 100 | 0·015 | 0·3 |
| etc. | →1 | →0 | →0 | →0 |

The large number of constant *K* can be obtained from the single curve *A* quite accurately, as the first four constants each dominates a narrow region only. The knowledge of *K* and of the differential heats $\bar{H}$ (curve *C*) renders possible a calculation of the individual heats of reaction $H_n$ and of the other thermodynamic constants. These results (see table) do not readily give the impression that, in concentrated solutions, four water molecules are firmly associated with the $H^+$ ion. There is a steady decrease both in the heats of reaction and in the free energies, and it requires some arbitrary assumption to differentiate between an 'association' and merely an attractive interaction. One could certainly not speak of an 'association' if the free energy of the reaction $-\Delta F$ is less than $RT$, and this places an upper limit on a hydration number of 4. But $-\Delta F = RT$ corresponds to a very loose association only, and if we stipulate that the free energy should exceed $2RT$ before we consider the association as a moderately firm one, we come to the conclusion that only two water molecules are firmly associated with the $H^+$ ion, and the second one much less firmly than the first.

No doubt it is this uncertainty in deciding the degree of hydration which has led different authors to different conceptions about the hydration of ions according to the methods employed for estimating the 'hydration number'. (For a review on ionic solvation see ref. 5.) The present investigation shows clearly that the concept of a fixed hydration number is too crude, and has to be replaced by a quantitative description of the thermodynamic properties of the individual hydration steps.

It is interesting to speculate on the high values of the entropy changes during the first two steps, from which it appears that these steps are different from subsequent ones. The first water molecule obviously changes the covalently bound hydrogen to the ionized hydronium ion. Presumably the latter is strongly 'ion paired' to the sulphonate group of the resin, and the vigorous electrostatic interaction with the negative ion causes a reduction in the number of possible configurations, which implies an increased entropy difference. Once the second hydration has taken place, the distance of the positive charge from the anion increases, and with it the configuration space and the freedom of rotation of the cation, as is shown by the steady decrease of the entropy differences with every further hydration step.

While some time must necessarily elapse before a detailed account can be given for a larger number of ions, it can already be stated from a cursory study of the experimental results that the same gradual decrease of the energies of hydration applies quite generally to all the alkali ions, to the alkaline earths, as well as to ammonium, silver and mercuric ions, and thus presumably is a characteristic feature of all metal cations.

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[2] Duncan, J. F., *Proc. Roy. Soc.*, A, 214, 344 (1952).

[3] Kunzler, J. E., and Giauque, W. F., *J. Amer. Chem. Soc.*, 74, 3472 (1952).

[4] Stokes, R. H., and Robinson, R. A., *J. Amer. Chem. Soc.*, 70, 1870 (1948).

[5] Bockris, J. O'M., *Quart. Rev. Chem. Soc.*, 3, 173 (1949).

# POTATO BLIGHT FORECASTING AND ITS MECHANIZATION

By DR. JOHN GRAINGER

Department of Plant Pathology, West of Scotland Agricultural College, Auchincruive, Ayr

THE fungus, *Phytophthora infestans*, causing potato blight, the most serious crop disease in Britain, has been shown by Beaumont[1] to begin its attack on the crop some 15–22 days after the occurrence of certain climatic conditions. These are a minimum temperature above 50° F. and a minimum relative humidity greater than 75 per cent, for a continuous period of at least forty-eight hours. During the past nine years I have used this method of forecasting with success in west Scotland when the recording instruments were near the potato crops (Fig. 1). It was, however, found necessary to establish a 'zero time'[2], before which suitable 'Beaumont' periods would not be regarded as valid. Zero time is July 1 for Ayrshire, but is a good deal earlier for the Atlantic islands. It would also be desirable to forecast the pattern and rate of blight development. Fig. 1 shows, however, that the ultimate build-up of this disease is not always closely linked with the occurrence of later 'Beaumont' periods. Experiments in Dumfriesshire and Perthshire suggest, however, that this difficulty may not be so important in practice as it appears in theory. When copper-containing sprays were applied according to blight forecasts in 1949 and 1950, increases in yield reached 28–30 per cent. These figures are high, for the average increase in overall crop cannot have been more than 20 per cent when sprays were given indiscriminately. Forecasts can introduce an important degree of precision into protective spraying, for blight cannot establish itself on foliage already coated with copper-containing sprays.

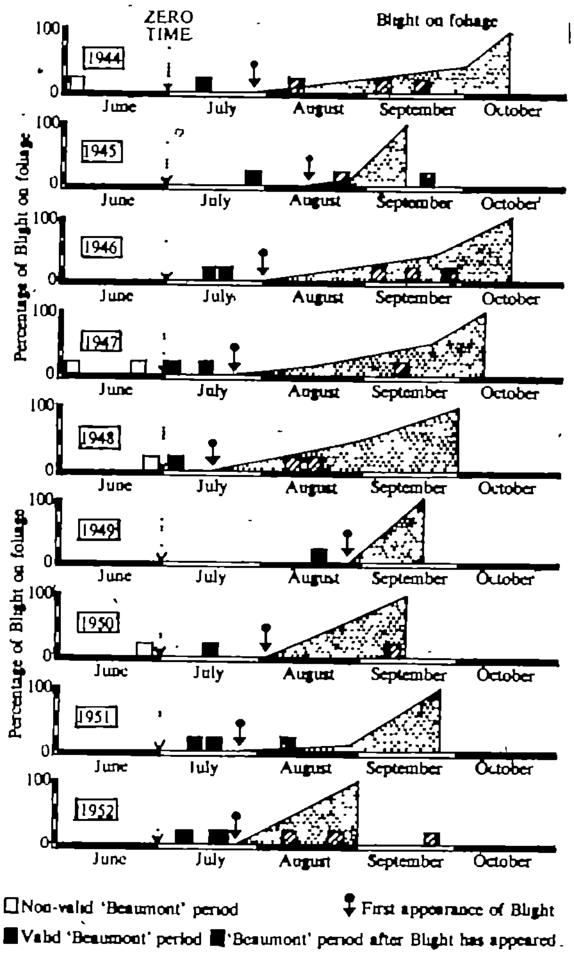

Fig. 1. The occurrence of suitable climatic ('Beaumont') periods and the average development of blight at Auchincruive during 1944–52. Where two valid periods are shown (1946, 1947, 1951 and 1952), the first would have been the operative one

The time of first appearance of blight is also important in another special connexion, namely, the lifting of Epicure 'seed' in Ayrshire. This is usually done in July, during which month the disease appeared in five out of the nine years mentioned in Fig. 1. Even small amounts of blight on the foliage when the crop is lifted infect the tubers, and storage losses are heavy. This type of infection can be prevented by destroying the foliage with sulphuric acid, sodium chlorate or by mechanical means, and waiting a fortnight before lifting. Blight forecasts would advise the farmer as to whether this operation were necessary or not, and here again they would bring precision to control operations.

Forecasts of the first appearance of blight are therefore useful in practice and can be made satisfactorily when recording gear is near a potato crop. It is, however, necessary to extend such a service to cover all potato crops in a given region. A certain measure of success has been obtained over the past three years for wider areas of the west of Scotland, in issuing unofficial forecasts based upon conditions reported by telephone from meteorological stations attached to aerodromes. This has been a most effective co-operative effort, and its only demerit is that the aerodromes are not near the largest potato-growing areas. It becomes increasingly obvious that a greater number of reporting stations is needed in closer relation to the crops if blight forecasting is to become a fully practical proposition.

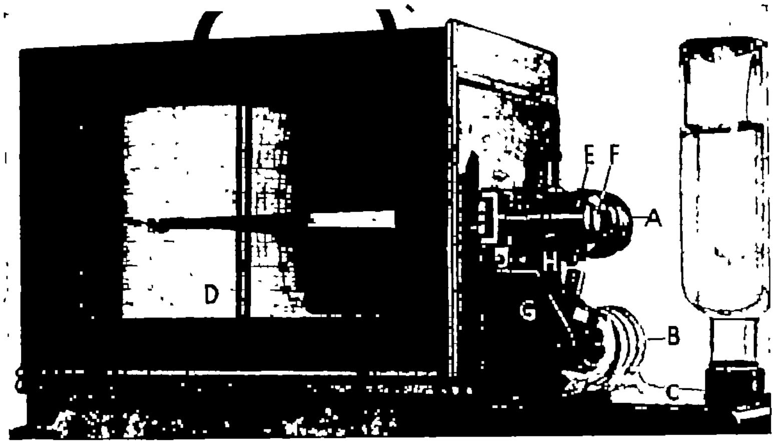

Fig. 2. The 'Auchincruive' self-calculating blight forecast recorder. For explanation of lettering, see text

Temperature can, of course, be recorded adequately by means of a bi-metallic thermograph, and even more accurately with a mercury-in-steel recorder. Relative humidity can be recorded directly by means of a hair hygrograph and by the Gregory humidity recorder; the first is temperamental, the second costly. Duplex wet- and dry-bulb instruments have the demerit that they record only temperature and the depression of the wet bulb, but not the actual percentage relative humidity. Successful forecasts of potato blight have nevertheless been made with such an instrument by Sir James Denby Roberts at Strathallan, Perthshire. Interpretation of the difference between the two traces for a relative humidity of 75 per cent or more is, however, rather difficult, because the depression varies with different temperatures. At 50° F., however, the depression of the wet-bulb reading for this humidity is 3·5° F. If, therefore, the two records are separated by less than this amount for forty-eight hours on end, it is fairly safe to forecast an outbreak of potato blight, provided the dry-bulb temperature is not much above 50° F. Another difficulty is that the two pens are set to record two hours distance apart on the chart, so that considerable skill is required in interpreting this differential comparison. There is thus a need for a forecast recording instrument which could be read and interpreted easily, accurately, and without special skill.

Figs. 2 and 3 show details of an inexpensive, accurate and easily interpreted instrument in which the recording elements are bi-metallic coils. Temperature is recorded in red ink by means of a pen (*E*) driven directly by a dry-bulb coil (*A*). A 'calculator'-pen (*F*), operated in a special manner from a wet-bulb coil (*B*), and marking in green ink, is so calibrated in relation to the temperature-pen that the lines they trace upon a rotating chart drum (*D*) will coincide at the relative humidity of 75 per cent, no matter what the temperature. Calibration of the instrument for this special purpose is done while the 'wet-bulb' coil is dry, when the calculator pen (*F*) is set to record higher than the temperature-pen (*E*). The higher reading is made equal to the depression of the wet-bulb temperature for 75 per cent relative humidity. This depression, and therefore also its corresponding higher reading, vary with different dry-bulb temperatures (see table). The varying higher reading is brought about by means of a cam (*G*) of special shape, driven by the 'wet-bulb' coil, and operating the calculator-pen through a roller movement (*H*) (Fig. 3).

The cam, though made of a single piece of metal, can perhaps best be thought of as having two parts—a basic section and a calculator section, which integrate two kinds of motion. The basic section, if used by itself, would impart a motion to the calculator-pen exactly similar to that of the directly driven temperature-pen for similar conditions around the coils which operate them. Added to the basic section, however, is the wedge-shaped calculator part (shown black in Fig. 3) which is responsible for the varying higher reading mentioned above. The working face of the cam is actually a very slight curve, to reflect the relation (not quite linear) shown in the table, and also the fact that the basic section edge would not be exactly a straight line.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Dry bulb temperature (°F.) | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 |
| Depression of wet-bulb reading for 75 per cent relative humidity in louvre screen (°F.) | 1·5 | 2·2 | 2 8 | 3·5 | 4·2 | 5·0 | 5·8 | 6·6 |

When the instrument is in operation, the wet-bulb coil is kept wet by a muslin sleeve fed by wicks dipping into the water reservoir (*C*). The calculator-pen then reads lower than its calibrated value, and, when the relative humidity is exactly 75 per cent, this depression due to evaporation-cooling of the wet-bulb coil equals the higher setting brought about by the calculator part of the cam. Calculator-pen records (green) are therefore on the same line as the temperature-pen records (red) for the particular relative humidity of 75 per cent, no matter what the dry-bulb temperature may be. Similarly, if the relative humidity is greater than 75 per cent, the

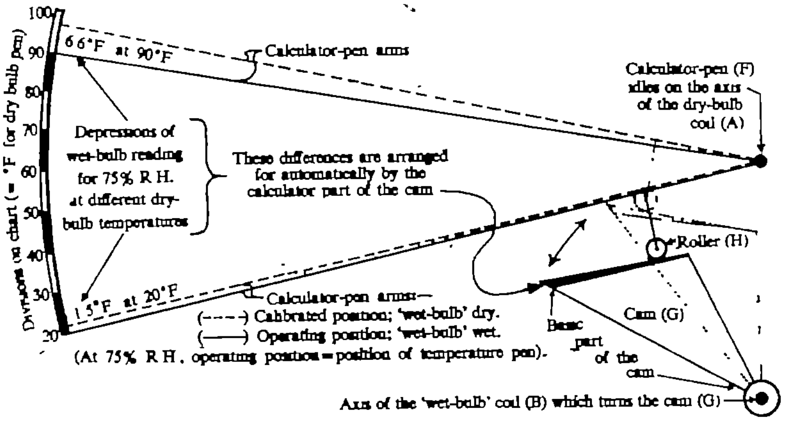
100
90
80
70
60
50
40
30
20
Divisions on chart (= °F for dry bulb pen)
6 6°F at 90°F
1 5°F at 20°F
Calculator-pen arms
Calculator-pen (F) idles on the axis of the dry-bulb coil (A)
Depressions of wet-bulb reading for 75% R H. at different dry-bulb temperatures
These differences are arranged for automatically by the calculator part of the cam
Roller (H)
Cam (G)
Calculator-pen arms:—
(----) Calibrated position; 'wet-bulb' dry.
(——) Operating position; 'wet-bulb' wet.
(At 75% R H. operating position = position of temperature pen).
Basic part of the cam
Axis of the 'wet-bulb' coil (B) which turns the cam (G)

Fig. 3. Method of operating the 'calculator'-pen (*F* in Fig. 2) from the axis of the 'wet-bulb' coil (*B*)

evaporation-cooling of the 'wet-bulb' coil is not sufficient to cause the calculator-pen to fall as far as the temperature record, and green reads above red. Conversely, if green reads below red, the relative humidity is less than 75 per cent. Beaumont's specification[1] of the climatic conditions necessary for a blight forecast are therefore given by the following simple rule:

Green (calculator) on or above red (temperature) and both on or above 50° F. for at least 48 hours on end.

The lag between the two records is reduced to minute proportions by arranging that the two pens only just clear each other. A blight forecaster may be placed within a louvre screen 4 ft. above the ground, or it may be placed in an aspirated screen if an electric fan is available to draw air over the elements. While the self-calculating mechanism as described is here worked from bi-metallic coils, it is equally applicable to mercury-in-steel recorders.

Protective spraying against blight is fully economic in many parts of Britain; but in some areas tuber production is usually complete by the time the disease destroys the foliage, and losses in overall yield are insufficient to balance the expenditure on sprays. Even in such districts, however, any factor which might delay planting in spring retards the growth-cycle, and protective spraying then becomes economic. Blight forecasts are thus of wide application in the improvement of control of this most widespread and severe crop disease.

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# X-RAY INACTIVATION OF POLYPLOID *SACCHAROMYCES*

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THE recent development by C. C. and G. Lindegren[1] of a family of polyploid yeasts provides the first opportunity of establishing the influence of polyploidy on X-ray inactivation through survival curve analysis. These analyses show that in each cell a single target sensitive to X-rays exists for each chromosome set.

Since polyploidy involves the replication of genetic units, interpretation of the survival curves on a multi-target basis is suggested. The multi-target theory[2] postulates that there is a number of independent targets in the cell, the probability that each target survives a dose $D$ of radiation being

$$P_i = \exp - KD,$$

where $K$ is a constant independent of cell concentration and dose. It is further postulated that there are $n$ sets of these targets (we shall identify $n$ with the number of chromosome sets in the cell), each set containing $m$ different targets (for example, genes or individual chromosomes). The probability $\theta'_i$ that the $i$'th target in one of the $n$ sets is killed is

$$\theta'_i = (1 - \exp - K_i D).$$

The probability that all the $n$ repetitions of the $i$'th target are inactivated is

$$\theta_i = (1 - \exp - K_i D)^n,$$

and the probability that at least one of them survives is

$$S_i = 1 - (1 - \exp - K_i D)^n.$$

Expanding the term in parenthesis by the binomial method, and confining ourselves to doses such that powers of $\exp - K_i D$ higher than the first may be neglected, we have:

$$S_i = 1 - (1 - n \exp - K_i D)$$

$$S_i = n \exp - K_i D.$$

Then the probability that at least one of the $n$ alleles of all the $m$ kinds of targets survives is:

$$S = \prod_{i=1}^{i=m} n \exp - K_i D.$$

Taking the logarithm:

$$\ln S = m \ln n - D \sum_{i=1}^{i=m} K_i. \qquad (1)$$

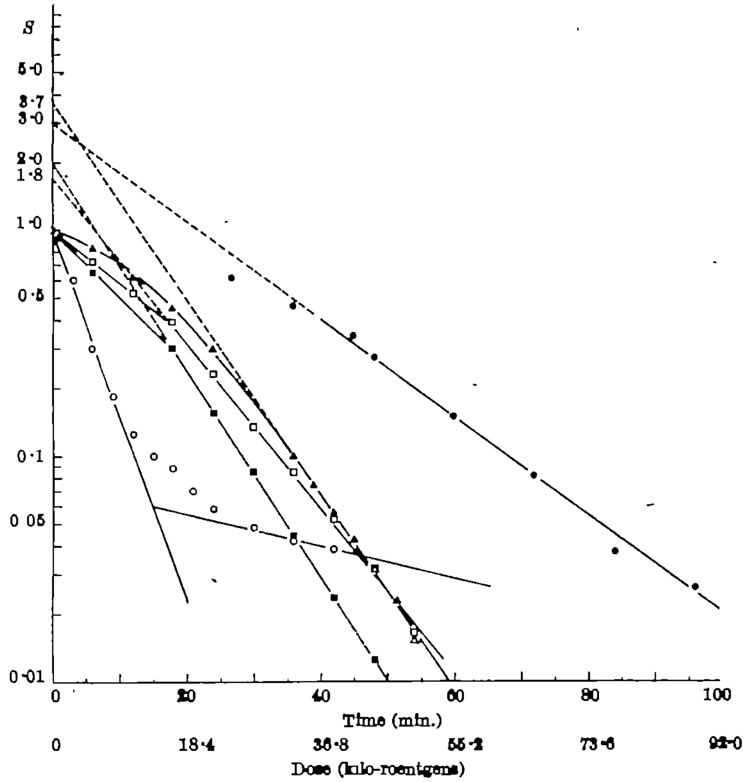
Extrapolation to zero dose gives

$$\ln S = m \ln n.$$

The experimental results are in agreement with equation (1) only for $m = 1$ and $n$ equal to the number of chromosome sets per cell. Under these conditions, all slopes should be equal. While the diploids and the tetraploid have the same slopes, the haploid is about twice as sensitive and the triploid twice as resistant. These figures have been confirmed independently by Pomper and Atwood (personal communication).

A triploid organism was obtained by mating the haploid gamete 13,894 and the diploid gamete 11,296, and a tetraploid was obtained by mating the two diploid gametes 11,294*aa* and 11,296*αα*. Gamete and hybrid clones were grown for 24 hr. on peptone–glucose slants and then refrigerated at 4° C. to serve as stock inocula. Samples of yeast were prepared for irradiation by transferring a heavy loop of cells from a stock inoculum to a 250-ml. flask containing 25 ml. of clarified *V*-8 juice (pH 3·9), a commercial mixture of several vegetable juices. After 44–48 hr. growth on a rotary shaker at 30° C., the cells were harvested, washed twice with 1/15 *M* potassium dihydrogen phosphate and resuspended in 1/15 *M* potassium dihydrogen phosphate to a cell count of approximately $5 \times 10^8$ cells per ml. Under these conditions, the cells were in a nearly uniform physiological state as indicated by the absence of budding and detectable reserves of glycogen and volutin, and the presence of a complement of numerous prominent mitochondria.

A quantity of 30 ml. of the suspension was transferred to a sterile Petri dish and irradiated by X-rays from a tungsten target tube operated at 180 kVp. at a rate of 920 r./min. as measured with a Victoreen 2,500 r. chamber. The total filtration was 3 mm. of aluminium. The suspension was agitated by means of a magnetic stirrer during irradiation. Exposures were made for successive 6-min. intervals. After each exposure a 1-ml. sample was removed, diluted in phosphate and plated in duplicate (controls in quadruplicate) in the following medium: 0·2 per cent Budweiser yeast extract, 0·1 per cent ammonium sulphate, 2·0 per cent dextrose, 0·15 per cent potassium dihydrogen phosphate, 0·05 per cent magnesium sulphate, and 2·0 per cent agar. Percentage survival was determined for each exposure by average macroscopic colony counts after incubation for three days at 30° C.



○—○—, Haploid (13,894), slope = 0·19 ; ■—■—, diploid (11,296), slope = 0·11 ; □—□—, diploid (11,294), slope = 0·086 ; ●—●—, triploid (13,894 × 11,294), slope = 0·050 ; Δ—Δ—, tetraploid (11,294 × 11,296), slope = 0·10

The points for the survival curves shown in the accompanying graph are averages of the survival values for the corresponding dosage as obtained from a number of independent determinations: five for the haploid; six for the diploid 11,294; four for the diploid 11,296; six for the triploid; and six for the tetraploid. Values for the extrapolate and slope were obtained by fitting the straight line portion of the curves by the method of least squares to the equation

$$\ln S = A - KD,$$

where $S$ is the surviving fraction, $A$ is the natural logarithm of the extrapolate, $K$ is the slope and $D$ is the dose expressed in minutes of exposure.

The average survival curves for haploid, diploid, triploid and tetraploid give extrapolates of 1, 2, 3 and 4, respectively (see graph). The extrapolates of individual survival curves were in general well reproducible. The scatter was small, and a good estimate of the extrapolate could be obtained by eye.

The experimental results indicate clearly a one to one correspondence between the degree of polyploidy and the number of targets per cell. It is not possible to state whether the target is a physical part of the chromosome set or is a consequence of the presence of the chromosome set.

An attempt to identify the target leads to the following considerations.

(1) Significant killing by the induction of dominant lethals is eliminated by the occurrence of extrapolates greater than one.

(2) If $m$ is taken to represent the number of genes per chromosome set, the experimentally determined value of unity eliminates recessive lethal mutation as an important aspect of inactivation in the polyploids, although recessive lethal mutation may account for the discrepancy between the haploid slope and the diploid and tetraploid slopes.

(3) If one assumes that all chromosomes have approximately the same sensitivity, and $m$ is taken to represent the number of chromosomes per set, the possibility that inactivation is due to the destruction of homologous chromosomes is eliminated as an important factor, since it is known that there are at least four chromosomes per set in *Saccharomyces*[3].

It may be suggested that the target is a particular chromosome in each set. This hypothesis evidently demands that the chromosome in question be be enormously larger than all the others or much more sensitive. The loss of a very large chromosome, however, would lead to an unbalance which would probably be lethal. The occurrence of an unusually sensitive chromosome seems unlikely in view of the demonstration of the equivalent break sensitivity per unit length in *Drosophila* chromosomes[4].

(4) Inactivation may be due to the destruction of a non-genic target. It is generally observed[5] that inactivated cells undergo several divisions before growth ceases. This indicates that the primary damage is not upon an enzyme or enzyme system but rather upon nuclear entities mediating their production and maintenance. The nucleolus and the central body are two vital extra-chromosomal structures associated with the nucleus. The central body is an unlikely target, since, in general, one exists per nucleus regardless of the degree of polyploidy. In polyploid *Saccharomyces*, it is not known at present whether a single nucleolus exists for each chromosome set or whether the several nucleoli are fused into a single body. Assuming that one nucleolus does exist for each chromosome set, the probability of hitting all nucleoli should not be greater than the probability of hitting homologous chromosomes, since there is no evidence that the nucleoli are significantly larger than the chromosomes.

It is known that radiation causes simultaneous damage to individual genes, enzymes, chromosomes and other organelles. While there is a remote possibility that the total of these damage factors is insignificant in comparison with damage to an as yet unidentified cellular structure, it is more probable that the observed integral extrapolates are expressions under the influence of polyploidy of an unusual inter-relation of these factors.

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[Oct. 14.

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# LETTERS TO THE EDITORS

*The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications*

## Statistical Nature of 'Facilitation' at a Single Nerve–Muscle Junction

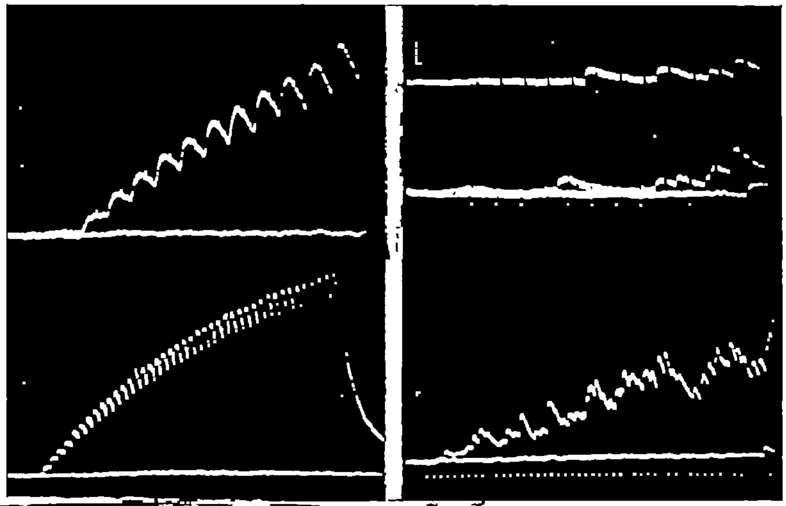
When an impulse arrives at a motor end-plate, it causes acetylcholine to be released at numerous 'key points' and in discrete quanta, each containing a large number of molecules[1]. The discharge of each quantal unit is an all-or-none event, and its success or failure is subject to independent statistical fluctuation. Its chances can be altered by various means, for example, by changing the ionic environment. Even under normal conditions, the probability of an individual 'quantum response' appears to be less than unity; that is, a nerve impulse excites at each junction only a fraction of the whole synaptic population. By lowering the calcium and raising the magnesium concentration, the chance of any one unit responding to a nerve impulse can be reduced to a very low value, and under these conditions, which apply to all the experiments described below, the statistical nature of the transmission process can be demonstrated most effectively.

It has previously been shown that individual quantal units discharge spontaneously, in the absence of nerve impulses[1]. This enables one to measure the mean unit size, and to determine the average number ($m$) of quanta responding to one impulse. Provided $m$ is not too large, it is given simply by the ratio (mean amplitude of response)/(mean amplitude of spontaneous potentials). When $m$ is a small number (the probability of each quantum response being very low), the actual numbers ($x$) in a large series of observations are found to vary at random and to be distributed in accordance with Poisson's law (their relative frequencies being given by $\exp(-m)\, m^x/x!$). The proportion of failures in such a series is $\exp(-m)$; hence the following relation is obtained:

$$\frac{\text{Mean amplitude of response}}{\text{Mean amplitude of spontaneous potentials}} = \ln \frac{\text{No. of nerve impulses}}{\text{No. of failures of end-plate responses}}$$

For example, Fatt and Katz (ref. 1, Fig. 9 and p. 120) described a case of a calcium-deficient end-plate at which 328 nerve impulses elicited 140 end-plate potentials, made up mostly (about a hundred) of single units, the remainder containing two or three quanta. The mean amplitude of 328 responses (including 188 failures) was 0·495 mV.; the mean size of spontaneously occurring potentials (that is, the mean unit size) was 0·875 mV.; hence $m = 0{\cdot}495/0{\cdot}875 = 0{\cdot}57$. From Poisson's law, for $x = 0$, $m = \ln 328/188 = 0{\cdot}56$. Thus, the statistical *average* response in this experiment consisted of less than one quantum per impulse, the observed responses showing a wide, discontinuous variation of amplitudes and a high proportion of total failures.

Some well-known phenomena such as 'facilitation' and 'fatigue', which are generally associated with transmission of impulses across synapses,[2] appear to involve a progressive change in the mean number of quantal units responding to successive impulses. Thus we found with intracellular recording that the second of a pair of nerve impulses, at a time interval of 5–10 msec., produced an increase of 50–80 per cent in the mean size of the end-plate potential. This is the well-known effect of 'facilitation'[3], which has been studied in the past by recording from a whole muscle the average response of hundreds of end-plates, arranged in parallel. We have used a more tedious method of determining the statistical mean, by measuring the average size of hundreds of successive responses from a single end-plate. In this way we found that the increased amplitude of the second end-plate potential is entirely due to an increase of its average quantum content, the second of the two responses following a Poisson series with a significantly lower proportion of failures and larger value of $m$. The chances of excitation of any one unit remained small, but were 50–80 per cent greater for the second of the two nerve impulses. It can be shown that this increased probability does not depend upon there having been a previous response of any unit; and that, in general, the particular units activated by the second impulse are not the same as those responding to the first.



Whole muscle

Single junction

Facilitation of end-plate potentials at the nerve–muscle junction. The records were from nerve–muscle preparations of the frog, blocked by the use of high magnesium (14 m$M$/L.) and low calcium (0·9 m$M$/L.) concentrations, during repetitive stimulation of the nerve at 100 impulses per sec. (in the right part, stimuli are marked by dots). Bottom records were taken on slower time base. Left: Surface recording from a junctional zone of frog's sartorius. Right: Intracellular records from a junction of a muscle fibre of M. ext. l. dig. IV. Note the single spontaneous discharges occurring at the end of the 'base-line' sweeps. Scales: 1 mV.

The statistical nature of 'facilitation' is further shown in the accompanying records. On the left side are records of end-plate potentials obtained with the usual method of surface recording from a whole sartorius muscle. They illustrate that during a rapid firing of nerve impulses, at 10-msec. intervals, successive potentials are not only additive, but grow progressively in amplitude. The growth of the response proceeds smoothly with only slight irregularities, and successive records of this kind show only a minor degree of variation. This is, of course, to be expected, for this method of recording gives us the averaged response from a large number of end-plates. On the right side we have records obtained with an intracellular electrode from a *single* end-plate, presenting a very different picture. The records show the fluctuating character of the response, there being at first a large proportion of failures with occasional 'single-quantum' responses and then an irregular building up of responses interspersed with occasional failures. In the accompanying table, success-and-failure counts of a large number of such records have been summarized. It will be seen that the proportion of failures progressively diminished during the period of stimulation (84 per cent of failures for the first, about 47 per cent for the tenth and 20 per cent for the fortieth impulse), which corresponds to a progressive increase in the Poisson value of *m*. If one measures amplitudes of successive end-plate potentials in the left part of the records, it is found that the tenth response is about five times larger, the fortieth response about ten times larger, than the first. A comparison with the results in the table indicates that this increase, or 'facilitation', must be entirely due to a statistical recruitment of quantal units from a large population of units available at each nerve–muscle junction.

RECRUITMENT OF RESPONSES AT A SINGLE JUNCTION

Summary of seven experiments. Intra-cellular recording from end-plates of frog's muscle, treated with high magnesium and low calcium concentration. Repetitive stimulation of nerve, as in records. Second column shows the total number of impulses in the denominator, and the number of end-plate potentials elicited in the numerator

| Serial No. of nerve impulses (tetani at 100/sec.) | No. of end-plate responses / No. of nerve impulses | Proportion of failures (= exp (− *m*)) | *m* | Facilitation factor ($m_n/m_1$) (mean and S.E.) |
|---|---|---|---|---|
| $N_1$ | $\frac{111}{710}$ | 0·84 | 0·18 | 1·0 |
| $N_{6-15}$ | $\frac{858}{1,615}$ | 0·47 | 0·83 | 4·7 ± 0 45 |
| $N_{16-35}$ | $\frac{799}{1,140}$ | 0·3 | 1 28 | 7·1 ± 0·66 |
| $N_{36-45}$ | $\frac{886}{1,105}$ | 0·2 | 1·72 | 9 9 ± 1·25 |

The basis of the quantal mechanism is unknown: it may be that each unit of discharge starts with the activation of a single 'key molecule', opening a local 'gate' in the nerve membrane and releasing a flood of acetylcholine ions. The activation of such key—or 'carrier'—molecules may result from spontaneous thermal agitation, and the effect of a nerve impulse may be to lower their activation threshold, thus causing a synchronized opening of many local 'gates' and a flooding of the whole end-plate with the transmitter substance. But while there is little doubt about the quantal nature of the end-plate response, and about some of the statistical rules by which it is governed, there is no evidence available at present to support speculations about the details of the quantal mechanism.

This work was supported by a grant from the Nuffield Foundation.

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April 1.

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## Radio Echoes observed during Auroræ and Terrestrial Magnetic Storms using 35 and 74 Mc./s. Waves Simultaneously

In an undisturbed and extended ionosphere, the maximum value of the frequency of radio waves which can be reflected by regular refraction processes is determined by the maximum electron density of the layer. The maximum value of the critical frequency at vertical incidence seldom exceeds 15 Mc./s.

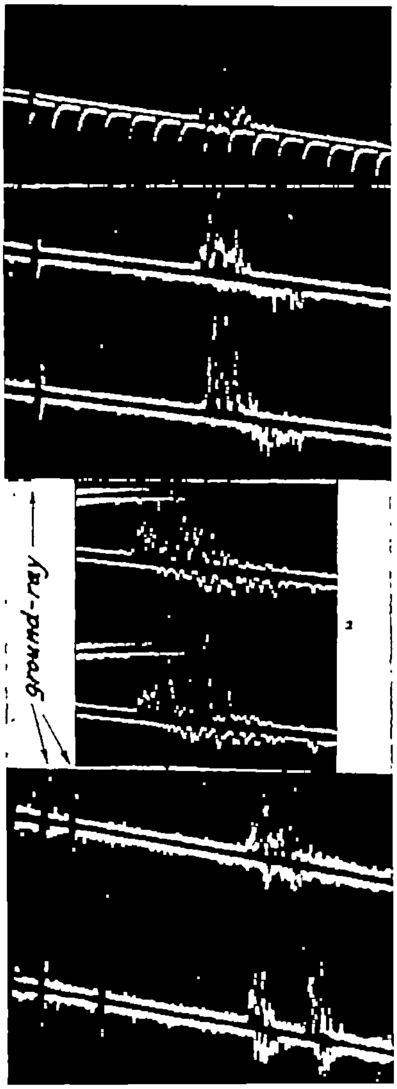
During recent years, considerable attention has been paid to scattering processes of radio waves in the ionosphere. In an inhomogeneous ionosphere it should be possible to get scattered reflexions from 'blobs' or stratifications in the electron densities using waves in the very high frequency band. Scattered reflexions in this have been observed in a number of cases[1]; and in all of them the reflexions have been associated with the appearance in the sky of definite auroral forms.

In the following, the results of observations during auroral displays and terrestrial magnetic storms made at Tromsö (near the auroral zone) and at Kjeller (near Oslo) will be given. The recording equipment consisted of two pulse transmitters on 35 and 74 Mc./s., both having a common pulse-modulator and high-tension supply. The energies and the shape of the two pulses sent out simultaneously could therefore be made identical (peak-power 25 kW. and repetition frequency 50 c./s.). Two geometrically identical six- or three-element yagis, with a half-width of the lobe of 65° directed towards the north, were used as antennæ; the elevation of the beam could be varied. The echoes were displayed on a double-beam cathode-ray tube with common sweep.

The echo records at Tromsö showed that echoes on 35 Mc./s. appeared regularly during auroral displays, and in a number of cases also on 74 Mc./s. A closer study of the echoes led to the conclusion that in the cases under discussion the echoes could not be explained by direct scatter from the ionosphere, but by reflexion of backwards scatter from land or sea via the lower part of the *E*-layer (the $E_s$-layer) the ionization of which increases strongly during auroral and terrestrial magnetic storms. Our explanation of the very high frequency echoes observed is therefore in opposition to the common assumption of direct and primary scatter from the auroral forms or inhomogeneities in the ionosphere. The arguments supporting our explanation of the mechanism of reflexion are as follows.

There is no correlation between the ranges of the echoes and the distances to auroræ simultaneously appearing. Even the most brilliant auroral forms appearing at distances from 80 km. (in the zenith) and up to 400–500 km. (low in the north) do not give the slightest traces of echoes appearing when the antennæ are directed against the auroral forms. But at the same time, echoes are observed with ranges of 600–1,800 km. when the antennæ were directed horizontally against the north. It has been assumed[2] that reflexions from an aurora mainly occur when the waves are incident normally to the direction of the earth's magnetic field. In this case we should get no reflexions from the auroræ observed visually in Tromsö. But it is difficult to imagine that this condition is so strictly maintained that the most violent aurora at 80 km. distance does not give the slightest trace of echoes.

In all cases the echoes on 35 Mc./s. showed a noticeably smaller range than the echoes on 74 Mc./s.



Simultaneous echoes on 35 and 74 Mc./s. recorded on a double-beam cathode-ray tube. The upper trace shows 35 and the lower 74 Mc./s., 50 c./s. repetition frequency, recorded on moving film; the distance between the pips represents 100 km. (1) Different reflexion distances for 35 and 74 Mc./s. scatter; (2) lack of correlation between the subsequent sweeps as well as between the 35 and 74 Mc./s. patterns, recorded on an expanded time-scale; (3) double-pulse is used with changing time-separation, and correlation between the echo patterns is obtained when the time separation is of the order of less than 2 millisec.

This difference in range varied and usually amounted to more than 100 km. (see Fig. 1).

The echoes were spread out in time corresponding to a difference in the range from 100 km. and up to several hundreds of kilometres.

Echoes on 35 Mc./s. were considerably stronger than on 74 Mc./s., and echoes on the higher frequency usually appeared during the stronger phases of the terrestrial magnetic storms.

Polarization tests were made on 35 Mc./s. The waves were sent out vertically polarized and received on vertical and horizontal polarized yagis simultaneously through two separate channels. Generally, there was no difference in field-strength of the echoes through the two channels.

With a repetition frequency of 50 c./s., there was no correlation between the echo pattern of subsequent sweeps. In Fig. 2, where the echo patterns are recorded on a fast-moving film, the subsequent echo patterns have changed completely. In this case an increased sweep velocity has been used for analysing the echo pattern.

There is no correlation between the structure of the echo patterns on 35 and 74 Mc./s.

By using double pulses, the distance between the pulses being made variable, it could be shown that a correlation between the echo structures appeared when the time interval between the two pulses was less than about 2 millisec. This corresponds to a ray-path of 300 km., in which case the two echo patterns appeared well separated in time. This is evident from Fig. 3.

There is a difference in character of the echo patterns on 35 and 74 Mc./s. The echoes on 35 Mc./s. exhibited usually a well-defined leading edge with maximum amplitude just after the leading edge. On 74 Mc./s. there was often no leading edge; the echo amplitude increased continuously from zero, and the maximum amplitude was usually considerably displaced towards greater distances.

During one severe terrestrial magnetic storm on November 28, 1952, pulses sent out from Kjeller were received in Tromsö, where they appeared undisturbed, having the same width as the pulses transmitted. During this severe storm the auroral zone had apparently been displaced towards the south and the $E_s$-layer acted as a mirror-like reflexion surface. The echoes received back at Kjeller, however, showed the usual distortion.

The characteristics of the echoes summarized above cannot be explained by primary scatter from the ionosphere, whereas the assumption of backwards-scatter from land or sea via the lower part of the ionosphere, the $E_s$-layer, fits in with the characteristics of the echoes described above.

A full account of the observations will be given in *J. Atmo. Terr. Phys.*

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B. Landmark
Norwegian Defence Research Establishment,
Kjeller, Norway. March 11.

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## Fractionation of Isotopes by Distillation of some Organic Substances

We have found that the distillation of chloroform, carbon tetrachloride, methyl alcohol and benzene leads, surprisingly enough, in all four cases to an enrichment of carbon-13 in the distillate, whereas the other heavy isotopes, such as chlorine-37 and oxygen-18, are enriched in the still pot.

The distillations were carried out in empty tube columns, consisting of a great number of narrow, unpacked parallel working tubes with individual reflux[1]. All distillations were carried out at 34·6° C. using very high reflux ratios. Samples withdrawn from the head and the bottom of the column were treated in the manner described below to yield gaseous products, such as carbon dioxide and hydrogen chloride, suitable for mass spectrometric analysis. The isotopic abundance ratios were determined by means of a 60° double-collector mass spectrometer (Consolidated–Nier 21–201).

According to the theories of Kuhn[2] and Westhaver[3], the height equivalent to a theoretical plate of empty tube columns may be reduced to a theoretical minimum given by the radius of the tubes (for example, 0·2 cm.), and distillations in which such high separation efficiencies have been very nearly obtained have been reported by Kuhn and Ryffel[4]. The hold-up, and accordingly the time required until equilibrium conditions are obtained, is very small in such columns. The number of effective theoretical plates $n$ of the columns at infinite reflux ratio can be calculated from the length $L$ and the radius $r$ of the tubes, from the average vapour speed $\bar{u}$ and from the diffusion constant $D$ in the vapour according to the relation[2]:

$$n = \frac{4LD}{r^2 . \bar{u}} . \qquad (1)$$

Expressions for $n$ in the case of finite reflux ratios have been derived recently[5].

From the number of theoretical plates $n$ and from the isotopic fractionation, the relative difference in vapour pressure of the isotopic species is calculated according to the following relation derived from the Fenske equation:

$$\frac{p_1 - p_2}{p_2} = \left(\frac{R_B}{R_D}\right)^{1/n} - 1, \qquad (2)$$

where $p_1$ and $p_2$ are the vapour pressures at the distillation temperature (34·6° C.) of the pure light and the corresponding pure heavy isotopic molecules respectively, $R_B$ and $R_D$ represent the isotopic abundance ratios in the still pot and distillate, respectively, of the heavy to the light atom under consideration, and $n$ is the number of effective theoretical plates.

The difference in boiling temperatures $\Delta T$ of the two isotopic species is approximately obtained from (2) and from the vapour pressure equation using Trouton's rule:

$$\Delta T = T_1 - T_2 = -\frac{T_1^2}{10{\cdot}7\, T_b n} \ln \frac{R_B}{R_D}, \qquad (3)$$

where $T_1$ and $T_2$ are the absolute boiling temperatures of the pure light and the pure heavy substance respectively at the pressure at which the distillation is performed; $T_b$ is the normal boiling temperature.

If there are several isotopic atoms of the same element in the molecule, for example, chlorine in the case of carbon tetrachloride, the indexes 1 and 2 in equations (2) and (3) can be shown to refer to two isotopic molecules of neighbouring molecular weight, for example, $C^{35}Cl_2{}^{37}Cl_2$ and $C^{35}Cl^{37}Cl_3$ or $C^{35}Cl^{37}Cl_3$ and $C^{37}Cl_4$. This holds in any event, whether exchange of the isotopic atoms between the molecules in the distillation process is possible or not, provided only that the difference in boiling temperatures between all pairs of neighbouring molecules is the same.

*Chloroform.* Already in 1945 we found that the distillation of chloroform in an empty tube column leads to an enrichment of chlorine-35 in the distillate, the ratio $^{37}Cl/^{35}Cl$ being shifted by amounts up to 12 per cent. The isotope analysis was performed at that time by density measurements, by a spectroscopic method[6], and by using the nuclear reaction $^{37}Cl(n,\gamma)^{38}Cl$[7]. We now find that the agreement with the mass spectrometric ratio determination as performed recently on samples which had been kept from this distillation is satisfactory.

Gaseous hydrogen chloride and carbon dioxide were obtained for mass spectrometric analysis by the reaction of chloroform with potassium hydroxide. The potassium chloride and formate obtained were, after oxidation of the formate to carbonate, treated with acid, liberating hydrogen chloride and carbon dioxide.

From the results of the isotope analysis and from the number of theoretical plates $n$ used in the distillation, the following results were obtained from equations (2) and (3):

Table 1

| $n = 610$ | Isotopic fractionation of chloroform with respect to: Carbon | Chlorine |
|---|---|---|
| $R_B/R_D$ | 0·62 | 1·06 |
| $\frac{p_1 - p_2}{p_2}$ | $-8\times10^{-4}$ | $+10^{-4}$ |
| $T_1 - T_2$ | + 0·02° C. | − 0·003° C. |

Purification of the chloroform for the density determination was carried out as follows. After shaking with concentrated sulphuric acid, the chloroform was distilled off and condensed under vacuum on tetra-salicylide with which, according to Anschütz[8], it forms a very specific addition compound. Upon heating this compound, some low-boiling impurities come off first and are rejected, the pure chloroform being obtained upon further heating. This procedure was repeated several times until no change in density (using the float method) could be observed. To apply the spectroscopic method referred to above, the chlorine must be present in the form of $HgCl_2$, which was obtained from the chloroform by alkaline hydrolysis, precipitation of the chlorine ions as silver chloride and fusing the dried silver chloride precipitate with mercuric sulphate. The mercuric chloride formed according to the reaction $2AgCl + HgSO_4 \rightarrow Ag_2SO_4 + HgCl_2$ is separated from the reaction mixture by repeated sublimation.

*Carbon tetrachloride.* Attempts to fractionate the chlorine isotopes by high-efficiency distillation of carbon tetrachloride have been reported by Grimm[9] and by Rank and Kargarise[10]. These authors, using the density method of isotopic analysis, did not, however, find any fractionation.

In our case the distillation was carried out in a column with $n = 80$, and the carbon tetrachloride samples were treated for analysis by passing a stream of hydrogen through them and burning the mixture containing some 10 per cent carbon tetrachloride in oxygen. The hydrogen chloride and carbon dioxide thus formed were trapped in an excess of barium hydroxide solution and separated as chloride and carbonate. Pure hydrogen chloride and carbon dioxide were liberated by acid treatment. The following results[1] were obtained.

Table 2

| $n = 80$ | Isotopic fractionation of carbon tetrachloride with respect to: Carbon | Chlorine |
|---|---|---|
| $R_B/R_D$ | 0·90 | 1·003 |
| $\frac{p_1 - p_2}{p_2}$ | $-1{\cdot}3 \times 10^{-3}$ | $+3 \times 10^{-5}$ |
| $T_1 - T_2$ | + 0·033° C. | − 0·001° C. |

The above results indicate that, while there is only a very slight enrichment of chlorine-35 in the distillate, the concentration of carbon-13 is increased considerably. The calculation shows that the resulting effects on the density are of the same order of magnitude but of opposite sign. This would account for the lack of any effect reported in previous studies[9,10].

*Methyl alcohol.* An enrichment of oxygen-18 in the residue of a methyl alcohol distillation has been reported by Roberts and Urey[11]. In our study, methyl alcohol was distilled in a column with 140 theoretical plates. The samples for investigation were burnt in oxygen of known isotopic composition and the gases thus formed were collected. Water and carbon dioxide were brought to exchange equilibrium at room temperature, and the $^{18}O/^{16}O$ ratio in the methyl alcohol was calculated from that in the carbon dioxide and from that in the oxygen entering and leaving. The results are shown in Table 3. An enrichment of $CH_3OD$ in the still pot was found qualitatively.

Table 3

| $n = 140$ | Isotopic fractionation of methyl alcohol with respect to : Carbon | Oxygen |
|---|---|---|
| $R_B/R_D$ | 0·97 | 1·50 |
| $\frac{p_1 - p_2}{p_2}$ | $-2 \times 10^{-4}$ | $3 \times 10^{-3}$ |
| $T_1 - T_2$ | + 0·0055° C. | − 0·07° C. |

*Benzene.* Pure benzene was distilled in a column with $n = 80$. The samples were burnt in a hydrogen–oxygen flame and the carbon dioxide thus formed was trapped in barium hydroxide solution. The carbonate was decomposed with acid to yield pure carbon dioxide, for which $^{13}C/^{12}C$ analysis led to the following results :

$$R_B/R_D = 0{\cdot}98, \quad \frac{p_1 - p_2}{p_2} = -2{\cdot}5 \times 10^{-4},$$

$$T_1 - T_2 = +\ 0{\cdot}006^\circ\ C.$$

The results obtained by the distillation of chloroform, carbon tetrachloride and methyl alcohol indicate the possible existence of a general rule stating that, in isotopic molecules having a central atom, the molecular variety containing the heavier isotope of the central atom will exhibit a somewhat higher vapour pressure than the variety containing the lighter isotope as central atom. Results in agreement with this rule have been found recently by Green and Martin[12] in the case of boron trichloride.

We wish to thank Dr. P. Massini for carrying out some of the distillations, Dr. K. Wieland (Zurich) for the spectroscopic isotope analysis of chlorine, and Dr. F. Alder, of the Physics Department, Basel, for the isotope analysis of chlorine by nuclear reaction. This work was supported by grants from the Eidgenössische Volkswirtschaftsstiftung, the Ciba-Stiftung and the Freiwillige akademische Gesellschaft.

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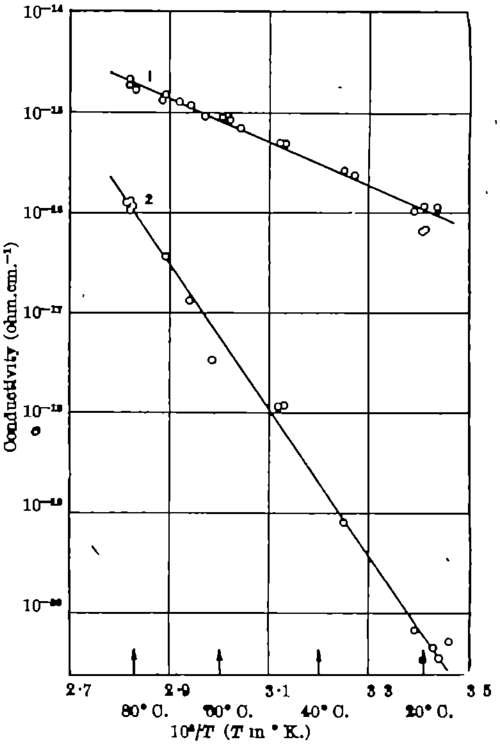
## Effect of Temperature on the Conductivity induced in Insulators by X-Rays

STUDIES of the induced conductivity in insulators due to X-rays[1] are difficult owing to the extremely low values to be measured, and hitherto have been made primarily with condenser chambers[2]. These allow only the after-effect of the radiation to be determined. If measurements of conductivity during exposure are to be made, the apparatus must admit no air gap at any point between the insulator under test and the electrometer, and in addition the volume of insulator irradiated must be as large as possible, so as to give sufficient current for measurement.

These difficulties were overcome in the present tests by using a length of 6 metres of polythene-insulated cable coiled into a flat spiral and connecting the end of the cable, outside the room, to a source of voltage and a D.C. amplifier. The coil was enclosed in a 'Perspex' box through which heated air could be passed to control the temperature. The object was to determine the temperature coefficient both of irradiated and unirradiated material, and hence the energy-levels of conduction bands under the two conditions from the general relationship,

$$\sigma = \sigma_0 \exp(-\ W/kT).$$

The X-rays were generated at 220 kV. (2·5 mm. copper half-value layer) with a dose-rate of about 8 r./min. The conductivity was measured every minute after commencement of exposure, and the present figures relate to the equilibrium conductivity which is attained after about ten minutes of irradiation. Graph 1 shows the relationship between log (conductivity) and $1/T^\circ$ K. for the range 20–80° C. The straight line confirms the above law for this material. The slope gives $W = 0{\cdot}42$ eV.



(1) Irradiated with X-rays ; (2) unirradiated

The corresponding graph (2) for the unirradiated material is also a straight line, which has a steeper slope, giving $W = 1{\cdot}5$ eV.

It will be observed that in either case the effect of temperature is large. Under irradiation at room temperature, the conductivity increases by 5·6 per cent per deg. C. The corresponding increase for unirradiated material is 19 per cent per deg. C. It is clear from these results that no accurate studies of induced conductivity can be made without very careful temperature control[3]. If such control is applied, however, consistent results are obtained which can be interpreted in terms of energy-level distributions, and the behaviour of the material is not unlike that of crystalline materials[4].

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## Degradation of Methionine by Hydrogen Peroxide

I have been searching for an appropriate method of oxidizing methionine from biological materials with hydrogen peroxide in order to be able to detect the amino-acid as its sulphone on paper chromatograms as a discrete spot. During the course of this work, it has been found that the heating of methionine in solutions of hydrogen peroxide leads to the formation of several ninhydrin-reacting substances, some of which are of biological interest as possible intermediates in the metabolism of methionine in animal organisms. In the present communication the procedures employed to effect the degradation of methionine, and the results obtained in a preliminary identification of the substances thus produced, are described.

To study the degradation of methionine in its various stages, 0·05 m$M$ aliquots of DL-methionine were added to 0·2–10·0 ml. of hydrogen peroxide solution, the concentration of which was 0·1 m$M$ per ml., thus producing mixtures with ratios of methionine to hydrogen peroxide varying from 1 : 0·4 to 1 : 20. These mixtures were sealed in glass tubes and heated in a boiling water-bath for 12 hr. The solutions were then removed from the glass tubes, evaporated to dryness under reduced pressure, and the residues dissolved in 0·5 ml. distilled water. Those reaction mixtures which became strongly acid, as the result of the formation of sulphuric acid, were neutralized with a solution of barium hydroxide, and the resulting precipitate was removed before evaporation. Similar experiments were also carried out starting with methionine sulphoxide and methionine sulphone.

One- and two-dimensional chromatograms were run according to the method described by Williams and Kirby[1]. A phenol – water (80 : 20, v/v) system and a collidine – pyridine – water (150 : 20 : 100, v/v) system were used as developing solvents. For two-dimensional chromatography, 1–10 μl. portions of the solutions of reaction products prepared as described above were used.

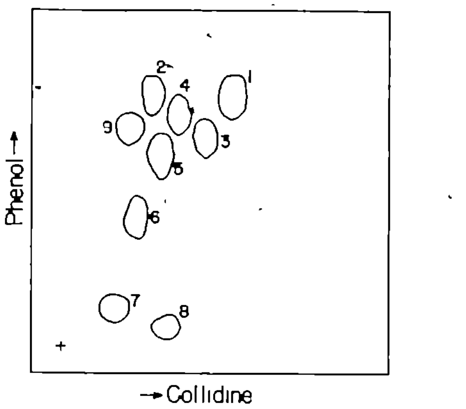


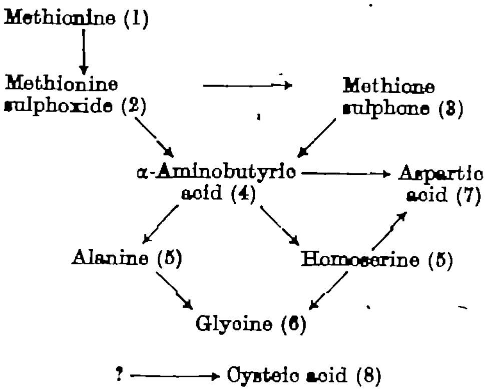
Diagram of two-dimensional chromatogram of ninhydrin-reacting substances derived from methionine by oxidation with hydrogen peroxide. 1, methionine; 2, methionine sulphoxide; 3, methionine sulphone; 4, α-aminobutyric acid; 5, alanine or homoserine, or both; 6, glycine, 7, aspartic acid; 8, cysteic acid, 0, unknown

The accompanying diagram is a composite one of the spots appearing on the two-dimensional chromatograms, and it shows all the ninhydrin-reacting substances derived from methionine by oxidation with hydrogen peroxide. All these spots on the paper chromatograms showed the typical ninhydrin reaction of amino-acids, and none of them survived the distinctive test for α-amino-acids reported by Crumpler and Dent[2]. Identification of these substances was carried out only by means of paper chromatography.

Neither of the solvents used in this study, nor their combination in the two-dimensional technique, could separate alanine and homoserine completely. In another experiment, solutions of alanine and hydrogen peroxide were heated in the presence of sulphuric acid. The chromatographic analysis of the product of this reaction could support the interpretation that glycine was formed from alanine. Since, as mentioned above, sulphuric acid is formed when methionine is heated in a solution of hydrogen peroxide, it might be suggested that spot 5 is alanine, and glycine (spot 6) is derived from alanine. However, it is possible that spot 5 is homoserine, because homoserine was found to give rise to glycine and aspartic acid under the same conditions. It was also found that under the same conditions α-aminobutyric acid can yield glycine, aspartic acid and spot 5. Therefore, spot 5 can be interpreted as being either alanine or homoserine; or it may represent both amino-acids.

All the spots shown in the diagram, except that of methionine, were observed in the reaction mixtures when the experiment began with methionine sulphoxide. When methionine sulphone was used instead, spots 4 and 5 could not be detected; and, of course, spots corresponding to methionine and methionine sulphoxide were absent in this case. The reason for the absence of spots 4 and 5 may be that methionine sulphone is very stable under the conditions of this experiment; α-aminobutyric acid and the substance represented by spot 5, which are less stable in comparison to methionine sulphone, are rapidly converted to other oxidation products.

Cysteic acid might be produced by a reaction between sulphuric acid and a 3-carbon moiety, though no proof of this has been obtained. The nature of spot 9 is unknown.



Possible pathway of degradation of methionine by hydrogen peroxide

A possible pathway for the degradation of methionine under the experimental conditions employed in this work is shown in the diagram. That α-aminobutyric acid can be derived from methionine through its sulphoxide, and very possibly also through its sulphone, is most interesting.

Thanks are due to Drs. T. Minoshima and H. Nakamura for their interest in this work.

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## Crystalline Trypsin

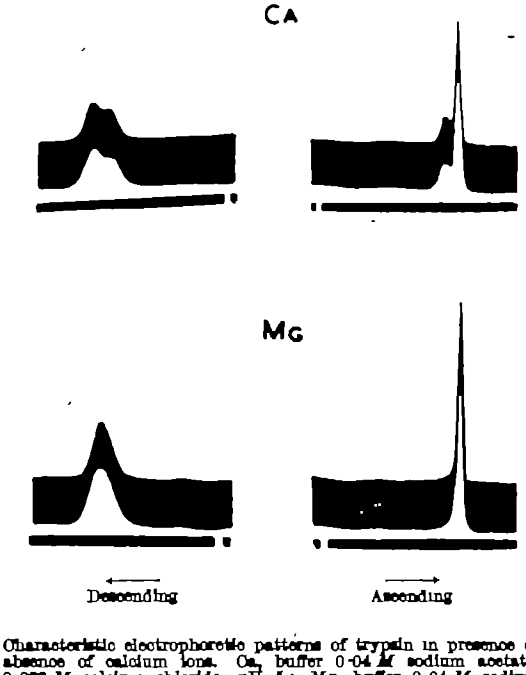
INVESTIGATIONS carried out during the past two years have revealed the existence of a complex interaction between trypsin and certain specific divalent ions, particularly calcium ions. These relations manifest themselves in various ways and have been studied in arbitrarily differentiated *p*H-stability zones of trypsin.

In the region of its optimum proteolytic activity, between *p*H 7 and 9, calcium and manganese ions were the only ones in a comprehensive list of ions tested which stabilize trypsin solutions[1,2]. By means of electrophoretic analyses performed in this *p*H region, it could be demonstrated that the calcium effect is due to a diminishing of the rate of self-digestion, and it was concluded that calcium causes a shift in the equilibrium existing between the native and denatured forms of the enzyme towards the former. This work also resulted in a redetermination of the isoelectric point of the enzyme, which lies in the neighbourhood of *p*H 10·8, and was amplified by a partial determination of the amino-acid composition[1]. The same ions, as well as cadmium and cobalt ions, were found to augment slightly the activity of the enzyme[3], while an investigation over the whole *p*H range has shown that the higher activity can be ascribed to the increased concentration of the active form of the enzyme[4]. On the other hand, calcium has shown itself to be without specific protective effect in inactivation of the enzyme brought about by ionizing radiation[5].

The maximum stability zone of the enzyme is at about *p*H 2·3. Ultracentrifugal sedimentation patterns are characteristic of a homogeneous protein having a sedimentation constant $s_{20,w}$ of 2·5 *S* [6] or 2·4 *S* [7]. On prolonged standing at the acid side of this *p*H, some faster sedimenting components appear as a result of the aggregation of the slowly denaturing enzyme which is not complicated by proteolysis. The sedimentation behaviour at *p*H 8 is quite similar to that observed at acid *p*H with the exception that, on prolonged standing, some slower sedimenting products of the self-digestion appear. The presence of either of these breakdown products or of the aggregated enzyme in acid solutions does not influence the sedimentation-rate of the remaining unaltered trypsin[7].

It is between the above two extreme *p*H regions that a number of other significant manifestations of the effect of calcium can be observed. It was reported that the sedimentation constant increases in this range, the maximum aggregation being at about *p*H 5 [6]. Our investigations resulted in the observation that this aggregation is strongly dependent on temperature, the sedimentation constant decreasing to about a normal value at 30° C. The presence of 0·05 *M* calcium chloride completely prevents this aggregation[7]. More direct evidence of an interaction between calcium and trypsin in this *p*H range was obtained by the study of the dissociation curves of trypsin. Calcium ions, in contrast to magnesium ions, give rise to a shift in the titration curves of the enzyme in the regions of the dissociation of carboxylic groups towards more acid *p*H values. The formation of the complex thus demonstrated causes the lowering of the dissociation constants of the carboxylic groups[4].

It was therefore to be expected that the decrease in net charge of the enzyme, due to the formation of the complex with calcium, could be evidenced by electrophoretic analysis. The characteristic patterns



Characteristic electrophoretic patterns of trypsin in presence or absence of calcium ions. Ca, buffer 0·04 *M* sodium acetate, 0·033 *M* calcium chloride, *p*H 5; Mg, buffer 0·04 *M* sodium acetate, 0·033 *M* magnesium chloride, *p*H 5 of trypsin at $pH$ 5, in 0·04 $M$ acetate buffer, in the presence of 0·033 $M$ magnesium or calcium chloride, all other conditions being equal, are shown in the accompanying diagram. It can readily be seen that, in the absence of calcium, trypsin presents an electrophoretic pattern characteristic of a homogeneous compound, the presence of calcium ions causing the separation of the moving boundary into two well-defined peaks. Of the two boundaries, the larger one moves with a mobility characteristic of trypsin in the absence of calcium, and the smaller boundary moves at a slightly slower rate. At a lower concentration of calcium ions, the appearance of the secondary peak is not so well defined; but further increase in the calcium ion concentration does not change the electrophoretic patterns. It is characteristic that identical patterns are also observed in the presence of manganese as well as cadmium ions which have already been mentioned as increasing the activity of the enzyme[2]. Cobalt, magnesium and barium ions, listed in order of decreasing effect, also increase the activity of trypsin, but to a lesser degree than calcium, manganese or cadmium ions, which are equivalent in their action. Under our experimental conditions, neither of the first three ions causes the characteristic change in the electrophoretic pattern; together with all other ions tested, they give rise to electrophoretically homogeneous patterns of trypsin. Nevertheless, there is no doubt that the two effects are due to the same cause.

After a prolonged electrophoretic separation, it was possible to obtain small samples of the faster and slower components. In four independent analyses, the tryptic activity of both components was found to be proportional to the concentration of the protein as determined by ultra-violet absorption at 280 mμ. Crystalline trypsin was also digested at $pH$ 8 in the presence and absence of calcium, and aliquot samples were analysed electrophoretically at 24-hr. intervals, the electrophoretic analyses having been carried out in the presence of calcium under the conditions already mentioned. It was thus possible to determine the rate of digestion of both components in the presence or absence of calcium. In both instances t was found that the ratio of the areas of the two components did not change in the course of the self-digestion, although the overall rate of digestion was considerably diminished by the presence of calcium. It appears, therefore, that crystalline trypsin is electrophoretically heterogeneous, containing two components both of which possess a similar tryptic activity and rate of self-digestion and both of which are subject to protection by calcium ions. An ndication of this heterogeneity has already been reported[1].

Another example of an electrophoretically heterogeneous protein in which all components have similar biological activity was found in ovomucoid[8], the antitryptic factor of egg-white. The aggregaion observed in the absence of calcium by ultracentrifugal analysis is viewed as resulting from a reversible interaction of the two components. As a consequence, only one peak appears in electrophoretic analysis, moving with the weighted average of the mobilities of the two components. Calcium, combining with the carboxyl groups, prevents this aggregation, resulting in a normal sedimentation behaviour and appearance of the two electrophoretic components.

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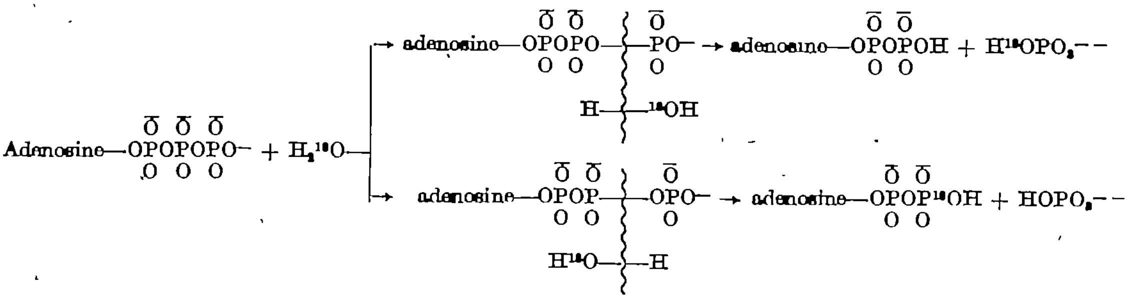
## Mechanism of Hydrolysis of Adenosine Triphosphate catalysed by Lobster Muscle

IN previous publications[1] evidence has been presented for the occurrence of displacement mechanisms in a wide variety of enzymatic reactions to which those of adenosine triphosphate are closely analogous. Assuming that the adenosine triphosphate reactions proceed by the same mechanisms, it can be deduced from the nature of the products that the adenosine triphosphate can undergo nucleophilic attack at any of its three phosphorus atoms. As examples, the Lohmann reaction with creatine[2] must involve attack at the terminal phosphorus atom, the coenzyme A reaction of Lipmann *et al.*[3] must involve attack at the middle phosphorus atom and the Kornberg reaction with nicotinamide mononucleotide[4] must involve attack at the innermost phosphorus atom. If the adenosine triphosphate is hydrolysed by an adenosine triphosphatase in ordinary water to adenosine diphosphate and inorganic phosphate, the pathway is not obvious, since attack at either the terminal phosphorus atom or the middle phosphorus atom would give the same products. This ambiguity can be avoided, however, by using $H_2{}^{18}O$, in which case the alternatives are clearly distinguishable (cf. reaction 1). The study of the mechanism of adenosine triphosphate hydrolysis in muscle was therefore performed in a medium of $H_2{}^{18}O$ and the products were analysed for their content of oxygen-18.

Lobster muscle strips (25 gm.) were thoroughly washed with potassium chloride solution and then incubated with $H_2{}^{18}O$ (100 c.c., 1·3 atom per cent excess) for 1 hr. until equilibration between the water of the medium and that of the muscle strips had occurred. Solid adenosine triphosphate (2·55 m$M$) was then added, and the solution was stirred for 30 min. until 77 per cent of the adenosine triphosphate had been hydrolysed to the diphosphate and inorganic phosphate. After removing the muscle strips, the phosphate compounds were precipitated as the barium salts and separated on ion exchange columns following the procedure of Cohn and Carter[5]. Operations subsequent to the enzymatic hydrolysis were performed in the cold under conditions which were shown to prevent appreciable decomposition of the labile compounds. To ensure purity of the separated products, only the middle fractions of each well-isolated peak were used in the subsequent analyses.



$$\text{Adenosine—}\overset{\bar{O}\,\bar{O}\,\bar{O}}{\underset{O\;O\;O}{OPOPOPO^-}} + H_2{}^{18}O \rightarrow \text{adenosine—}\overset{\bar{O}\,\bar{O}}{\underset{O\;O}{OPOPO}}\overset{\bar{O}}{\underset{O}{—PO^-}},\ H—{}^{18}OH \rightarrow \text{adenosine—}\overset{\bar{O}\,\bar{O}}{\underset{O\;O}{OPOPOH}} + H^{18}OPO_3{}^{--} \quad (1a)$$

$$\rightarrow \text{adenosine—}\overset{\bar{O}\,\bar{O}}{\underset{O\;O}{OPOP}}\overset{\bar{O}}{\underset{O}{—OPO^-}},\ H^{18}O—H \rightarrow \text{adenosine—}\overset{\bar{O}\,\bar{O}}{\underset{O\;O}{OPOP^{18}OH}} + HOPO_3{}^{--} \quad (1b)$$

Determination of oxygen-18 showed that the terminal group of the adenosine triphosphate, the terminal group of the diphosphate, and the inorganic phosphate contained 0·0514, 0·00513 and 0·815 atom per cent excess per atom of oxygen, respectively.

Control experiments were performed in which (*a*) the medium contained ordinary water, and inorganic phosphate labelled with phosphorus-32 was added with the adenosine triphosphate, and (*b*) the medium contained $H_2{}^{18}O$ but only inorganic phosphate was added to the solution. In experiment (*a*), the hydrolysis was 64 per cent complete, and the adenosine tri- and di-phosphate and the muscle strips contained 0·11, 0·016 and 4·3 per cent of the total counts added, respectively. In experiment (*b*) the inorganic phosphate had 0·026 atom per cent excess.

From the small oxygen-18 content of the adenosine diphosphate, it is clear that the mechanism of hydrolysis catalysed by the muscle phosphatase(s) involves a nucleophilic displacement on the terminal phosphorus atom. The oxygen-18 present in the unhydrolysed adenosine triphosphate results predominantly from exchange with, or synthesis from, the intracellular inorganic phosphate, since the quantity of labelled element determined agrees with that calculated from the phosphorus-32 control experiment if appropriate corrections for diffusion-rates and extent of hydrolysis are made. The oxygen-18 content in the adenosine diphosphate is likewise correlated with its phosphorus-32 content in the control experiment.

The oxygen-18 content of the inorganic phosphate per atom of oxygen would be one-quarter that of the medium from the direct hydrolysis of adenosine triphosphate (cf. reaction 1 *a*). The fact that it is considerably higher than this shows that the muscle preparation catalyses a net transfer of oxygen between inorganic phosphate and water. This is further confirmed by the observed exchange in control experiment (*b*). The total exchange is less in the latter case than in the hydrolysis experiment presumably because the inorganic phosphate is released inside the cell in the hydrolysis experiment, whereas in control (*b*) the inorganic phosphate is initially extracellular. From the measured metabolic-rates in the lobster muscle preparation it can be calculated that the increased oxygen-18 content of the inorganic phosphate is caused only in minor part by the recycling of inorganic phosphate through adenosine triphosphate, and must be due in large part to a more direct exchange reaction. A somewhat similar exchange which does not go through high-energy phosphate has been observed in mitochondrial preparations by M. Cohn[6]. Since it has been shown that the exchange with inorganic phosphate can be catalysed by a single enzyme[1b], it is conceivable that the reaction in the muscle may also be caused by an individual enzyme which catalyses a nucleophilic attack on phosphorus.

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## Possible Role of Proteolytic Enzymes in Protein Synthesis

BERGMANN[1] has proposed that proteolytic enzymes mediate in the biological synthesis of proteins from amino-acids. The 400–4,000[2] or more[3] calories per mole required for peptide bond formation from *free* amino-acids can, however, be provided only when synthesis is coupled with an energy-yielding reaction[4]. To accommodate this energy requirement, Brenner, Hanes, Fruton and co-workers[4-6] have demonstrated that a variety of proteolytic enzymes catalyse a reaction of esters, amides, or peptides (including the naturally occurring peptide, glutathione) with amines or amino-acids in which new amides or peptides are formed. The enzymes show their usual specificity; that is, they synthesize only those peptide bonds that they also hydrolyse. The energy requirement is me by the initial ester, amide or peptide linkage which is split, for there is presumably very little difference in energy between the bond destroyed and that formed. These workers have shown beyond doub that some or perhaps most proteolytic enzymes can catalyse polypeptide synthesis from amino-acids providing there is an independent method o 'energizing' the amino-acid (ester, amide, peptide etc.). From there it is possible to speculate that in a similar way these proteolytic enzymes play a part in normal protein synthesis.

As a test of this hypothesis, Hendler and Greenberg[5] have recently studied the metabolism of labelled γ-glutamyl-glycine; but they found that this particula compound is not significantly involved in any o several living systems that incorporate amino-acid into proteins. The evidence presented here also doe not appear to be consistent with the hypothesis outlined above.

We have described techniques for measuring the rate of incorporation of various radioactive amino-acids such as glycine and alanine into the protein of tissue slices, and have outlined reasons for believing that this is closely related to biological protein synthesis[6]. Using these techniques, we have incubated α-aminobutyric acid-1-$^{14}C$ with rat liver slices. When the protein is isolated and the amino-acids separated by chromatography[7], we find that the labelled aminobutyric acid has been incorporated into the protein to only a very slight extent, if at all. The ratio of alanine incorporation to aminobutyric acid incorporation is at least one hundred and fifty to one, and may be much higher when improved chromatographic techniques are used. We find, however, that these two amino-acids are oxidized to the α-keto-acids and to carbon-14 dioxide at a similar rate by the liver slices, and that there is, at the end of the experiment, about the same intracellular level of aminobutyric acid as of alanine. Clearly, we have shown that aminobutyric acid is as actively carried into the cell as alanine, and as effectively utilized in some reactions, but that those enzymes which are responsible for protein synthesis in the living cell are sufficiently specific to reject aminobutyric acid, the next higher homologue of alanine and the next lower homologue of valine.

Such specificity is striking and is in agreement with the concept, which has gained so much support from the recent work of Sanger and Tuppy[8] on the structure of insulin, that a protein is a specific compound with a perfectly definite amino-acid sequence. One may ask whether every protein of the cell has such a definite structure.

Are the proteolytic enzymes of the cell sufficiently specific to reject α-aminobutyric acid 150 to 1 with respect to alanine? It is inherent in the theory of catalysis that the catalyst should not affect the equilibrium of a reaction; hence that it must accelerate the forward and reverse reactions equally. The catalytic activity of a given enzyme in synthesizing aminobutyrylglycine can be roughly estimated by measuring the rate of hydrolysis of the dipeptide. To be precise, the rate of hydrolysis corresponds to the rate of synthesis from two free amino-acids, the rate of ethanolysis corresponds to synthesis from the ethyl ester and one free amino-acid, etc.

In all cases that have been reported, aminobutyric acid-peptides are split at rates comparable with the corresponding alanyl-peptides. However, the enzymes used were extracellular. Smith and Polglase[9] found that α-aminobutyric acid amide was split by leucine amino-peptidase from intestinal mucosa at a rate between alanyl- and leucyl-amide. We have measured the rates of hydrolysis of alanyl-, aminobutyryl-, and leucyl-glycine by the proteolytic enzymes of freshly homogenized rat liver, that is, precisely the tissue which rejects aminobutyric acid for protein synthesis. The accompanying results show that aminobutyrylglycine is split by these intracellular enzymes at about the same rate as alanylglycine under these conditions.

While this may be taken as evidence against the participation of proteolytic enzymes in normal protein synthesis, it is not conclusive. A wide range of aminobutyric acid peptides should be tested. It is also possible that the great degree of specificity of protein synthesis is found in the enzymes acting on the larger peptides. We feel, however, that unless an enzyme system does discriminate against aminobutyric acid or an aminobutyric acid peptide, the system being studied should not be considered as part of the mechanism of biological synthesis of protein.

HYDROLYSIS OF PEPTIDES

| Substrate | Concentration | % Hydrolysis |
|---|---|---|
| DL-Alanylglycine | 0·16 *M*<br>0·08 *M* | 41<br>85 |
| DL-α-Aminobutyrylglycine | 0·17 *M*<br>0·09 *M* | 37<br>63 |
| DL-Leucylglycine | 0·12 *M*<br>0·06 *M* | 10<br>16 |

1 gm. of fresh rat liver homogenized in 10 c.c. 0·1 *M* phosphate buffer, *p*H 8·2; suspension centrifuged, supernatant diluted 1 : 40 with same buffer, and used as source of enzyme. Incubation mixture: 1 c.c. of enzyme solution, 1 c.c. of peptide solution, 0·01 c.c. of toluene. Temp. 37°.

Incubation time, 6 hr. Hydrolysis determined by ninhydrin method (ref. 10). Per cent calculated for L-isomer only; hydrolysis of D-isomer considered to be negligible.

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## A Disulphide Interchange Reaction

IN experiments designed to determine the position of the —S—S— bonds in insulin, cystine peptides were separated from a partial acid hydrolysate, and their structures determined after oxidation to the corresponding cysteic acid peptides. It was found that many more cystine peptides were present than could be accounted for by any one unique structure for the insulin molecule, and it seemed likely that a transfer reaction of the type:

$$R^1\text{—S—S—}R^2 + R^3\text{—S—S—}R^4 \rightleftharpoons R^1\text{—S—S—}R^3 + R^2\text{—S—S—}R^4$$

had taken place during the hydrolytic treatment, leading to a random rearrangement of the —S—S— bonds. That such a reaction can take place was illustrated by the following model experiment, in which *mono*-2 : 4-dinitrophenyl-cystine is formed from a mixture of cystine and *bis*-2 : 4-dinitrophenyl-cystine.

1 mgm. *bis*-2 : 4-dinitrophenyl-cystine and 10 mgm. cystine were incubated with 2 ml. of 12 $N$ hydrochloric acid. After 24 hr. at 37°, 5 ml. water and 10 ml. ether were added and the mixture shaken. Nearly all the yellow colour was found in the aqueous layer, indicating the presence of *mono*-2 : 4-dinitrophenyl-cystine. In a control experiment without cystine, all the colour which was due to *bis*-compound was in the ether layer. The reaction-rate is rapid in strongly acid or in neutral solution and is minimal in dilute acid (about 0·1 $N$ hydrochloric acid). This probably explains the fact that insulin is inactivated more readily by heating in neutral than in dilute acid solution[1], if the rearrangement of the —S—S— bridges is assumed to cause inactivation.

The mechanism of the reaction is not clear at present and is under investigation. It may involve the intermediate formation of an —SH compound by reduction or hydrolysis, in which case the actual rearrangement would be brought about by the reaction :

$$—R^1—\mathrm{SH} + R^2—\mathrm{S}—\mathrm{S}—R^3 \rightleftarrows R^2—\mathrm{SH} + R^1—\mathrm{S}—\mathrm{S}—R^3.$$

In this case the $R^2$—SH formed would be available to react with a further disulphide, so that only a catalytic amount of an —SH compound could bring about considerable rearrangement[2].

I wish to thank Dr. G. Weber for some valuable advice in connexion with this work.

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## Structural Features of Antitumorigenic Corticoids

THE antifibromatogenic potency of deoxycorticosterone—prevention of œstrogen-induced abdominal fibroids—diminishes through the substitution $O{=}C_{11}$ (Kendall's compound *A*) and especially through OH−−$C_{17}$ (Reichstein's compound *S*)[1]. The antifibromatogenic potency of cortisone, which differs from deoxycorticosterone by both these substitutions, is also strikingly diminished ; there were fibroids even with as much as 1,000 $\mu$gm. of cortisone acetate per day. But, on the other hand, there apparently was some antifibromatogenic activity of compound *F*, or 17-hydroxy-corticosterone (OH−−$C_{17}$ and OH—$C_{11}$); we had thus to raise the question of a 'protective' action of OH—$C_{11}$ against OH−−$C_{17}$. However, in view of the variations of the fibrous tumoral effect met with in similar experiments, and especially in view of the small number of experiments performed with compound *F*, the conclusion as to the supposed 'protective' action of OH—$C_{11}$ against OH−−$C_{17}$ remained doubtful[1]. In the meantime, we have been able to settle this question in what seems to be a definite manner, thanks to the kindness of Messrs. Merck and Co., who put at our disposal the necessary quantities of compound *F* acetate.

Ten animals (castrated female guinea pigs) were used in the experiment, which lasted 91–92 days. An average of 81 $\mu$gm. of œstradiol per day was absorbed from subcutaneously implanted tablets ; 268–447 $\mu$gm. (average 350) of compound *F* acetate was absorbed per day from two tablets (a new implantation six weeks after the first one). There were fibroids in nine out of ten animals ; average fibrotumoral effect, 5·2 ; average weight of uterus 4·6 gm. The quantities of compound *F* were indeed smaller than in some animals of the former series, in which there apparently was prevention ; but there is the fact that fibroids were present in the new series, even with quantities as large as 350–447 $\mu$gm. of compound *F* acetate per day. It is thus evident that OH—$C_{11}$ does not afford 'protection' against OH−−$C_{17}$, by which antifibromatogenic potency is so greatly diminished (compound *S*).

Although we must drop our original concept of 'protection' by OH—$C_{11}$ against OH−−$C_{17}$ with reference to antifibromatogenic corticoids, it is very remarkable that the same concept seems to be valid with reference to the inhibition of the growth of the chick embryo, as evidenced by certain findings of Stock[2]. The effective growth-inhibiting dose of deoxycorticosterone is 250 $\mu$gm. ; that of compound *S* (OH−−$C_{17}$) is as high as 5,000 $\mu$gm.; but the effective dose of compound *F* (OH−−$C_{17}$ and OH—$C_{11}$) is only 20 $\mu$gm.

Attention may also be directed to a comparative discussion of the structural features of antifibromatogenic and antilymphomatogenic corticoids[3].

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## Multi-spots in Paper Chromatograms

DURING investigations on the synthesis of nucleotides in this laboratory, extensive use has been made of the paper chromatography of phosphorus-containing compounds. In the early experiments it was observed that in a descending pyridine – ethyl acetate – water system, disodium hydrogen phosphate gave two clear spots of approximately equal intensity with $R_F$ 0·17 and 0·55 on spraying with molybdate reagent[1]. Identical spots were obtained with sodium or potassium mono- or di-hydrogen phosphates, whereas ammonium phosphate and free orthophosphoric acid gave only the faster-running spot. Trisodium phosphate showed largely the slower spot with some trailing. (These $R_F$ values are quoted to give an indication of the positions of the spots. The temperature was not strictly controlled. Other experiments showed the effect was not due to complexes with pyridine as the same 'double-spot' phenomenon occurred in a butanol – water system. By buffering the phosphates with acid and alkali it was found that the number of spots depended on the $p$H of the solution in which the phosphate was applied to the paper. Potassium dihydrogen phosphate below $pH$ 3 gave only the faster running spot; between $pH$ 3 and $pH$ 9, both spots at $R_F$ 0·17 and 0·55 were in evidence, but by $pH$ 10 (caustic soda added) only the slower spot appeared. Above $pH$ 12 only a spot at $R_F$ 0·05 was obtained with a horseshoe appearance (compare Paterson and Reincke[2]).

Further experiments were carried out using phosphoric acid containing phosphorus-32. When used in tracer amounts, it was found that the counts from the radioactive phosphorus agreed in position with the colours from the spraying. As an indication of the discreteness of the spots, it was found that a count of 6,000 a minute at the site of the spots fell between them to less than 100. When, however, phosphoric acid having a specific activity of 1 mC./ml. was diluted with water and adjusted in $pH$ with suitable acetate buffers, it was found that in this case, with the quantity of phosphate infinitesimal compared to the usual concentration of 0·04 $M$, there were no double spots'. Instead, at $pH$ 2·5 there was one site of counts at $R_F$ 0·55, whereas at both $pH$ 4 and $pH$ 5·5 counts were only at $R_F$ 0·17. As before, at $pH$ 14 the phosphate concentration was at $R_F$ 0·05.

It is considered from these results that it is possible that the spot at $R_F$ 0·55 is given by the $H_2PO_4^-$ ion, that at $R_F$ 0·17 by the $HPO_4^{--}$ ion and that at $R_F$ 0·05 by the $PO_4^{---}$ ion.

The mechanism of the separation of these spots is difficult to visualize. If the equilibrium $H_2PO_4^- \rightleftharpoons HPO_4^{--} + H^+$ were disturbed by the separation of the faster-running $H_2PO_4^-$, then the equilibrium should readjust itself and cause extensive trailing. One explanation is that the time of proton transfer in this equilibrium is slow. An experiment was devised that could to some extent check this. $H_3{}^{32}PO_4$ was mixed with $Na_2H^{31}PO_4$ and the mixture out on a chromatogram. If the $H_3{}^{32}PO_4$ (which existed as $H_2{}^{32}PO_4^-$) did not exchange with the $H^{31}PO_4^{--}$, then no counts should be found at the slower-running spot. When this experiment was carried out, counts were found at both sites. This means that the time required for equilibrium must be shorter than that required for the spots to separate on paper.

There have been other reports of double spots in paper chromatographic experiments[1,2]; but in these cases it is possible that they were due to interference of un-ionized compounds with inorganic ions or to impurities in the paper. All the experiments described above were conducted on No. 1 Whatman paper which had been washed with 2 $N$ acetic acid, and it is not considered possible for this multiplicity to be caused by contamination.

Evidence that the $pH$ of the solution in which the specimen is applied to the paper affects the $R_F$ of the resultant spot has been amply demonstrated in the case of the amino-acids[3], and it has been suggested that the separation of lysine into different ionic species may be due to association with phenol in the developing solvent[4].

Whatever the cause, this double-spot phenomenon does mean that, where polyvalent ions are encountered, it is possible that multi-spots may be obtained.

Two examples encountered subsequent to the work with inorganic orthophosphate may serve as an indication of the care necessary in the interpretation of experiments that have been followed by paper chromatography. Pure 2′ : 3′-*iso*propylidene adenosine-5′-dibenzyl phosphate[5] was hydrogenated in an effort to obtain 2′ : 3′-*iso*propylidene adenosine-5′-phosphate. The final product could not be crystallized but showed on chromatography in an ascending butanol – acetic acid solvent two spots of $R_F$ 0·56 and 0·64. On acid treatment to remove the acetone group, only adenylic acid remained, and since it was not a case of one of these spots being either adenylic acid or a monobenzyl ester of it or the acetone derivative, it is possible that they are both derived from the divalent 2′ : 3′-*iso*propylidene adenosine-5′-phosphate. The other example was that of adenosine diphosphate run in a descending butanol – acetic acid solvent giving one spot when in low concentration, and this splitting into two spots when the concentration was increased.

I would like to thank Prof. A. R. Todd and Dr. G. W. Kenner for much advice during these investigations.

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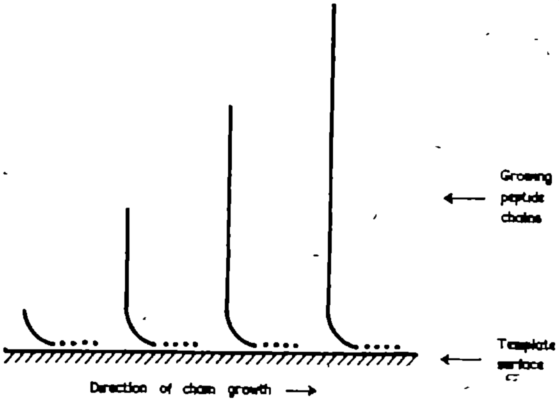
## The Template Theory and the Role of Transpeptidation in Protein Biosynthesis

THE synthesis of protein occurs without detectable evidence of free peptide intermediates. This fact, and the specificity of proteins, have been explained by the so-called 'template theory', in which it is assumed that the amino-acids are laid down in their correct order on a template (? consisting of nucleic acid) with subsequent bond formation and separation from the template[1]. Recent work has shown that transpeptidation occurs with peptides in artificial systems[2], and evidence has been sought for the participation of transpeptidation in protein synthesis. In these experiments protein synthesis has been brought about in the presence of isotopically labelled amino-acid. The resultant protein is degraded, the appropriate amino-acid isolated from two different parts of the chain and the specific activities compared. It is assumed that if the template theory is correct, all amino-acids must be laid down on the template effectively simultaneously, so that differences in activity of the same amino-acid residue in different parts of the chain are evidence for transpeptidation[3]. We wish to show that this assumption is not necessarily justifiable.

Energy considerations make it most unlikely that a complete protein molecule is formed on a template surface and afterwards separates as a whole from the surface. It is much more probable that amino-acids become attached to the surface of the template, and that as the amino-acid residues link together, the growing peptide chain 'peels off' behind the zone of formation of peptide bonds, as has been postulated in the recent theory of Dounce[4]. In such a case the protein does not finally separate from the surface until it is complete (so that no intermediate steps are observed); but only a small region is attached to the template at any time. Moreover, after a 'wave' of biosynthesis has passed down the template surface, the latter can be reactivated, further replacement by



amino-acids can occur, and a further 'wave' of biosynthesis may pass along. Many peptide chains at different stages of growth may thus be attached to the template at the same time, as is suggested in the diagram.

If a template were to carry simultaneously twenty growing protein molecules in different stages of development, the actual time of biosynthesis of each molecule would be twenty times the apparent time per molecule. Thus the time of biosynthesis of a protein may be much longer than is generally supposed. In the biosynthetic experiments, the amino-acids are drawn from a pool with which the labelled amino-acid may or may not have become equilibrated. In any normal biological system, the specific activity of the pool changes with time, and to show that differential degrees of labelling of the same amino-acid residue in different parts of a protein chain are due to transpeptidation, it must be shown that the difference is too great to be accounted for by changes with time in the activity of the pool. Conclusions are therefore not valid without evidence of the time of biosynthesis of a single molecule of the particular protein being investigated. No such evidence appears to be available, so that transpeptidation cannot yet be said to have been demonstrated in protein biosynthesis.

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## Quantitative Estimation of the Total Solids in Fresh Whole Milk by Oxidimetry

Since the major organic constituents of milk, with the possible exception of the fat, carry readily oxidizable groups, it should be possible to measure their amount by oxidimetry. Although the fat itself may not be readily oxidizable, it may possibly be measured indirectly by means of the substances associated with it in the fat phase and which are probably present in proportion to the amount of fat. Thus it would appear reasonable to believe that an oxidimetric method could be devised for measuring the total solids of milk. Such a test could be carried out much more rapidly and simply than by the methods usually employed.

After several trials using ceric sulphate in $N$ sulphuric acid and ferrous-*o*-phenanthroline as oxidant and indicator respectively, the following method was tentatively adopted as a means of testing the theory.

The milk was secured from the weigh-tank and 10 ml. was diluted to 100 ml. with distilled water and well mixed. 10 ml. of the diluted milk was transferred to a casserole containing 20 ml. of distilled water, two drops of ferrous-*o*-phenanthroline were added and the mixture titrated against 0·01 $N$ ceric sulphate in $N$ sulphuric acid until the orange colour was discharged. The titration was continued after the lapse of one minute, and the total number of millilitres of ceric sulphate used was taken as the titre value of the milk. (It was found that titrating at a constant rate yielded closer agreement between duplicates.)

Thirty-one samples of herd milk representing milk from five different breeds of cows were tested by this method, and the results compared with the value for total solids obtained with the A.O.A.C. gravimetric method ("Methods of Analysis", A.O.A.C., 7th edit., 1950).

The results yielded a coefficient of correlation between titre values and total solids values of $r = 0·912$ with a standard error of estimate of ± 0·238 per cent total solids. It is noteworthy that the error between duplicate titrations was approximately ± 0·05 ml., causing a final error of ± 0·22 per cent in the total solids, which is in good agreement with the standard error of estimate.

While the above method in its present form may not serve as a practical means for measuring the total solids in milk, it does justify the view that such measurements may be done by oxidimetry, and should serve as a starting point in the search for a rapid and accurate method.

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## A New Linkage in Tobacco

In about seven genetic linkages so far found in *Nicotiana* species, only one concerns *tabacum* and another *rustica*. The rest of the five linkages were discovered in interspecific crosses involving *N. tabacum* *N. langsdorffii* and *N. sanderæ*[1]. Kelaney[2] found a linkage between a gene *Br* for broad-constricted leaf with the gene *Pk* for carmine-pink flowers with a 7·5 per cent crossing-over. Boortzev[3] mentions linkage of 4·35 per cent between seed colour and compact habit in *N. rustica*. Clausen and Cameron[4] have isolated twenty-four monosomics of tobacco and were able to locate cytologically eighteen genes for sixteen characters in nine chromosomes by crossing the monosomics with a standard tobacco type. In six of the chromosomes identified, more than one gene has been found, but the authors do not mention the position of genes and distances between them.

We present here a new case of linkage between a gene for petiolate condition and absence of auricle of leaf found in a cross made during 1949–50 between Lanka and Yellow-Special varieties of *N. tabacum*

| $F_2$ | $Pt\ Au_2$ | $Pt\ au_2$ | $pt\ Au_2$ | $pt\ au_2$ | Total | $\chi^2$ | $P$ |
|---|---|---|---|---|---|---|---|
| Obs. | 16 | 2 | 2 | 5 | 25 | | |
| Exp. 9 : 3 : 3 : 1 | 14·06 | 4 69 | 4·69 | 1·56 | 25 | 10·953 | 0 01 |
| Exp. 16 6 per cent cross-over | 16·84 | 1·91 | 1·91 | 4·34 | 25 | 0·1508 | 0·90–0·95 |
| Exp. 19·988 per cent cross-over | 16·5012 | 2·2482 | 2·2482 | 4·002 | 24·99 | 0·4030 | 0 80 |
| Back-cross | | | | | | | |
| Obs. | 16 | 5 | 4 | 18 | 43 | | |
| Exp. 1 . 1 : 1 . 1 | 10·75 | 10·75 | 10·75 | 10·75 | 43 | 12·5263 | < 0·01 |
| Exp. 20·93 per cent cross-over | 17·00 | 4·50 | 4·50 | 17·00 | 43 | 0·2288 | 0 80–0·90 |
| Exp. 19·988 per cent cross-over | 17 2026 | 4·2974 | 4·2974 | 17·2026 | 43 | 0·2402 | 0·80–0 90 |

Lanka is an indigenous variety grown exclusively in the islands formed by the Godavari River ; it has a petiolate leaf with no auricle, but very slight growth of tissue in its place. Yellow-Special is a flue-cured type originally obtained from America, and has sessile leaves with large auricles which extend down the stem. The $F_1$ was petiolate and developed only a thin fringe at the leaf base, which was slightly more prominent than in Lanka, indicating that petiolate condition and absence of auricle are dominant characters. The $F_2$ generation consisted of eighteen petiolate and seven sessile plants. For the other character also there happened to be eighteen non-auricled and seven auricled plants. Thus both the characters showed monogenic inheritance. The back-cross ($F_1$ × Yellow-Special) confirmed the $F_2$ behaviour. The gene pairs are designated *Pt*-*pt* and $Au_2$-$au_2$.

When the $F_2$ and back-cross data were considered for joint segregation of the two characters, in both cases there was significant disagreement between the observed and the expected frequencies on the basis of independent assortment of the two genes. Determination of linkage intensities gave 16·6 per cent cross-over for $F_2$ and 20·93 per cent cross-over for back-cross. A pooled estimate[5] from the two populations gave 19·988 ± 5·49 per cent cross-over. The relevant data are presented in the accompanying table.

From these results it can be concluded that the gene *Pt*, for petiolate condition of leaf, is linked at about 20 morgans with the dominant gene $Au_2$ for absence of auricle.

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Nov. 4.

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[4] Clausen, R. E., and Cameron, D. R., *Genetics*, 29, 447 (1944).

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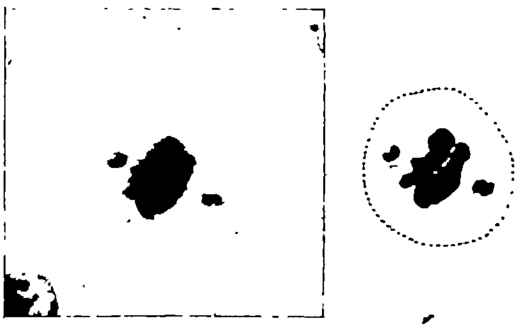
## Production of 'Three-Group Metaphases' in the Bone-Marrow of the Golden Hamster

A FEW years ago, a new type of chemically produced abnormality of mitosis, henceforth termed 'three-group metaphase', appearing shortly after an injection of hydroquinone, in the intestinal germinative cells of the mouse, was reported in *Nature*[1]. Later, the rat also proved itself to be a convenient material, while the guinea pig, the chick and chick fibroblast cultures were not responsive as regards this effect[2].

With the opportunity of using new techniques and material, the same phenomenon has been observed not only in the intestine but also in the bone marrow of the golden hamster in the first six hours following an intraperitoneal injection of hydroquinone, in doses varying from 0·150 mgm. to 0·200 mgm./gm. These mitoses, characterized by an apparently normally formed metaphase plate and by aberrant chromatic bodies localized at the poles of the spindle, appear with high incidence in the cells of the granular series, whereas the erythroblast divisions remain apparently unaffected. Almost at the same time, pycnotic nuclei become more and more numerous and the number of white cell mitoses gradually decreases, so that after twenty-four hours mature polynuclears are relatively more abundant.

With this possibility of further investigation into the mechanisms of this peculiar lesion, it has now become evident that the hypothesis of chromosome breakage put forward in our first publication cannot be maintained for mammals, even though it has been demonstrated to hold true in plant cells[3]. In fact, the polar Feulgen-positive bodies can be ascertained to represent well-formed and defined chromosomes, with their longitudinal fissuring very often apparent. Our further suggestion[4], that these aberrant chromosomes were retained in the centrosome region and did not undergo their pre-metaphase migration, gains strong support from the evidence of morphological features of some of the altered metaphases. Indeed, this explanation is in accordance with the finding of numerous asymmetrical figures—metaphase plate and one polar group—which cannot be attributed to an early anaphasic migration of the smaller chromosomes after their normal division.

Furthermore, seeking for intermediary figures, a few later stages have been discovered, which, obviously independent of chromosome fragmentation, strongly enhance the hypothesis of the possible completion of these mitoses. They consist of early anaphases with the metaphase plate clearly split in two. At this stage, the aberrant chromosomes are still visible



Bone marrow of golden hamster 1½ hr. after an injection of 0·150 mgm./gm. hydroquinone. Feulgen-squash preparation. Myelocyte 'three-group metaphase' showing early anaphase movements, the two central groups of chromosomes being already clearly distinct at the poles of the spindle (see photograph). Later, they can no longer be identified as they probably become hidden among the normal and rapidly migrating chromosomes. After six hours, when the destructive action is most evident, some of the 'three-group metaphases' have been observed to participate in the pycnotic effect. The three separate groups sometimes undergo chromatic condensation, giving rise to another peculiar image which could be termed 'three-group pycnosis'. While they are not visible twenty-four hours after the injection, there is still no evidence that all the 'three-group metaphases' are destroyed in this manner.

More detailed observations on the action of hydroquinone and related substances on the bone-marrow and other tissues of the mouse, the rat and the rabbit, and on the cellular changes causing this new type of pathological mitosis, will be published shortly elsewhere.

These experiments were started during a short stay at the Chester Beatty Institute, London, and I wish to express my thanks especially to Dr. P. C. Koller.

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Brussels.

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## A New Method in Staining Bacteria on Microscope Slides

A NEW method of providing dyes for some of the commoner staining procedures has been developed and tested. A small volume of the required dye solution is prepared according to the appropriate formula. The fluid is placed in a large dish, and rounds of No. 4 Whatman filter paper are soaked in it. After a few seconds the paper is removed by means of flat forceps and hung over a glass rod to dry. The dye-paper is then cut into suitable 'chips'—papers 1½ in. long by ½ in. wide are found to give good results. One round of 11 cm. diameter paper will provide a useful number of dye-papers which can be stapled together in the form of a booklet, with a plain paper cover. The dye-papers do not stain dry fingers and they can be made by unskilled labour in any laboratory.

For use in simple staining, a drop of distilled water is placed on the fixed film and a dye-paper placed on it; two more drops of water will give enough concentration of dye to stain the bacteria in the operative time. The paper is then washed off and the film dried.

Papers soaked in the following dye solutions are now in use for simple staining: aqueous crystal violet, aqueous and carbolic fuchsin, and aqueous safranin. Aqueous or carbolic methylene blue is used for demonstrating granular diphtheroid bacteria, and for counterstaining after carbol fuchsin in staining spores by the Ziehl–Neelsen method (carbol fuchsin is followed by a sodium sulphite paper). Carbol fuchsin papers are used for staining capsulated cells and flagella[1].

The advantages of the dye-paper method, with the dyes so far tested, include: (1) elimination of fluid stains in bottles; (2) economy of dye; (3) economy of storage space; (4) non-spoilage (as by rubber, oxidation, etc.); (5) ease of preparation; (6) negligible cost.

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Que., Canada. Nov. 5.

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[1] Gray, P. H. H., *J. Bact.*, **12**, 273 (1926); **45**, 301 (1943).

## Elimination of Inconclusive Results in the Treponemal Immobilization Test

WORKING with Nichols's pathogenic strain in th treponemal immobilization test, it is a commo experience[1] that some sera constantly yield inconclusive results and, further, that from time to time whole series of results must be discarded, becaus one or another of the controls shows poor surviva of the treponemes.

When the test is performed in an atmosphere o 95 per cent nitrogen and 5 per cent carbon dioxid 'contaminated' with about 0·2 per cent oxygen inconclusive results are relatively often obtained Even when all oxygen is removed by slow passag of the air through a heated tube of quartz filled wit copper chips, there still remain a few sera givin inconclusive results. Consequently, it is necessar to remove all the oxygen; but even then, satisfactor survival of the treponemes is not always obtained.

It was thought that great reducing power in th survival medium might be of importance. Henc the treponemal immobilization test was performe with a medium containing four times the concentration of sodium thioglycollate ('Difco') prescribed b Nelson.

Preliminary experiments with increased amount of sodium thioglycollate showed that it was possibl to get just as satisfactory results in the test with th above-mentioned oxygen-contaminated atmospher as with a 'normal' concentration of sodium thioglycollate in an oxygen-free mixture. When the tes was performed with four times the normal concentratio of sodium thioglycollate in an oxygen-free mixtur it was to be expected that none or only very fe sera would give inconclusive results. As a matte of fact, no inconclusive results have been observe since this modification has been employed (150 se examined).

Hence it is assumed that substances in the testicula extract from rabbits now and then are able to rais the oxidation reduction balance (redox potential of the medium to such a level that it is incompatibl with satisfactory survival of the spirochaetes. However, the same might happen in sera giving inconclusive results in experiments in which other se give satisfactory results. So far no bad influence the increased amount of sodium thioglycollate ha been observed.

Further experiments are in progress, and it intended to measure *Eh*, *rH* and *p*H through th different phases of the treponemal immobilizatio test. Special electrodes and beakers, manufacture by Radiometer, Copenhagen, have made this possibl

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June 13, 1952.

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[1] Durel, P., Sausse, A., and Borel, L. J. (personal communication Nelson, R. A., *Amer. J. Hyg.*, **48**, 120 (1948). Nelson, R. A Zheutlin, H. E. C., Diesendruck, J. A., and Austin, P. G. M *Amer. J. Syph., Gonor. and Ven. Dis.*, **34**, 101 (1950). Turner, (personal communication).

# FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

### Monday, June 8

British Society for the History of Science, Philosophy of Science Group (in the Joint Staff Common Room, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Dr. E. H. Hutten: "Models in Physics".

Royal Geographical Society (at 1 Kensington Gore, London, S.W.7), at 8.15 p.m.—Mr. Ian Stephens: "Two Principalities in Central Asia".

### Tuesday, June 9

University of London (in the Anatomy Theatre, University College, Gower Street, London, W.C.1), at 5 p.m.—Madame S. Filitti Wurmser (Paris): "Étude quantitative de l'isohémagglutination humaine" *

### Wednesday, June 10

Geological Society of London (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Scientific Papers.

University of London (in the Anatomy Theatre, University College, Gower Street, London, W.C.1), at 5 p.m.—Madame S. Filitti Wurmser: "Les isoagglutinines anti-B de divers génotypes".*

### Thursday, June 11

Royal Society (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Sir Ronald Fisher, F.R.S.: "Population Genetics" (Croonian Lecture).

Mineralogical Society (at the Geological Society of London, Burlington House, Piccadilly, London, W.1), at 5 p.m.—Scientific Papers.

Royal Aeronautical Society (at the Institution of Mechanical Engineers, Storey's Gate, St. James's Park, London, S.W.1), at 6 p.m.—Sir Hubert Walker: "Some Problems in the Development of Air Transport in West Africa" (Ninth British Commonwealth and Empire Lecture).

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# APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Vice-Principal (with honours degree in mechanical or aeronautical engineering, and considerable teaching and industrial or research experience)—The Principal, Royal Aircraft Establishment Technical College, Farnborough, Hants (June 13).

Assistant Lecturer in Physics (with good honours degree)—The Secretary, St. Mary's Hospital Medical School, Paddington, London, W.2 (June 15).

Lecturer in Agricultural Zoology (preferably with special interest in ecology), a Lecturer in Physiology (preferably with special interest in the physiology of the special senses and neurophysiology), an Assistant in Zoology, and an Assistant in Physiology—The Secretary of University Court, The University, Glasgow (June 15).

Assistant Lecturer in Geology (with honours degree in geology, and preferably some research experience in stratigraphy and palæontology)—The Secretary, University College, Gower Street, London, W.C.1 (June 15).

Research Assistant (with degree in chemistry) in the Department of Chemistry and Biology, for polarography and other electrochemical techniques, general microchemistry and design of apparatus, etc.—The Secretary, Norwood Technical College, Knight's Hill, London, S.E.27 (June 15).

Entomologist at the Royal Army Medical College, Millbank—The Civil Service Commission, Scientific Branch, Trinidad House, Old Burlington Street, London, W.1, quoting S.4214/53 (June 18).

Lecturer in the Department of Physiology, Biochemistry and Pharmacology, to teach medical organic chemistry—The Registrar, King's College, Strand, London, W.C.2 (June 18).

Senior Scientific Officers as Research Engineers in the Royal Naval Scientific Service, for post (*a*) structural, (*b*) mechanical, (*c*) mechanical—hydraulics, in the Naval Construction Department, Bath—The Civil Service Commission, Scientific Branch, Trinidad House, Old Burlington Street, London, W.1, quoting S 4212/53 (June 18).

Assistant Experimental Officers (2) at the Forest Products Research Laboratory, Princes Risborough, for work on the strength of timber in its various uses—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting C.98/53A (June 19).

Demonstrator in Physiology—The Secretary, London Hospital Medical College, Turner Street, London, E.1 (June 20).

Geologist (with honours degree in geology, and preferably with experience in geological mapping and economic geology)—The Secretary, Southern Rhodesia Government, Rhodesia House, 429 Strand, London, W.C.2 (June 20)

Senior Principal Scientific Officer as Head of the Admiralty Petroleum Laboratory, Brentford—The Civil Service Commission, Scientific Branch, Trinidad House, Old Burlington Street, London, W.1, quoting S.4210/53 (June 25).

Senior Research Officer or Research Officer (with a degree in veterinary science and postgraduate training or experience in bacteriology or serology) at the Animal Health Laboratory, Parkville, Victoria, to carry out researches on approved aspects of bovine contagious pleuropneumonia, and to be responsible for the production of vaccine—The Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting 201/74 (June 27).

Junior Lecturers (2) in Chemistry (one to teach Advanced Physical Chemistry and the other to teach Elementary Inorganic Chemistry and to assist in the supervision of First Year Laboratory Classes) at Auckland University College—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (July 15).

Senior Lecturer in Civil Engineering at the University of Queensland—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (July 31).

Applied Physicists and Research Engineers (senior and junior posts) in the Sheffield laboratories, for research in industrial metal working processes such as rolling and forging—The Personnel Officer, British Iron and Steel Research Association, 11 Park Lane, London, W.1, quoting "Metal Working".

Assistant Biochemist (basic grade) (with university degree or equivalent) to work under general direction of group pathologist and senior biochemist—The Secretary, Preston Royal Infirmary, Preston.

Experimental Officers and Assistant Experimental Officers (Engineers or Physicists with a strong interest or research experience in electronics or telecommunications, line and radio) in the Royal Naval Scientific Service, in the London area and Gloucestershire—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.130/53A.

Lecturer (male) (with honours degree in agricultural science specializing in agricultural zoology, or honours degree in zoology) in the Biology Department, to give lectures in zoology as applied to agriculture, etc.—Dr. N. T. Gill, Harper Adams Agricultural College, Newport, Shropshire.

Physicist (with first- or second-class honours degree or equivalent in physics) in the Metallurgy Department, Royal Aircraft Establishment, Farnborough—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.136/53A.

Plant Pathologist (with honours degree in science and postgraduate research and practical experience in plant disease control) for investigational and experimental work in connexion with plant diseases, more particularly diseases of bananas, in the Cameroons Development Corporation Estates, West Africa—The Rubber and Mining Agencies, Ltd., 52 Leadenhall Street, London, E.C.3.

Vice-Chancellor—The Registrar, University of Otago, P.O. Box 56, Dunedin, New Zealand; or the Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1.

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# REPORTS and other PUBLICATIONS

*(not included in the monthly Books Supplement)*

### Great Britain and Ireland

Sir John Cass College. Report, Session 1951–52. Pp. 20. (London: Sir John Cass College, 1953.) [204

Air Ministry: Meteorological Office. Meteorological Reports No. 12: Aviation Meteorology of the Route Marseilles—Rome—Athens—Cairo. (M.O. 535g.) Pp. ii+68. (London: H.M. Stationery Office, 1953.) 2*s.* 6*d.* net. [204

Department of Scientific and Industrial Research: Radio Research. Special Report No. 23: Characteristics of the Ionosphere Observed in Great Britain, 1930–1946. Pp. vi+16. (London: H.M. Stationery Office, 1953.) 1*s.* 6*d.* net. [204

British Museum (Natural History). Guide for the Identification and Reporting of Stranded Whales, Dolphins, Porpoises and Turtles on the British Coasts. By F. C. Fraser and H. W. Parker. Second edition. Pp. viii+42. 2*s.* Instructions for Collectors, No. 3: Reptiles, Amphibians and Fishes. Sixth edition. Pp. 28. 9*d.* (London: British Museum (Natural History), 1953.) [214

Report of the Proceedings of the 1952 Conference of the Universities of Great Britain and Northern Ireland, convened by the Committee of Vice-Chancellors and Principals, and held in the William Beveridge Hall, University of London, Senate House, on Friday and Saturday, December 12th and 13th, 1952. Pp. 103. (London: Association of Universities of the British Commonwealth, 1953.) [214

British Non-Ferrous Metals Research Association. Thirty-third Annual Report, 1953. Pp. 59. (London: British Non-Ferrous Metals Research Association, 1953.) [214

Fire Protection Association. Technical Booklet No. 11: A Comparison of the Extinguishing Effects of Chlorobromomethane Methyl Iodide and Carbon Tetrachloride. By E. H. Coleman. Pp. 12. Technical Booklet No. 12: The Surface Spread of Flame on Surfaces treated with Nitrocellulose Lacquers. By R. W. Pickard. Pp. 12. Technical Booklet No. 13: The Heating of Panels by Flue Pipes. By D. I. Lawson, L. L. Fox and C. T. Webster. Pp. 20. (London: Fire Protection Association, 1952.) [214

Annals of the Cape Observatory. Vol. 15: Stellar Parallaxes (3rd, 4th and 5th Series) determined in the Years 1931–1938 with the Victoria Telescope of the Royal Observatory, Cape of Good Hope, under the direction of Dr. J. Jackson. Pp. vii+315. (London: H.M. Stationery Office, 1953.) 35*s.* net. [214

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Metallurgical Abstracts, General and Non-Ferrous. Vol. 19, 1951–52. (New Series.) Editor: N. B. Vaughan. Pp. iv+511. (London: Institute of Metals, 1952.) [284

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Cambridge University Educational Film Council. Sixth Report, 1953. Pp. 8. (Cambridge: Cambridge University Educational Film Council, 1953.) [304

Textile Institute. Annual Report, Balance Sheet and Accounts for 1952. Pp. 20. (Manchester: Textile Institute, 1953.) [304

University of Leeds. Report to the Worshipful Company of Clothworkers of the City of London of the Advisory Committee on the Departments of Textile Industries and Colour Chemistry and Dyeing during the Session 1950–51. Pp. 41. Report to the Worshipful Company of Clothworkers of the City of London of the Advisory Committee on the Departments of Textile Industries and Colour Chemistry and Dyeing for the Session 1951–52. Pp. 38. (Leeds: The University, 1951–1952.) [304

Science Museum. Navigation Today: a Special Exhibition at the Science Museum, London, from April–September 1953. By D. Chilton. Pp. v+21+7 plates. (London. H.M. Stationery Office, 1953.) 1s. 6d. net. [304

The Work of Aslib for the Year ended December 1952. Pp. 22. (London: Aslib, 1953.) [304

Philosophical Transactions of the Royal Society of London. Series A: Mathematical and Physical Sciences. No. 904, Vol. 245: A Transformation of the Hodograph Equation and the Determination of certain Fluid Motions. By T. M. Cherry. Pp. 583–626. (London: Cambridge University Press, 1953.) 9s. 6d. [304

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Some Elementary Notes on the Theory of Phase Contrast Microscopy. Pp. 18. (Zeist: Nederlandsche Optiek- en Instrumentenfabriek Dr. C. E. Bleeker N.V., 1953.) Free. [94

Annals of the New York Academy of Sciences. Vol. 56, Art. 3: Virus and Rickettsial Classification and Nomenclature. By Sir MacFarlane Burnet and 28 other Authors. Pp. 381–622. (New York: New York Academy of Sciences, 1953.) 4 dollars. [204

Canada. Department of Mines and Technical Surveys, Mines Branch. Technical Paper No. 1: The Determination of Thorium in Ores by the Column Method. By R. J. Guest. Pp. vi+24. 25 cents. Technical Paper No. 2: The Constitution of Bone China, Part 1, High Temperature Phase Equilibrium Studies in the System Tricalcium Phosphate-Alumina-Silica. By P. D. S. St. Pierre. Pp. v+107. 50 cents. (Ottawa. Department of Mines and Technical Surveys, 1953.) [204

Proceedings of the California Academy of Sciences, Fourth Series. Vol. 27, No. 18: Some Hepaticae from the Galapagos, Cocos and other Pacific Coast Islands. By Lois Clark. Pp. 593–624 (plates 37–41). (San Francisco: California Academy of Sciences, 1953.) [204

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California Institute of Technology. Annual Report, 1951–1952. Pp. v+110. (Pasadena: California Institute of Technology, 1953.) [204

United States Department of the Interior: Geological Survey. Geological Survey Circular 229. Water-loss Investigations, Vol. 1, Lake Hefner Studies; Technical Report. Pp. viii+153. (Washington, D.C.: Government Printing Office, 1952.) Free. [204

Royal Society of New Zealand. Report of the Seventh Science Congress, Christchurch, May 15–21, 1951. Pp. vi+256. (Christchurch: Royal Society of New Zealand; London: High Commissioner for New Zealand, and Wheldon and Wesley, Ltd., 1953.) [204

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Forest Research in India, 1948–49. Part 1: The Forest Research Institute. Pp. iv+111. (Delhi: Manager of Publications, 1952.) 8.6 rupees; 13s. 6d. [204

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# THE BASIS OF RESEARCH

IN the address on the significance of information in present-day industrial society which Prof. T. U. Matthew delivered to the Aslib Conference at the Hayes, Swanwick, last September, he rightly stressed the value of personal contact and initiative, although his theme was the extension and specialization of information services. This factor is often overlooked, and while Prof. Matthew suggested that the information function should now be formally recognized as a new function of management, and that the effective use of existing information depends largely on the extent to which management is 'information minded', he quite as explicitly recognized the vital importance of the initiative, enthusiasm and personality of the information officer or librarian himself. There was no suggestion that we can solve the problem of securing the effective utilization of existing knowledge by relying purely on mechanical means, such as adequately equipped libraries and information services, efficient organization or the latest and most elaborate devices for recording, filing and finding information.

To a large extent this view was reflected in the subsequent discussion; but one remark made by Prof. Matthew, and the discussion centring on it, suggest that the limitations of mechanization are still far from being fully understood; we are apparently not without danger of attempting to set up elaborate organization or equipment to do what will always be done more effectively by personal contact, and the cross-fertilization of minds which results therefrom. New information, said Prof. Matthew, is accumulating in scientific literature at a rate much faster than can be used effectively. That, of course, has always been true and is likely to remain so—no system of coding and indexing chemical compounds is likely to result in more than a mere fraction of the vast number of organic chemical compounds becoming more than laboratory chemicals. It is not surprising that the chlorinated diphenylethane now known as DDT should have remained a laboratory curiosity from its synthesis in 1874 until its value as an insecticide was recognized in 1939 as a result of a systematic search for moth-repellents. What is surprising is that Prof. Matthew and those who questioned him on the point should be so disturbed at a position which has many parallels. Scores of chemical substances have been prepared, described and recorded in the literature, and remained of a purely scientific interest until some technical development made urgent, for example, the discovery of products for use in accelerating the vulcanization of rubber, in preventing the oxidation and deterioration of rubber, fats and oils, foodstuffs, textiles and other materials, in preventing the icing of aeroplane wings or the freezing of the cooling systems of internal combustion engines, for the control of some pest or the treatment of some disease in animals or human beings. Once the need is recognized and the technologist can begin to formulate the requirements of the product he desires, it is often a simple matter to work by analogy through a series of compounds until one is found which will provide at any rate a temporary solution.

Often, it is true, that is the starting point for extensive applied research, and even for more fundamental work; but it is well to remember that necessity is still the mother of invention. The limits of information services must be recognized, as indeed Prof. Matthew emphasized. No information service can supply the answer until the appropriate and specific question is put to it: it is no part of the process of invention or creation, though information services are an indispensable tool of the inventor and an invaluable aid to the creative worker.

In stressing, therefore, the contribution which efficient and adequate library and information services can render to technical and economic development, care should be taken not to claim too much. It is equally important to view the relations between science and technology in a proper perspective. Technology and applied science are not necessarily synonymous terms: not all technology has grown out of science; some science has grown out of technology. Engineering, for example, is sometimes described as applied physics, and it is true that to a large extent physics provides the theoretical basis for engineering. Nevertheless, from the earliest times down to the present, the technology has often come first, and only afterwards has physics supplied the explanation or theoretical basis. Frequently physical advance has depended on engineering science supplying the instruments and equipment for its investigations, and sometimes also the fundamental knowledge has been acquired in the course of what might be described as technological studies or research.

Indispensable as may be the help of the librarian or information officer to the research worker, the technologist or the industrial manager and administrator, mere mechanical efficiency and comprehensiveness must not be our objective. As Prof. E. Bright Wilson, jun., remarks in a recent book, "An Introduction to Scientific Research", wise selection rather than all-inclusiveness is the key to library work. Intelligent individuality and enthusiasm are the right counter to the cramping or isolating tendency of the growing mass of recorded scientific and technical information, and this applies to the user of such information as well as to the librarian.

For that reason alone, no improvements in abstracting services, indexing practices or other mechanical means for the dissemination of information and co-operation in information services will ever eliminate the need for contact between individual scientists and technologists themselves. It is probable, indeed, that even informal contacts, particularly where research is concerned, do in practice far more than is commonly appreciated to bridge the gaps in existing coverage of scientific and technical periodicals by abstracting services, and that in consequence the omissions to which Dr. S. C. Bradford directed attention twenty years ago are in any event not sufficiently serious to justify the expenditure of effort and resources which would be required to give complete cover. However that may be, the British Commonwealth Scientific Conference in Australia last yea fully recognized the importance of personal contact between scientists through visits to countries of th Commonwealth. Such visits were rightly regarded a fundamental to the success of Commonwealth collaboration in science, and the Conference attache the greatest importance to generous governmen provision being made to facilitate such visits.

Although the Conference was concerned mainly with the exchange of visits within the Commonwealth, it was manifestly equally aware of the valu of the interchange of visits with scientists of othe countries also. Free movement of scientific men across national frontiers and the reduction of vis and passport formalities and other restrictions to th minimum consistent with national security are a firs condition of scientific and technical advance, thoug admittedly the situation to-day is one in which balance has to be struck in any one country betwee opposing considerations. That balance should, however, be struck with a full appreciation of the pric that has to be paid, and should take full account o changing economic and other conditions which may rapidly upset the appropriateness of the balanc struck at any particular time.

If due care is taken in this respect and decision are manifestly seen to be reasonable and not arbitrary or archaic by those directly affected, much less harm may be done to the interchange of thought and o information upon which the advance of science an technology depends. It is the former, indeed, that i vital, for progress depends above all on ideas. Th danger in restricting the flow of information lie mainly in the risk that the creative mind may b deprived at the critical moment of some piece o information that might supply the missing clue to new synthesis or invention.

There is, of course, the danger that the atmospher of secrecy or restriction always tends to depress o hinder creative activity. Such an atmosphere can b fatal to creative processes of any kind, and althoug Mr. Brewster Ghiselin compiled his anthology "Th Creative Process"* mainly with the view of assistin creative workers themselves to gain some insight int the factors or conditions which determine th efficiency or fruitfulness of their minds in creating and thus enable them consciously to increase th efficiency of developed and active intelligence, it ha a clear message for all those who are concerned with the control or direction of creative workers and th conditions under which they work.

Mr. Ghiselin does not distinguish clearly betwee creation and invention; but the anthology of writing collected in this symposium by some two score me and women who have paused to consider and describ the characteristics of their own creative processe cannot fail to help the creative worker who know little of this literature or where to find it. The scienti or technologist will note some surprising omissions—Helmholtz and Rutherford, for example, and Nicolle' "Biologie de l'Invention" and Graham Wallas's "Ar of Thought" are not quoted—and may find most interest in Poincaré's essay on mathematical creation, from "The Foundations of Science"; Einstein's letter to Jacques Hadamard, taken from "The Psychology of Invention in the Mathematical Field"; Herbert Spencer's conversation with George Eliot, taken from his autobiography; and R. W. Gerard's paper on the biological basis of imagination. The selection, from the point of view of the scientific worker, seems a little unbalanced, though allusions in Mr. Ghiselin's introduction and in Mr. Gerard's paper restore the balance slightly; but there is much more than Mr. Ghiselin's introduction to the volume to give unity to the book. There are passages in some of the accounts of how composers and poets work, such as in Morton Prince's remarks on subconscious intelligence underlying dreams, which recall and repair some of the more obvious omissions—a well-known passage in Nicolle's "Biologie de l'Invention", for example—and the scientist or technologist who reads these varied accounts will find much that bears closely on his own inventive efforts.

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* The Creative Process: a Symposium. Edited by Brewst Ghiselin. Pp. xii+259. (Berkeley and Los Angeles: University California Press; London: Cambridge University Press, 1952 6.50 dollars.

It is not suggested that the evidence here presented of the way, in varied fields, in which creative minds work is likely to help the reader, whether scientist or not, to manage his own creative processes, assuming he is capable of such work. In fact, there is clear evidence that at a certain stage too much conscious control of thought may kill the new idea which the unconscious mind is developing. Mr. Morton Prince's account of the writing of a poem as a subconscious process, following a dream and vision which had succeeded several days of attempts to write verse and of reading much poetry, recalls both Sir J. J. Thomson's remark that new ideas about a subject come when one is not thinking about it, though one must have thought about it a good deal before, and the way in which sudden insight or the solution of a problem sometimes seems to occur at the moment of waking.

This point has frequently been stressed in disussions of the subject, notably by C. Nicolle in "Biologie de l'Invention", by W. B. Cannon in "The Way of an Investigator" and especially by J. Livington Lowes in his study of the working of Coleridge's imagination. This last, "The Road to Xanadu", is the only one mentioned by Mr. Ghiselin, and although he emphasizes the parallel between Lowes's study nd the biological study of Dr. Gerard, so far as the scientific man is concerned this book can be usefully supplemented by others such as those of Poincaré nd Hadamard, or by following up the clues suggested in some of the chapters of Prof. W. I. B. Beveridge's "The Art of Scientific Investigation".

What emerges most clearly from this anthology is hat while we can do little positively to encourage he creative process, the moment of intuition or illumination, or the act of invention, it is fatally easy o discourage or repress such moments of vision or creation. Every care should be taken to avoid the disturbances that are fatal to such activity, though it not suggested that it is practicable or desirable for he creative worker, be he inventor or scientist or artist, to be immured in an 'ivory tower'. Indeed, to do so would often remove the vital stimulus and the intellectual stress and tension that precede creation.

Few have brought out the position better than Helmholtz, who distinguished three stages in the act of invention or creation: first, a period of preparation in which the problem is examined; next, a period of incubation, in which often the mind is not consciously occupied with the problem; and third, the moment of illumination, which is usually spontaneous and unpredictable. To these, Wallas and Poincaré add a fourth stage, that of verification when the subject is worked out in its entirety. A very similar analysis was given by Sir Henry Cohen in his Harveian Lecture, "Harvey and the Scientific Method", in March 1950, and clearly the first and last stages call for conscious hard work, and for a determined effort animated by a passion for the subject. At the first stage also, stimulus—not, however, distraction of the type already suggested—can be fruitful.

It is in the full sense of all that is involved in preparation of this type that Pasteur's adage applies, "Chance only visits the prepared mind"; or, in the words of Nicolle, "Chance favours only those who know how to court her". This granted, it is of the second and third stages that we need to take care and in the sense indicated by Helmholtz's well-known remark: "Happy ideas come unexpectedly without effort, like an inspiration. So far as I was concerned, they have never come to me when my mind was fatigued, or when I was at my working table. . . . They came particularly readily during the slow ascent of wooded hills on a sunny day".

Sir Michael Sadler put it similarly: "The ideas come—not when I am under great strain or threadbare with overwork, but after a period of rest (including physical exercise and distraction of thought) following on a period of very hard work and of grappling with real unsought difficulties . . . the ideas come to me unsought and I find them in my mind exactly as I might find a half-crown that somebody had put into my pocket while my coat was hanging up in my absence". To the testimony of Helmholtz and Sadler the attention of the administrator might well be directed. He can do little to assist the mobilization of the contents of memory, which C. J. Renier defined as the essence of imagination, still less to assist the perception of the value of qualities which in Shelley's view was the essence of imagination. Administrative action can scarcely protect the artist or the investigator from the anxieties and strains to which their fellow men are exposed, and indeed from such tensions may result the stimulus to some great moment of discovery, creation or invention. There are, however, innumerable smaller matters that can seriously prejudice such moments by the irritation and distraction they cause, and with these the administration is closely concerned. Restrictions on the interchange of scientific or technical information may, for example, well deprive the man of science of some invaluable fact or clue which in the period of incubation his subconscious mind may transmute into some new idea or insight. Even if harm is not done in this way, he may be deprived of the invaluable stimulus of personal contact, or the irritation engendered by unnecessary restrictions may cause a frame of mind utterly opposed to that tranquillity in which Helmholtz found new ideas came most readily.

That is the real reason why restrictions on scientific intercourse and the exchange of information should be such as manifestly commend themselves to scientific men as reasonable, and are accordingly accepted without a feeling of irritation or frustration. We do not yet know how the imagination works, but we know at least some of the conditions which are inimical to it. Mr. Gerard's paper does not indeed take us a great way further than Lawes, with whose brilliant analysis of the working of Coleridge's mind, in effect, he starts. Creative imagination, to Mr. Gerard, is an action of mind that produces a new idea or insight, and while he admits that a satisfactory interpretation of imaginative phenomena in terms of neural mechanisms is a matter for the future, his discussion of the psychology, anatomy, pathology and physiology of imagination in essence largely confirms the conclusions reached by others who have attempted to record their experience of the creative process. He points clearly to the danger of reason stifling imagination; and the challenge to education which the teaching of rigour without stifling imagination still presents is set forth unmistakably.

Nor are the emotional factors overlooked. Quoting Pavlov's insistence on the need for passion, in the conscious work preceding that of imagination, Gerard remarks that the unconscious work goes on over problems that are important to the waking mind only when the mind's possessor worries and cares passionately about them. This, it is true, relates to the conscious work recognized by Poincaré and Helmholtz as preceding the unconscious work of imagination—to the mastering of accumulated knowledge, gathering new facts, observing and experimenting, developing technique and skill, selection and discrimination, which are all more or less conscious and voluntary activities, as Ghiselin points out.

To the second period of conscious work recognized by Poincaré as preceding the unconscious work of imagination Gerard attributes, however, a second emotional factor—that of courage. Without courage the unfamiliar will not be faced, or that which is different or new espoused, no matter how well prepared the climate of opinion may be. It is at least arguable that certain anti-scientific trends to-day have enhanced the importance of this emotional factor. At the best, invention is liable to be precluded by distrust of deviation. Ghiselin's anthology will not give much fresh guidance as to the working of the creative mind, or how the process of invention or creation occurs. None the less, it shows clearly enough that the mind in creation and in preparation for creation usually requires some management; and to the creative worker and to the administrator alike it indicates both conditions which are favourable to the creative process and also some of the factors, disturbingly active to-day, which discourage creative and imaginative work in science, art and technology, and which cause the waste and frustration to which Mr. Ghiselin directs attention.

# ALBERT HEIM (1849–1937)

Albert Helm

Leben und Forschung. By Marie Brockmann-Jerosch and Arnold and Helene Heim. Pp. 268+15 pl. (Basel: Wepf and Co., 1952.) 17.80 Swiss francs.

SCOTS geologists a few years ago were commemorating the one hundred and fiftieth anniversary of the death of James Hutton (1726–97). Now Swiss geologists have issued a volume to mark the centenary of the birth of Albert Heim (1849–1937). Towards the close of the fifty-odd years separating the two events, Arnold Escher von der Linth reported on wonders of large-scale tectonics, which he had recognized in the Glarus Canton and neighbouring regions of the Alps. It was in relation to these wonders that Heim achieved unique international fame. Two of his publications are outstanding, his "Mechanismus der Gebirgsbildung" (1878) and his "Geologie der Schweiz" (1919–22). Heim was fortunate at both ends of his career, fo inheritance from Arnold Escher allowed of a flying start, while support received from pupils, especiall his son Arnold Heim, was of great service in late years. In addition, he was a very remarkabl man.

The book here under review considers this remarkable man from a number of different aspects: fo example, his family life, tectonic and glacial research drawings and relief models, academic activities application of geology to welfare and safety, joy i mountains, breeding of Newfoundland dogs, an finally ethics, including total abstinence.

The child Heim promised well; but it seems tha he would have been lost to science except for a strang accident. He came to be afflicted with recurren headaches, so much so that he had to be remove from school and set to work on a farm. Here, fortunately, in 1865, he was overrun by a shy-hors (*von einem scheu gewordenen Pferd*) with its cart i tow. It broke him in seven places; but whe eventually he got out of bed, though he had t supplement a shortened leg with a thick sole to h boot, his head was clear and he was able to resum his studies.

Many anecdotes enliven this book. They ar written with becoming piety, but not without humou There is, for example, the story of a trick Baltze played during the 1907 celebration of the centenar of the London Geological Society. Heim, on retur from Oxford, where he had received an honorar doctorate, found an invitation from a lord (*ein Lords*) to a reception in evening dress. Heim, wit a strong prejudice against dress clothes, declin with thanks. Then arrived a package with a lett purporting to come from the lord, "who regarde it as an honour to offer the great scholar Hei evening clothes for his reception". Baltzer an his conspirators were repaid with no little anxiet during the ensuing ceremony lest Heim shoul elude them and publicly thank the lord for h ***Aufmerksamkeit***.

In 1920 the trickster was Dame Nature herself. fissure opened on the mountain face above the villa of Linthal, threatening a landslip of 100,000 cub metres. The cleft was kept under observation ar increased daily by 1–27 mm. Eventually Hei delivered a speech to the villagers, the draft of whi occupied some fifty pages. He besought them evacuate; but their hesitating partial concurren drove him to despair and brought him sleeple nights. Then, though blocks continued to thunder into the valley, the mass as a whole came to a standstill. It is sad to read that their escape led the inhabitants to ridicule geologists in general, and Heim in particular. As a rule, however, Heim's advice on practical matters won great respect; and among the people at large he was better known for his views on water, tunnels, avalanches and landslips than for his theories on mountains and glaciers.

Heim was not only a first-class field geologist and an excellent writer, but also an artist, who found expression in drawings and relief models. Probably geologists have learned more from his pictures and sections than from those of any other, except perhaps W. H. Holmes, of Grand Canyon fame, and W. M. Davis, of altogether different style. It is interesting, too, that it was passion for relief modelling that introduced Heim to geology.

When not quite ten years old, after his first mountain trip with his father, Heim began to reproduce what he had seen by pasting together little stones and capping them with sugar in place of snow. When twelve he saw for the first time a genuine relief, and realized what he had been striving to attain. Then he found a 1 : 50,000 map of the Glarus Canton exposed in a shop window; and a year of window-gazing and perpetual intercession persuaded his parents to spend the 3 francs necessary for its purchase. Modelling from this map in potters' clay brought only short-lived joy, for Heim soon realized that the map was incorrect. So in 1865 he got permission to wander for eight days among the Tödi mountains and make drawings of his own for guidance. Thus during the next year he was able to include a relief of the Tödi group, 1 : 25,000, among his drawings for the Canton school examination. Hearing of it, Escher, though a stranger, called at his father's house to see this exploit of a schoolboy; and, recognizing its worth with delight, invited its young author to attend his excursions. In these Heim came to realize that to produce a really correct model of a mountain one must learn its composition and development.

Heim with his own hand did much of the backward engraving on stone or copper required for reproduction of his illustrations, often setting up the original in front of him and proceeding without further help. He published his first panorama at about the same ime as he exhibited his Tödi model. In after years when he took his students to the mountains, he would halt them and say: "Let us draw".

As might be expected, the book gives us the tale of Heim's conspicuous mistake, the Glarus double fold, and of his splendid recovery in 1902. Perhaps, however, the most welcome single feature is a full eport of a speech Heim made on his eightieth birthday, when he led his last excursion to the Locheitenkalk at the type locality of the Glarus overhrust. In it he explained that for the past few years he had been searching through half-published and unpublished records of Escher's observations, and had come to realize as never before the fullness of his master's appreciation of nappes in the make-up of the Helvetian Alps.

It is a small matter, but British geologists will be pleased to see reproduced Heim's portraits of Peach and Horne, the "Investigator Twins" as he happily alled them. These portraits he sketched during a famous excursion to the North-West Highlands in 1912.

E. B. BAILEY

# A HARMONY OF PROPORTIONS

## Symmetry

By Hermann Weyl. Pp. vii+168. (Princeton, N.J.: Princeton University Press; London: Oxford University Press, 1952.) 24s. net.

THIS intriguing book represents what was, in effect, Prof. H. Weyl's farewell to the Institute for Advanced Studies in Princeton. It deserves to be read by anybody who not only desires some guidance through the subtleties of symmetry, but who also is willing to respond to the æsthetic bearing of the subject. This link is the essence of the author's contribution: it is fundamentally more important than the elegant proofs of transformations, translations and rotations which occur in abundance. For, after all, with a little trouble they can be found elsewhere, but the examples of symmetric ornament cannot. Perhaps it is admissible to remark that here we have a new—and most welcome—recruit to the very restricted literature of shape in relation to beauty (both natural and artificial) associated particularly with the names of Birkhoff, Speiser and (as editor) Whyte. On the periphery comes Wittkower and his treatise on humanist architecture. Thus, these pages cannot be read in isolation; whatever their exact origin may have been, their outlook is too synthetic and their implications for the whole of culture too wide. Symptomatic of the age, they are distinguished by their emphasis upon a topological habit of mind, and by a certain sturdy objectivity in showing that many of the delights of Nature are but straightforward examples of a minimal-energy economy, rather than instances culled from metaphysical speculations. In this way, Prof. Weyl does good service to science without introducing ontological arguments set in a plane of discourse for which they are often inappropriate. At the same time, there is an undercurrent of sympathetic understanding for the artist, whose works are necessarily unique, and incapable of inclusion in any algebra of classes.

The reader is confronted with four main divisions —bilateral symmetry; translatory, rotational and related symmetries; ornamental symmetry; and crystals. Appendixes deal with the highly specialized subjects of 'proper' and 'improper' rotations.

In his choice of historic examples of mathematical embellishment, the author excels. This is where the book is *sui generis*, good as the formal parts undoubtedly are. The Sumerians had a passion for strict bilateral devices; by contrast, Western tendencies were to loosen rigid symmetry. To the crystallographer there is something compelling in a design such as that of the Etruscan tomb of the Triclinium. Here we meet with a certain 'imperfection' (akin to 'real' crystals) which, judged by formal standards, makes the pose of the horsemen and the stance of the animals on the side-panels much more interesting than they would otherwise be.

Turning to architecture, Prof. Weyl mentions the great central church of S. Maria degli Angeli at Florence (by Brunelleschi) which is octagonal. As he remarks, pentagons and hexagons are rarer, though, as a matter of fact, they occur in designs in Serlio's fifth book of 1547. Apparently, deliberate structures seldom simulate the five-fold character, so frequent in the floral kingdom.

All this, and more, is to be found in this well-produced little volume. Occasionally we hear of encouraging signs that men of science and humanists are not only trying to find common ground for studying natural and man-made forms by comparative methods, but are also succeeding. Here, indeed, is a book to help them. F. I. G. Rawlins

# ZOOLOGICAL LITERATURE OF 1950

## The Zoological Record

Vol. 87, being the Records of Zoological Literature relating chiefly to the Year 1950. Edited by G. Burder Stratton. Pp. vi+1507. (London: Zoological Society of London, 1953.)

The serious student of zoology is greatly indebted to the Zoological Society of London for the production of the annual volumes of the "Zoological Record" in spite of continually increasing costs. It is difficult to imagine how any systematist could ever succeed in tracing the literature of his subject without this annual list of titles of zoological papers, published usually within thirty months or less of the end of the year to which any particular volume relates. The present volume, No. 87, deals principally with the literature of 1950 and comprises more than thirteen thousand references, classified into eighteen sections, and a final chapter giving a list of new generic and sub-generic names.

The activity in different branches of the subject is to some extent indicated by the number of titles in each section, ranging from Porifera, with only sixty-six titles, up to Insecta, which overwhelms all other sections with a total of 3,101 titles, almost a quarter of the whole volume. A glance through these sections reveals some rather unexpected figures, for under Aves one finds more than sixty new species and subspecies recorded, although the ordinary zoologist would have imagined that at least in this class very few new forms remain to be discovered.

Each section begins with a list of titles followed by a subject index briefly indicating the papers dealing with particular branches. Thus the subject index of Protozoa has sections on text-books, history, biography and obituary, bibliography, taxonomy, technique, structure, physiology, locomotion, sexuality, effects of environment and stimuli, effects of chemicals, development, evolution and genetics, ecology (including parasitism), economics and distribution (both geographical and geological) and, finally, a systematic index. The sections may be purchased separately from the Zoological Society of London (Regent's Park, London, N.W.8), except for the section "Insecta", which is obtainable only from the Commonwealth Institute of Entomology (41 Queen's Gate, London, S.W.7). It is rather surprising that, judging from the sales, more use is not being made of these sections of the "Zoological Record", for as a result of various donations they are supplied at a price far below the cost of production.

Zoologists are greatly indebted to the specialists responsible for the compilation of the various sections, and whose services are obtained more or less on a voluntary basis. One notable change occurs on the title page. The present volume is edited by Mr. G. Burder Stratton, librarian of the Zoological Society of London, whose name replaces Dr. A. Malcolm Smith, who has been editor of the "Record" since 1938 and to whom zoologists throughout the world owe a special debt of gratitude for his valuable services. Edward Hindle

# INDIA'S FOOD PROBLEMS

## Food and Population and Development of Food Industries in India

Pp. xv+357. (Mysore: Central Food Technological Research Institute, 1952.) 10s.

Of all the free nations of the world, few have more difficult food problems than the Union of India. The population is about 357 millions, an increase of some 40 millions over that of 1941; the area of sown land per head in 1951 was 0·6 acre and has long been shrinking, for in 1911 it was 0·9 acre. This shrinking area has to provide not only food but also cash crops, especially cotton and non-edible oil seeds. Some land is still unused, but it usually has some disability more or less difficult or costly to remove; there is still the possibility of more irrigation which would enable the land to carry two crops a year instead of one and also to give higher and more certain yields. But meanwhile the health services are improving: anti-malarial operations are saving great numbers of lives, and it has been estimated that, even if all the optimistic plans of 1951 could be carried through, the nation's food position in 1956 would be no better than it is to-day.

One of the most hopeful features in this difficult situation is the seriousness with which Indian agriculturists and food experts are dealing with it. The numerous problems involved were discussed in two impressive symposia held in May 1951 at the Central Food Technological Research Institute in Mysore, a remarkable organization under the direction of Dr. V. Subrahmanyan: both food production and food processing were dealt with. The papers are collected in this volume, and they give an admirable summary of the ideas and methods of the Indian experts and of the problems as they then stood.

The discussions ranged chiefly around the possibilities of increasing production of food grains, of increasing yields of all crops, improving methods of storage and preservation, reducing wastes and losses, and utilizing more widely foods at present confined to certain localities but capable of considerably higher output per acre than those at present grown. The main facts are already well documented; but they are set out here with great clarity and in handy form. If there is a certain amount of repetition, it is justified by the grim importance of the subject.

Serious complications arise in India from the circumstance that the choice of food is governed not simply by economic but also by social and religious factors: custom especially plays a large part. Great numbers of the population will eat only rice as their staple food, although cassava would give much higher yields per acre. Dr. Subrahmanyan has ingeniously made a 'synthetic rice' by moulding a mixture of tapioca and groundnuts into grains of the size and shape of rice grains; how far these will prove acceptable remains to be seen. Other possibilities discussed include the utilization as human food of various oilseed residues, groundnut and others, at present fed to cattle or used as manure. The current grain shortage is about 10 per cent of the total consumption, but this is increasing yearly: Indian agricultural experts are making great efforts to narrow or even close the gap. The book gives an excellent description by the workers themselves of the way they are setting about their task. E. John Russell

## The Yearbook of the Universities of the Commonwealth, 1953

(Thirtieth Issue.) (Published for the Association of Universities of the British Commonwealth.) Pp. liv+1805. (London: G. Bell and Sons, Ltd., 1953.) 63s. net.

THE Commonwealth Universities' "Yearbook" has become firmly established as a 'hardy annual' and one the blooms of which grow bigger with each successive year. The edition for 1953 (the thirtieth) is larger than ever because the staffs and activities of the individual universities are increasing and because new institutions are continually being established. Thus the present edition contains new entries for three Indian universities (Baroda, Bihar and Visva-Bharati) and for one in Pakistan (Karachi); in Canada the Nova Scotia Technical College now has a full entry on becoming a member of the National Conference of Canadian Universities, and in the United Kingdom the entry for Southampton has been moved from the college to the university section.

In Appendix 1 of the "Yearbook" the usual account of the qualifications required for admission to a first-degree course in United Kingdom universities has been augmented with similar material for Canada, Australia and South Africa. The eight other appendixes have all been revised and in some cases increased, especially Nos. 2 and 3, dealing with United Kingdom postgraduate awards tenable at home and overseas, respectively. The introductory surveys that are to be found at the beginning of each national section have also been considerably revised and, in particular, those for Canada, India and Pakistan completely rewritten. The name index now runs to 151 pages, with a grand total of thirty thousand names.

The seventh quinquennial congress of the universities of the Commonwealth will be held in Cambridge later this year, and this volume should prove of inestimable value to the delegates as a reference work; but its usefulness will not be confined to the congress, for experience shows that this volume is a reference book which quickly shows honourable marks of constant use.

## Introduction to Metamathematics

By Prof. Stephen Cole Kleene. (Bibliotheca Mathematica, Vol. 1.) Pp. x+550. (Amsterdam: North-Holland Publishing Co.; Groningen: P. Noordhoff N.V., 1952.) 32.50 fl.

THERE will be a warm welcome for a book of this nature by one who is a distinguished member of the American mathematical fraternity. Outside the *Journal of Symbolic Logic*, which cannot be expected to be suitable for teaching purposes, it is hard to find an English text wholly fitted for university work in meta-mathematics. The advantage of the present volume is that it contains practically everything necessary (somewhat massive as it is) between the same two covers.

There are four main sections, namely, the problem of foundations, mathematical logic, recursive functions, and some additional topics in mathematical logic. Actually, the last is almost a supplement dealing with the predicate calculus and consistency proofs. It may not always be wholly advisable to follow the author's preference for starred and unstarred paragraphs: the same applies in general to an encounter with Gödel's two famous theorems before tackling the lemma establishing the primitive recursive character of certain predicates. But these are details. The main strength of the development followed by Prof. Kleene stands out at the end of Part 1, where he collates the essential ingredients of the 'full picture'. These are (*a*) the informal theory, (*b*) the object theory, and (*c*) the meta-theory, in which (*b*) is examined.

An adequate bibliography, a list of symbols and notations, and an index bring a most valuable compilation to a close.

F. I. G. RAWLINS

## Chemistry in Action

By Prof. George M. Rawlins and Alden H. Struble. Second edition. Pp. viii+575. (Boston, Mass.: D. C. Heath and Co.; London: George G. Harrap and Co., Ltd., 1952.) 21s.

THIS book describes a one-year course in chemistry for American high-schools. The author's plan seems to be to make chemistry attractive by stressing fascinating applications of it to everyday affairs. The scope covers approximately the requirements of the British matriculation syllabus, with the addition of more than a hundred pages on hydrocarbon chemistry; this permits alluring discussions on such topics as textiles, food, penicillin, stain-removal and insecticides. The whole is built on a rather slight framework of theory. The book is replete with illustrations; most of the half-tone plates illustrate not fundamental principles but interesting and occasionally sensational applications of the science. Much information is given in the form of tables, and some by picture and caption only. There are many sets of questions and numerous reading references.

The worth of the book is its content of interesting up-to-date factual matter. Pleasing to look at and read, it would serve to acquaint a non-scientist with the role of chemistry in everyday life. There is too little of the grammar of science for the book to be used in Britain as an examination text, but, as a supplementary reader or as an aid to a teacher to brighten his lessons, it is worth consideration.

G. F.

## General Genetics

By Adrian M. Srb and Ray D. Owen. (A Series of Biology Texts.) Pp. x+561. (San Francisco: W. H. Freeman and Co.; London: Bailey Bros. and Swinfen, Ltd., 1952.) 5.50 dollars; 47s.

AS a text-book for courses in elementary general genetics, this book constitutes a welcome addition. There are features which make it valuable, though unfortunately the price is not one of these. First, there is novelty and variety in the choice of examples; second, the illustrations are particularly effective; third, the developments of the past ten years are amply dealt with; and fourth, there is a very salutary discussion of the principles involved at every step in the logical sequence of the chapters. This last quality ensures that the student will be well aware of the fields in which genetical theory is most promising and of those in which it is weaker. Among the criticisms which might be made, one is shared with all other previous text-books, namely, the inconsistent use of the words "gene", "allele" and "locus", though, of course, a good deal of the inconsistency is in the nature itself of the concepts. Another criticism is that the chapters on quantitative inheritance and on population genetics are rather slight. On the whole, this text-book is likely to be useful to those who have the task of teaching elementary genetics to students who have a varied background and not much of it at that.

G. PONTECORVO

# THE LIFE AND TIMES OF SIR RICHARD GREGORY, BT., F.R.S., 1864–1952*

By SIR HAROLD HARTLEY, K.C.V.O., F.R.S.

IT was at our meeting last year at Belfast that for the first time for more than fifty years we missed the presence of our most constant member, whose friendships and devotion to science, and his keen mind and sense of humour had given him a unique position as a vitalizing and constructive force in the work of the British Association. It is most fitting that this Pedler Lecture, which was his way of commemorating the work of Sir Alexander Pedler as secretary of the British Science Guild, should be a tribute to the life and work of our old friend Richard Gregory himself.

His life-history is a record of successful endeavour that would have delighted the heart of Samuel Smiles as an example of what courage and grit and devotion to science can accomplish. It is a thrilling story of heredity, circumstance, education and opportunity. Gregory was proud of his ancestry, and in his study hung a photograph of the inscription to his grandfather, a shoemaker of Bideford:

"He was a consistent member of the
Wesleyan Society for 65 years,
And as a local preacher and Class Leader,
His Labours were blessed
To the Salvation of Many Souls."

John Gregory, his son, followed the same craft but also was one of Nature's poets. I found among Richard's papers this charming letter from H. G. Wells to the old man when Richard had sent him one of his father's slender books of verse in 1907.

> "Dear Mr. Gregory,
>
> "You will I hope forgive my writing to you to tell you how much I like and value your book of poems. Your son has just given it to me and I have been reading in its contents a constantly increasing delight and surprise. He had often told me you wrote verse but he had given me no idea of the simple, curiously straightforward graciousness of your songs. They come I think most appropriately with this spring time; they have so much in common with the bright freshness of primrose and aubrietia and all the daffodils and narcissuses with which the garden is singing. I have been reminded of Blake and Herrick and of all that is most truly English as I read. R.A.G. is one of my earliest friends—I didn't expect at this date to find a quite new reason for liking and respecting him—in such a book as this.
>
> "I am myself a sort of literary man though I've never risen to either verse or science. That must be my excuse for bothering you with these praises.
>
> "Yours very sincerely,
> "H. G. WELLS."

Richard was born in 1864 in Bristol, where his father had moved from Bideford. When he was six he went to the Wesleyan Day School at Baptist Mills, where three hundred boys were taught in groups in one large schoolroom heated by a single fire-grate. In 1874 he entered the secondary school, now called Queen Elizabeth's Hospital, a boarding school with a uniform rather like Christ's Hospital, where his interest in science began. He left school early owin to his delicate health and began life like Faraday a a newspaper boy, and with his father more intereste in poetry than shoe-making, it sometimes happene that his mother could buy no food until Richar returned with his weekly earnings. John Gregor must have had something in common with Blak and his idealism left its mark on Richard. One o his poems reveals his attitude towards wealth:

"My heaven is not paved with gold;
For all that has been writ of it,
I would not have it if I could,
There's blood on every bit of it.

I would not harm my angel's feet
With such a hateful use of it;
I loathe, I scorn the thought unsweet,
Because of man's abuse of it."

When Richard was fifteen he was apprenticed t a boot factory for five years to learn the trade o clicking, that is, cutting out the various shapes o leather that were to be the uppers of boots and shoes. He was unhappy in his work and spent all his spar time attending evening classes in the Bristol Trad and Mining School (now the Merchant Venturers College) and reading in the St. Agnes Club Library

John Gregory was one of a band of socialis reformers in Bristol actively engaged in establishin the socialist and labour movement. The grou included Ben Tillett, Jim O'Grady, later Sir Jame and High Commissioner in the Commonwealth o Australia. Ramsay MacDonald joined them for short time in 1884 when he came to Bristol to hel with a boys' club. At that time he meant to becom a science teacher, and when he was Prime Ministe he said to Richard, "You chose the better part".

Richard and his father were great friends and i those early years he was closely associated with hi in his social work. At evening meetings John woul give an address on some labour problem or recit some of his poems and Richard would sing or give talk on a scientific subject, often astronomy, i which he was even then keenly interested. Joh Gregory became a well-known figure in Bristol an in 1912 he was given an honorary degree by th University, an honour which Richard was to shar with him thirteen years later.

When he was seventeen he won the Latin prize a the Trade School. Canon Wilson, a great education reformer, was then headmaster of Clifton; he wa an admirer of the personality and poems of Richard father and often came to see him. He encourage Richard with his Latin, and knowing his wish t leave the factory and learn science, he offered hi the vacant post of laboratory assistant at the Colleg Richard had to secure his release from his indentu and paid an indemnity of £5, which A. M. Worthin ton, the physics master, lent him, to be deducte from his first term's wages. One of his congeni duties at the College was the care of the fine eight-inc telescope.

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* Alexander Pedler Lecture of the British Association, delivered in the Royal Institution, London, W.1, on May 28.

Here at last came the opportunity he had dreamt of during his years at the boot factory and he took full advantage of it, continuing his studies in science and mathematics to such good effect that three years later he gained a scholarship in the Science and Art Department examinations which enabled him to become a science teacher in training at the Royal College of Science, South Kensington. Huxley was then dean of the College, and a new world opened for Gregory. He gained first classes in astronomy and physics and two years later, in 1887, he became a science demonstrator in H.M. Dockyard at Portsmouth. His main interest was still astronomy, and in 1889 he returned to the Royal College of Science as computor to the Solar Physics Committee and assistant to Norman Lockyer.

At each stage of his life Gregory was fortunate in his friends. At South Kensington he and H. G. Wells were fellow students and they were close companions. Wells has described in "Love and Mr. Lewisham" and in his "Experiments in Autobiography" the aims and hopes and struggles of the students of the College at that time. Forty years later he wrote of Gregory: "He emerges in my memory as a bland and sturdy figure in the debating society, a little troubled then as ever about the letter 'r', friendly, hilarious, hard-up and working hard, one of the cheerful and often quite audible group which includes William Burton, the potter, and A. T. Simmons. We had no relatives to push us on, we had to do all our own pushing, and sometimes the pushing was very hard indeed.

"Gregory pushed his upward course by way of sunspot computation to the stars. He won the respect and confidence of Sir Norman Lockyer. But before his footing was well established there were some precarious times. I had not so much pushed my way up as out by starting the *Science School Journal* (which is now the *Phoenix*) and similar depravities and my times were even more precarious. We collaborated in a book on 'Physiography' (Gregory got the job for me) and earnt £10 each. Ten pounds were worth getting in those days. We lent each other money and returned it (though social observers declare that such returns never happen). We followed our destinies. All sorts of things happened to me but nothing ever changed the steadfast friendship and helpfulness of Gregory."

Gregory's work with Lockyer was of a routine nature, measuring the areas and positions of sunspots and faculæ in photographs taken during 1878–81 at Dehra Dun, Mauritius and Melbourne. He was also concerned in some unproductive work on the widened lines in sunspot spectra and he photographed the spectra of a number of elements. That was his only direct contact with research, and his name does not figure in any paper. But Lockyer's work on the orientation of temples in Greece and Egypt appealed to Gregory and was the start of his life-long interest in the relations of astronomy and religion.

Soon after he joined Lockyer's staff, Gregory's articles and reviews began to appear in *Nature*: in 1889 "On the Determination of Masses in Astronomy" and "The Planet Uranus"; in 1890 on "Comets of Short Period", "Lunar Photography" and "Electrical Storms on Pike's Peak". In the same year he became an Oxford University extension lecturer on astronomy and physics, and in 1892 he left the Royal College to become a free-lance lecturer and writer. Lockyer, however, had realized the quality and promise of his literary work and in 1893 made him assistant editor of *Nature*, which first brought him into touch with Macmillans, its publishers. So the opportunity came to Gregory to devote his life to securing recognition for science and scientists, and to ensuring that they were given the chance to make the contribution to progress on which he believed the future depended. He had come up the hard way and he did his best to awaken a realization of the readjustments in social and economic conditions that the new technical age was making imperative. Gregory used every means of reaching his objective: education, journalism, the British Association and the British Science Guild.

## Education

Gregory had had to fight so hard for his own education and had suffered so much from the lack of text-books that he saw here a great opportunity. His first book, "Elementary Physics and Astronomical Geography", was published in 1891. It was the first of many text-books that flowed from his ready pen or were inspired by his editorship. His own books were notable for their clear writing, systematic arrangement, for their recognition of the relation of theory and practical work, and for the lively interest they created in the practical applications of science. His second book was an elementary physiography, a description of the laws and wonders of Nature. After that came "Honours Physiography" with H. G. Wells in 1893, and in the same year "The Vault of Heaven", and next year "The Planet Earth". Meanwhile, he was getting experience as an Oxford University extension lecturer and in 1898 he became professor of astronomy at Queen's College. The same year saw the beginning of his long partnership with A. T. Simmons, with whom he started the *School World* (later incorporated in the *Journal of Education*) and the series of joint text-books, which they produced in new editions until Simmons's death in 1921.

In 1905 Gregory became scientific editor to Macmillans, a position he held until 1939. Under his editorship and inspiration some two hundred text-books were published, many with him as co-author.

In the years when science was becoming an increasingly important subject in the schools, this comprehensive series of text-books covering elementary and advanced courses was a contribution of great value. Gregory devoted himself to this work, and many authors, young and old, were grateful for his encouragement and his wise advice and criticism. Editorship for him meant a working partnership with the author at every stage of a book.

But his interest in education did not end with writing and editing books. He was keenly interested in the technique of teaching, in the many problems to be found in the introduction of what was often a new subject and in securing the proper place for science in the curriculum. It was these wide interests that led him to take such an active part in the formation of Section L (Education) of the British Association in 1901. He was its first secretary and then its recorder, and one of its most active members from the start. The turn of the century had seen a big extension of school science and many experiments were being tried.

Gregory, in his presidential address to Section L, when it came of age in 1922, gave a sketch of its aims and progress. It had been formed to devote attention to education in all its branches with the object of introducing scientific conceptions into every sphere of educational activity. Gregory defined the business of education as the promotion of the right adjustment of a growing human being to its environment. The scope and character of the subjects of instruction should be determined by this biological principle and must be adjusted to new conditions in the world. "Science has become a kingdom potent with possibilities for good or evil—an inheritance which cannot be renounced—and to let any children grow up unfamiliar with their entailed possession is to neglect an obvious duty. . . . Science permeates the atmosphere in which we live, and those who cannot breathe it are not in biological adjustment with their environment—are not adapted to survive in the modern struggle for existence."

Gregory knew the kind of science teaching he wanted to see in schools; its purpose was not "to prepare for vocations but to equip pupils for life as it is and as it soon may be".

He was chairman of a British Association Committee in 1917 which was appointed to report on the essential place of science in school education. It included among its members several outstanding teachers like Sanderson of Oundle and Archer Vassall, and the report with its suggestions for science courses was the foundation of the movement towards general science. Gregory insisted that general science should be more than an amorphous collection of topics from physics and chemistry with a little natural history thrown in as a sop to the biologists. "It should provide for good reading as well as for educational observation and experiment; should be humanistic as well as scientific. The subject which above all others has the double aspect is geography. . . . Rightly conceived, geography can be made the earliest means of education as both Comenius and Locke regarded it, and it can be used as the unifying principle of all the generalized scientific instruction in schools." To-day with our greater knowledge of the world's resources and demands, of the needs of backward countries, of the principles of nutrition and disease, Gregory's forecast is seen in a new light.

He was very critical of examination syllabuses of the type of university entrance examinations which meant sacrificing the needs of the many to the interests of the few. While recognizing the value of laboratory work as a training in method, he was insistent on its being accompanied by broad courses which would excite wonder and stimulate the imagination, while providing a knowledge of everyday phenomena and the applications of science. His address was a plea "for the expansion of scientific instruction in this humanizing spirit, and for widening the gateway into the land of promise where the destinies of the human race are shaped. . . . I want science not only to be a means of stimulating real and careful thinking through doing things, but also a means of creating interest and enlarging the working vocabulary of the pupils and thus truly increasing their range of intelligence. So may scientific instruction be made a power and an inspiration by giving, in the words of the Book of Wisdom (vii, 16–20):

"An unerring knowledge of the things that are,
To know the constitution of the world and the operation of the elements;
The beginning and end and middle of time,
The alternations of the solstices and the changes of seasons;
The circuits of years and the position of stars;
The nature of living creatures and the raging of wild beasts,
The violences of winds and the thoughts of men,
The diversities of plants and the virtues of roots."

The late Poet Laureate shared Gregory's views. He spoke at the great meeting that was held in May 1916 to direct attention to "The Neglect of Science" which was prejudicing in many ways our war effort. It is probably scarcely even a memory to many; but the recollection of it is a reminder of the progress we have made since then, thanks in no small degree to Gregory's persistent advocacy. Robert Bridges in his final sentence crystallized the inward significance of this new view of scientific learning in the schools. "It is," he said, "the living grammar of the universe, without which no man can ever hope to read in its full significance the epic of his spiritual experience."

For his presidential address to the Science Masters' Association in 1928, Gregory chose as his subject "Contacts of Science and Literature". "As my main functions in life," he said, "seem to be those of a scribe and guide, it is perhaps appropriate that in this address I should deal with language and literature in relation to science rather than with scientific education or progress." Gregory was an omnivorous reader all his life and he had a good literary memory. He begins by comparing the outlook of the scientist and the poet, the one desiring to see things as they are, the other to display the emotional feelings aroused by them. But as Gregory shows by quotations from Tennyson and Shelley, their intentions are not necessarily opposed. Scientific truth may often be turned to poetic purpose. He quotes the verse from "The Cloud":

"I am the daughter of earth and water,
And the nursling of the sky;
I pass through the pores of the oceans and shores;
I change, but I cannot die."

Those lines had often been set for comment in elementary science examinations, and Gregory wonders whether students of English could interpret them so successfully. That leads him on to question whether the indifference to science among the teachers of English is not more general than the neglect of literature by students of science. Gregory was always pressing for a balanced education, and he resented the intransigent attitude of scholars and writers educated in classical schools towards the claims of science to an essential place among the new humanities. He rejects on the evidence of the psychologists the concept that the exercise of the mind on one kind of material improves the faculty to deal with all kinds of material, part of the basis of the claim that training in the classics is of unique value. But Gregory was a Hellenist with a deep appreciation of "the passionate regard for truth, disinterested research, imagination, acute reason and creative intelligence, which were the essence of the Greek spirit". He admits that "to certain minds a grammatical generalization is more readily understood than a principle derived from laboratory measurements, and on that account some pupils who have been trained to apply scientific method to language may be better prepared to take up the study of science seriously than those in whose minds are nothing but loose ends". What judgment could be fairer? And he ends with an appeal to teachers of English, classics and history to understand and interpret the human contacts of science with their own subjects, resulting in "a unity of interest which will give power and a new meaning to all cultural effort".

His book "Discovery" was one of Gregory's many services to education. Published in 1906, it ran through many editions until in 1949 Gregory revised and shortened it for the Penguin Press, so that the younger generation will not read it in its original form. This I regret, as it had a quality of its own in giving a picture of the working of the minds of the great discoverers. Instead of following the historical sequence, Gregory's chapters deal with the different aspects of discovery: outlook and endeavour, the scientific mind, belief and evidence, law and principle, scientific motive and practical purpose. The book is a revelation of his wide reading, of his first-hand knowledge of the classics of science and of his amazing literary memory. It is interspersed with long quotations from the classic authors which are so aptly chosen that they fall imperceptibly into line with his own lucid lively sentences, while revealing the thoughts of many of the greatest scientists of the past and the literary quality in which they found expression. The quotations at the head of each chapter show, too, Gregory's range and discernment. The book has such freshness and vitality, it arouses human interest on every page, it is written with such zest and enthusiasm that it should be reprinted in its original form.

Sir Edward Salisbury, a few weeks ago, when he was opening the new biological laboratory of the University College of the South West of England, spoke of the present-day danger of specialization of the young scientist confined within the ever-growing complexity of his own field. Gregory's appeal was for some knowledge of the purpose and accomplishment of science by the young layman. His book "Discovery" seems to me so admirably suited to meet this dual need as an introduction which will arouse interest and stimulate wider reading. Gregory carried in his mind the whole story of discovery through the ages, he knew the personalities of the great men and their writings, and so with the touch of the journalist at his best, carrying his learning lightly, he has given us this vivid picture of the different aspects of the advance of knowledge. Astronomy, geology, biology, chemistry and physics are all woven together, as he drew his examples from the old masters and the new.

### Journalism

Almost from the day that Gregory became Lockyer's assistant in 1889 he was writing popular articles on astronomy, and Lockyer was quick to see the qualities—his lucid style, his gift of phrase, his sense of the significant—that were to make Gregory the greatest scientific journalist and editor of his time. Love of science and an imaginative sense of the part it was destined to play in human affairs were the mainsprings of Gregory's life. But in addition he had the shrewdness and the practical judgment, sharpened by his early struggles and adversity, which helped so much in the success of his editorship of *Nature*. Of all his presidential addresses—and he must easily hold the record both for their number and the variety of their subjects—his address on "Science and the Press" to the Association of Special Libraries and Information Bureaux (now Aslib) at Oxford in 1934 is in some ways the most significant as it contains a searching analysis of the parts an editor and a manager must play in the life of a newspaper. It reveals how his keen mind had appreciated the factors that make for success or failure. It is nteresting to compare it with the terse crisp sentences n which C. P. Scott wrote "On Journalism" in the centenary number of the *Manchester Guardian*. The two men thought alike. "In all living things," wrote Scott, "there must be a certain unity, a principle of vitality and growth. It is so with a newspaper, and the more complete and clear this unity, the more vigorous and fruitful the growth. . . . A newspaper has two sides to it. It is a business, like any other, and has to pay in order to live. But it is much more than a business; it is an institution; it reflects and influences the life of a whole community; it may affect even wider destinies. It is, in its way, an instrument of government. It plays on the minds and consciences of men." *Nature* under Gregory certainly became an institution, both in the international and in the national fields, for he made it a clearing-house for new ideas. A letter to *Nature* became the accepted channel of rapid communication to the scientific world of a preliminary note of some new technique or discovery. But that was only one of its functions.

Lockyer made Gregory his assistant editor twenty-four years after he had founded *Nature*. As years went by, more and more of the work fell to Gregory and he was virtually editor a long time before Lockyer resigned the office to him in 1919. Gregory had his own ideas, and new features were introduced, like the leading articles, the first of which appeared in October 1915 on "Science in National Affairs". From November 1919 when he took over, they appeared every week, many from his own pen, dealing with scientific developments which had national importance. Some of their titles in 1919–20 indicate Gregory's wise discrimination and foresight in the subjects he chose: the nurture of key industries, the need for aircraft research, the organization of scientific work in India, meteorology and the State, science and the new Army, the cost of scientific publications, the present state of the dye industry, naval education, aerial navigation and meteorology.

The years of Gregory's editorship saw an immense increase in the number of scientific workers and a rapid growth of specialization with the increasing complexity of problems in each field. Entirely new fields of investigation were opened with new techniques, and there was a great extension of industrial research. All this combined to make it more difficult to watch developments all over the world. But under Gregory's skilful guidance *Nature* made this possible.

The late Lord Rayleigh, in thanking him for his Hinchley Lecture to the Institution of Chemical Engineers, on "Scientific Knowledge and Action", spoke of the great debt that all scientific men owed to Gregory for more than a generation. Looking back on his own scientific life, he said that he found it difficult to imagine how he could have carried on if he had not had the constant privilege of reading the pages of *Nature*, a journal which kept one in touch with science in all its branches. I remember very well as a schoolboy being introduced to *Nature* by H. B. Baker—"dry reaction Baker"—and I read it eagerly each week. When I returned from a scholarship examination at Oxford, Baker greeted me by saying, "Well, your reading of *Nature* must have paid a good dividend", and from my point of view it certainly had.

Lord Rayleigh spoke of the nice discrimination with which *Nature* avoided any reference to discoveries like the death ray which were trumpeted in the daily press, and his own reliance on the authority of *Nature*. He wondered how Gregory managed to keep in touch with all branches of science in all countries; "but somehow or other the thing was done and scientists as a whole were glad to benefit by the result, even if they were mystified by the process".

In his early years Gregory stood almost alone as a scientific journalist, and in his Aslib address he lamented the scant encouragement given to science writers, since so few newspapers or periodicals had on their staff someone capable of dealing intelligently with scientific subjects, of equal standing with their special critics of art and music, or of racing, golf and tennis. As a result the public lack in science the enlightened guidance they receive in other matters. "Most people have yet to learn," he said, "how and why science and scientific thought are the determining factors in the chief problems of progressive life."

Gregory admitted that one difficulty was that many investigators were too busy and were often ill-fitted to be popular interpreters, which made it all the more important that there should be a class of science writers with some organization behind them, like Science Service, the non-profit-making corporation in the United States, founded in 1921 by a newspaper editor and proprietor, the late Mr. E. W. Scripps. He ended with an appeal to the press and to the men of science to get together and find a remedy.

That address was given nearly twenty years ago, and Gregory's advice has not gone unheeded. Particularly in the B.B.C. much has been done to make the public realize the outlook of the scientist and the impact of his work in almost every field of social and political well-being. Gregory took an active interest in establishing the Association of British Science Writers, of which he was the founder president.

It needed the experience of a Second World War to drive home the lessons of the First, but that demonstration of the power of science left in the minds of many a deep mistrust. Gregory himself repudiated the use of the atom bomb as repugnant to the ethics of the civilized world.

## British Association and British Science Guild

Of the many attachments Gregory formed during his life the longest and the most intimate was his membership of the British Association, and it was there that he was best known to the younger generation. He joined as a life member in 1896 and his attendance came near to being proverbial. In his telegram last year to us at Belfast he spoke of unbroken attendance at fifty-two meetings. From the first he threw himself into the work of the Association with immense energy and devotion, not only in Section L, but also on endless committees and as a member of Council for many years. He was always ready with constructive suggestions and he was one of the stalwarts who gave continuity to our meetings. The B.A. owed much to Gregory, but the debt was amply repaid when at the meeting in South Africa in 1929 he met in Johannesburg his future wife. She, too, has won our affection by her devoted care of her husband, who relied more and more upon her as years went by. Let me quote Gregory's own tribute to her: "My dear wife Dorothy has brought into my life more happiness than anyone else and whatsoever I may possess when I am called away cannot be more than a poor return for her sweet love and tender care".

But much as Gregory believed in the British Association, he followed Lockyer in thinking that its activities should be extended to influence public opinion and promote closer contact between science and public affairs.

In his presidential address at Southport in 1903 on "The Influence of Brain-Power on History", in which he paraphrased the title of Captain Mahan's famous book which did so much to arouse public interest in the Royal Navy, Lockyer urged the need for an organization to enable science to speak with a collective voice, so that it might counter the neglect which had become so dangerous, when Britain's industrial and military strength were both threatened with severe competition from abroad, competition based on education and scientific research. Lockyer gave striking figures to show how science was being starved in Britain as compared with the large sums being spent in Germany and the United States on the endowment of universities and research. He quoted Huxley's dictum that we were in the presence of a new "struggle for existence", a struggle in which science and brains take the place of swords and sinews, the result of which would be decided in the school, the university, the laboratory and the workshop.

It is perhaps difficult for the present generation to realize how backward we were. The total annual Government grant to universities and university colleges in Great Britain in 1905 was £155,000, while the University of Berlin ten years earlier was receiving £167,000. Lockyer pleaded for a duplicate of the Navy Bill of 1888 when £21½ million were voted for a five-year building programme.

Quoting the last words of the original objects of the British Association—"to obtain a more general attention to the objects of science and a removal of any disadvantages of a public kind which might impede its progress"—Lockyer argued that here was a great opportunity to expand its functions. "This magnificent, strong and complicated organization would become a living force, working throughout the year instead of practically lying idle, useless and rusting for fifty-one weeks out of the fifty-two so far as its close association with its members is concerned."

However, the Council did not see its way to set up such a wide organization as Lockyer had outlined possibly doubting the wisdom of becoming involved in national and political affairs. So the British Science Guild was formed in 1905, with Lord Haldane as its first president, with the objects of creating a general awareness of our future dependence on scientific method and research, of pressing for greater support for universities and research institutions, and of bringing to the notice of Parliament the scientific aspects of matters affecting the national welfare.

Gregory was at first a little doubtful about this breakaway from the Association; but he soon saw the advantages of the Guild as an agency for propaganda, backed by men in public life like Lord Haldane, Lord Sydenham, Lord Montagu of Beaulieu and Lord Melchett. By public meetings, by reports of committees, by lectures and by close contact with members of Parliament, it was able to stimulate public interest continuously during the critical years of scientific development. Some twenty urgen national problems concerned with scientific effor were investigated by strong committees, and in this way the Guild made a major contribution towards a number of improvements, among them: the Treasur grant for developing a National Physical Laboratory the creation of the Development Commission fo Agriculture; the establishment of a Department o Scientific and Industrial Research; the Patent Ac of 1932; and the formation of the Parliamentar Science Committee.

In all of this Gregory soon became the moving spirit, and from 1922 he was chairman of the Executive Committee. He drafted many of the reports, and the work of the Guild had strong support in *Nature*. He organized the exhibitions of British Scientific Products in 1918 and 1919, for which he received the recognition of a knighthood.

There is no doubt that the Guild did most valuable work, and the Norman Lockyer and Alexander Pedler Lectures founded in 1925 and 1929 were a constant reminder of the importance of science in human progress. In 1923, when the first suggestion was made to unite the Guild and the Association, Gregory was opposed to it, as in his view the two bodies were essentially different. "The B.A. consists of priests and noviciates of science, while the B.S.G. represents a missionary effort to proclaim a new gospel." Negotiations were renewed from time to time, and finally in 1936 proposals for amalgamation were approved by the British Association at the Blackpool meeting. In 1938 the Division for Social and International Relations of Science was formed with a committee embodying the existing British Science Guild Committee, with powers to hold meetings not necessarily confined to the annual meetings of the Association, and a new journal, *The Advancement of Science*, was substituted for the old annual report.

It is true that the Division under Gregory's presidency kept the Association active during the War. But looking back at what the Guild accomplished and looking forward to the problems Great Britain has to face, I question whether the fusion was in the best interests of science. Has not Gregory's original objection been fully justified by the results? The Guild could enlist the sympathy and leadership in the cause of science of men in public life. It provided a forum where a group of men of affairs could discuss with men of science. Under Lockyer's and later Gregory's watchful eye it could and did address itself immediately to national problems when science was concerned. Its success in later years was due largely to the energy and vision of Gregory and his friends. It was not only a missionary but also an invaluable watchdog. Has its offspring, the Parliamentary and Scientific Committee, effectively taken ts place?

## The Visit to America

In December 1938, just as he was leaving the editorial chair of *Nature*, Gregory was invited to give a series of lectures in the United States at the Carnegie Institution, Columbia, Harvard and Johns Hopkins Universities, and to address our sister body, the American Association for the Advancement of Science.

The tour was a great success, for Gregory was at his peak in his seventy-fifth year as an eloquent xponent of the gospel of science, and he felt the hrill of the occasion. He had seen clouds gathering n the horizon and his addresses were a declaration of his faith in what science could contribute to a disordered world if it were not perverted to destructive uses in the lust for power. Gregory feared the growing tide of nationalism as a disintegrating force in a world which science could help to unify. In 1938 he recalled oddy's Cassandra-like prophecy of the atom bomb.

The Greeks had dreams of the Golden Ages of the past, they had no word for progress; but Gregory had visions of the Golden Ages of the future, if man would use his new understanding of Nature to good purpose.

His Elihu Root Lecture to the Carnegie Institution of Washington, on "Cultural Contacts of Science", was the most finished and carefully argued of all his addresses, and it gave the best picture of the run of his mind and interests. It deserves to be reprinted, as it is unknown in his own country. In it he counters the view that scientists are materialists, insensitive to beauty and incapable of deep emotion, that the scientist's idea of the evolution of mankind is the law of the jungle, "Nature, red in tooth and claw". Through all his American addresses there runs the motive of his favourite quotation from Huxley, his dean at South Kensington, in "Evolution and Ethics": "In place of ruthless self-assertion it demands self-restraint in place of thrusting aside, or treading down or competition, it requires that the individual shall not merely respect but shall help his fellows; its influence is directed not so much to the survival of the fittest, as to the fitting of as many as possible to survive".

The future of the world depends, Gregory said, on the use of science in the spirit of the Sermon on the Mount.

One of the themes of the Elihu Root Lecture was the relation of science and literature. He quotes fine passages from Kepler and Newton, examples of de Quincy's "literature of power" as contrasted with "literature of knowledge", which "survive because of their human feeling naturally expressed". He quotes the famous passage in Wordsworth's introduction to Lyrical Ballads: "Poetry is the wealth and fine spirit of all knowledge . . . it is the impassioned expression which is in the countenance of all science". "Poetry," says Gregory, "and other forms of literary and artistic expression once followed more closely on knowledge than they do to-day. . . . Poetry, philosophy and science all began life together as children of one family. . . . The greatest singers of antiquity were the most alive to science." Then he turns to the history of the earliest science, astronomy—"The science most closely associated with spiritual feeling", and traces its relationships through the ages to religion and other reflexions of current thought in literature and philosophy. He follows the gradual emergence of the conception of law and order to Nature and of divine purpose through the study of celestial bodies in Babylon, in Egypt and in Greece. Then from his knowledge and love of literature he illustrates the inspiration that came from man's contemplation of the skies in the Bible and in the poems of Virgil and Lucretius, of Dante, Chaucer and Milton.

Through all this Gregory is tracing the pursuit of truth and its high moral and spiritual influence in whatever field it is the motive of action. Science is not to be regarded, "merely as a store house of facts to be used for material purposes, but as one of the great human endeavours to be ranked with arts and religion as the guide and expression of man's fearless quest for truth".

When he returned from America, Gregory collected all the materials for his lectures and embodied them in a book, "Religion in Science and Civilization". This was published in 1940, but alas nearly all the copies were destroyed in an air-raid, and then with his energy unabated at the age of eighty, he set to work and recast it under the title of "Gods and Men", which was published in 1949. Among the many appreciative letters he received about the book, those from Dr. George Trevelyan and Mr. Mackenzie King gave him special pleasure. Dr. Trevelyan said he was astonished that one who had given his life to science should have been able to take so wide and deep an interest in history. "I see you are a great age now which makes my wonder of the book all the more." Mr. Mackenzie King, writing just after his resignation of the premiership of Canada, said that the book had given him what he most needed—"A place of new beginning; something to restore a true perspective".

## Presidency of the British Association

In 1939 came the Second World War and Gregory had been elected president at Dundee the day before war broke out. The annual meetings of the Association had to be abandoned, but the formation of the Division for the Social and International Relations of Science gave the opportunity under Gregory's leadership for a series of conferences to discuss questions that would be in urgent need of solution when the War ended. The ideas of the founders of the British Science Guild were thus given scope for expression and action. There were eight conferences in all over which Gregory presided, and at the first, on "Science and World Order", he enunciated a "Declaration of Scientific Principles" which was in effect a Hippocratic Oath for scientists.

These conferences kept the Association in action during the War and they certainly achieved their object in providing opportunities for the discussion of post-war problems. Their subjects covered a wide field and perhaps the most successful were those on mineral resources, the place of science in industry, and science and the citizen, at which Gregory read a paper on "Science and the Press", in which he emphasized the need for continued education on the impact of science on social relations.

Gregory's was the record presidency of seven years, from 1939 until 1946, when he delivered his presidential address at the first short post-war meeting in July. His subject was "Civilization and the Pursuit of Knowledge". In it he recurs to the favourite topic of his later years, the gradual emergence of civilization through the ages and the history of early religion with its close association with the heavens. Then he outlines the development of the schools of philosophy and the growth of natural knowledge, science and invention. Gregory's anxiety was the use that man might make of his new powers, and he ends with a moving appeal for goodwill and goodness of heart in the choice between the good and evil fruits of knowledge.

His last speech to the Association was at Birmingham, when he moved the vote of thanks to Bishop Barnes for his Sunday evening discourse on "Science, Religion and Moral Judgments". The Bishop's subject was close to Gregory's heart and he was at his happiest in his appreciation of the address, with all his old zest and enthusiasm and his readiness to find *le mot juste*. We saw him for a brief space at Edinburgh, where he was taken ill; for a year he was an invalid and then in September 1952 his active spirit quietly flickered out.

## Epilogue

I began with the idea of making this lecture mainly a study of the times of Richard Gregory, but I quickly found those times becoming just a background to the human interest of his life of endeavour and success—a success which is so encouraging a story in the days when there were few of the educational escalators of the present time. I have told the story so far as possible in his own words, which were so well chosen.

Gregory's long life of nearly ninety years saw the most rapid and eventful changes in the outlook and fortunes of mankind. First came the battle between the evolutionists and creationists and the emergence of the liberal interpretation of the Holy Scriptures that we know to-day. Next came the gradual recognition of our social responsibility for the human adjustments that are needed in an industrial civilization, which has changed so profoundly the social structure of Britain. Alongside them came that pride of discoveries, the electron, the nucleus, the quantum and relativity, that have given a fresh insight into the nature of matter, of life and of the universe. With that deeper insight has come a new humility in response to the ever-receding vistas of the complexity of the unknown.

With the advance of knowledge came a new power of man over his environment, the possibility of a new partnership with Nature in place of the struggles of primitive man. Evolution has moved fast, quickened by the needs of two world wars, that have left such deep scars behind them.

Of all this Gregory, so far as science was concerned, was the interpreter, or as he called himself once 'the standard bearer', and he had ideal qualities for the task. He was no specialist, nor in that sense a profound thinker; he did not engage in the details of polemics. He saw the broad picture and its human bearings, for he was essentially a humanist. He had the gift of leadership—persuasive, resourceful and quick in action. He had a ready humour and a fund of stories. But above all he was one of the most generous of men, generous in his help and gifts, generous in his praise, and sometimes too generous of other people's motives.

Success and recognition came to him in many ways and he enjoyed them to the full. It was his generosity towards others that made his successes such a pleasure for his friends. The honours that pleased him most were his knighthood and his baronetcy, his election to the Royal Society under Statute 12 in recognition of his conspicuous service to the cause of science, his election to the Athenæum under Rule II, his honorary membership of the Old Cliftonian Society, the presentation to Lady Gregory and himself from the British Science Guild, and finally his presidency of the British Association.

Gregory was an optimist: he saw the best in everything and everybody. This made him sympathetic to new movements, which seldom came to him in vain for help. Perhaps, too, it was partly the inveterate old journalist in him peeping out, eager for news. From first to last he was a member of more than seventy societies and institutions and a moving spirit in so many. But it is as the editor of *Nature* that he will be best remembered in the future, for his wise, shrewd, imaginative guidance that gave *Nature* its unique position in the scientific literature of the world. The driving force behind all he did was his devotion to the interests of science and his belief in its message for the future. Gregory wrote his own epitaph:

> "My grandfather preached the Gospel of Christ;
> My father preached the Gospel of Socialism;
> And I preach the Gospel of Science,
> But the ethical principles of all three are
> pursuit of truth and righteousness for the
> improvement of man and society."

# STORAGE OF NORMAL TISSUE GRAFTS

A SYMPOSIUM, under the chairmanship of Dr. A. S. Parkes, on the "Preservation of Normal Tissues for Transplantation" was held in the rooms of the Ciba Foundation during March 16–18, 1953. Like other colloquia organized by the Foundation, its purpose was to provide not merely for the formal presentation of scientific papers but also for the informal discussion of problems of common interest to the participants. The symposium kept closely to the subject defined by the title; tumour transplantation was left aside because tumours are 'abnormal', and the storage of semen because semen is not a tissue.

Tissue storage, for practical medical purposes, is a storage of spare parts for surgical replacement. It is possible to envisage situations in which a patient's tissues might be stored for his own future use—for example, a surgeon might deliberately remove a little more skin than was necessary at an orthodox grafting operation, and keep the excess in store in case some of the grafts he actually used failed to heal properly—but for nearly all practical purposes, storage for replacement surgery entails the use of tissues from other human beings. This being so, the surgical use of stored tissues is bedevilled by the fact that some living tissues will not form permanent grafts after transplantation from one individual to another. They elicit immunity reactions which end by destroying them. Problems of tissue storage are thus closely interwoven with problems of tissue transplantation immunity.

In opening the scientific proceedings, Prof. P. B. Medawar (University College London) said that living skin, when transplanted into positions formerly occupied by skin, was probably the most exacting of all tissues in this regard; skin so grafted between one adult and another did not survive longer than a few weeks. Other tissues enjoyed special dispensations from the rigours of transplantation immunity, the nature of which could only be understood if the normal process of immunity were first defined. There is no doubt at all that intolerance of homografts had the properties of an actively acquired immunity reaction, but a reaction of what particular kind? A certain combination of properties points unmistakably to membership of that class of immunity reactions of which tuberculin sensitivity and sensitization to simple chemical compounds were also members. The most recently discovered of these properties, so Mitchison had found, was that immunity could be passively transferred by living cells but not by serum.

A homograft could be made more acceptable to its host either by changing the antigenic propensities of the graft or by modifying the reaction of its host. Under the latter heading, Prof. Medawar outlined experiments done in collaboration with R. E. Billingham and L. Brent which showed that if an animal were presented with living foreign cells in fœtal life, its power to react against those cells in later life was reduced or wholly abolished. This was not due, as had been widely assumed, to an adaptation of the grafted cells, but to an adaptation of the host, for 'actively acquired tolerance', once established by inoculation of the fœtus, extended to cells freshly transplanted in later life—cells which therefore had had no opportunity to adapt themselves to alien soil.

Dr. W. P. Longmire (University of California and U.S.A.A.F.) proceeded to survey the clinical uses of tissue homografts in general. One could make a broad distinction between homografts which had to be alive if they were to serve a permanently useful purpose, and homografts which could act as a guide and sometimes a stimulus to natural regeneration irrespective of whether they remained alive or not. Skin and endocrine glands came pre-eminently into the former category, of 'homovital' grafts. 'Homostatic' grafts included those of artery, bone, cartilage and possibly cornea. Grafts of some of these tissues did not even have to be alive on transplantation, but corneal grafts which were dead on transplantation had not given successful results. Dr. Longmire mentioned that plastic substitutes behaved differently from homostatic grafts: they might be tolerated by, but were not incorporated into, the body. Turning to experiments on fundamental problems, Dr. Longmire said that he and his colleagues were engaged with studies on the success of skin transplantation in chicks as a function of age. A small proportion of skin homografts were successful when exchanged between newly hatched chicks of different breeds; but the proportion of successes fell off rapidly to zero by the time the chicks were two weeks old. By holding the age of the recipient constant, it had been found that younger skin had somewhat less power to provoke immunity than older skin.

Dr. J. W. Pate (U.S. Naval Medical Centre) adopted Dr. Longmire's classification of homografts, and said that, inasmuch as certain homografts did not have to be alive on transplantation, their storage in the living state raised unnecessary complications. Some storage treatments entailed chemical modification of the grafted tissue; generally, storage by freezing or freeze-drying was therefore to be preferred. Experiments showed that vitality of arterial homografts was not merely unnecessary but undesirable: frozen-dried arterial homografts were superior to fresh living homografts, and frozen-dried bone was not inferior to living bone. Frozen-dried skin could be used as a homostatic graft for providing a temporary physiological dressing for raw areas on severely burnt patients, in full recognition of the fact that they contained no living cells. Frozen-dried skin was as useful as a living skin homograft for such a purpose.

Dr. W. R. Earle (National Institutes of Health, Bethesda) described his methods for cultivating tissues *in vitro* in large quantities and for long periods. Such mass cultures could be started from single cells grown in capillary tubes, and might be subdivided into sublines which proved to have different properties; nor was growth confined to 'two-dimensional' sheets, for the incorporation of glass helices into the medium provided a framework for solid growth. Dr. Earle had cultivated human skin for 1½ years *in vitro*, and one such culture attained a total area of 1,600 cm.$^2$; he emphasized the tremendous possibilities for research which such materials and techniques now placed at the investigator's disposal.

The second session of the conference was concerned with the problem of storing and grafting endocrine tissue. Dr. Parkes (National Institute for Medical Research) began with a paper by Dr. Audrey Smith and himself on ovarian grafts. Early experimenters, he said, had approached the problem of endocrine homografts with complete disregard of immunological complications, and whether this attitude were wholly justifiable or not, he himself was convinced that endocrine homografts were both practicable and effective. Ovarian tissues impregnated with 15 per cent glycerol in normal saline and slowly frozen to − 190° C. did not deteriorate after a year's storage; when thawed and transplanted into ovariectomized recipients, vaginal œstrous cycles were restored. Rat testes, and probably the pituitary, could be stored in the same way, but the adrenal gland had proved more difficult.

This work was concerned purely with the endocrine activity of stored ovarian tissue; Dr. R. Deanesley (National Institute for Medical Research) considered the degree to which it retained its gametogenic power. Small pieces of ovary from 7-day old rats were frozen and later grafted into older recipients; nearly all the ova had disappeared twenty-four hours later, but healthy follicles could be identified in specimens removed for microscopic examination after 6–10 days. These follicles increased in size with age, and became prematurely luteinized. Similar experiments with frozen testis material showed that it, too, survived such treatment: it remained capable of maintaining histological structure of the seminal vesicles of castrated hosts and gave evidence even of sperm formation.

Dr. P. J. Gaillard (Leyden) recapitulated the results of earlier experiments of his which showed that fœtal tissues could acquire differentiated functional activity if cultivated in media derived from older animals. These experiments opened up the possibility of using endocrine grafts originally derived from fœtuses. Human fœtal parathyroid glands had been maintained in culture for seven weeks, the last stages of cultivation being in media derived from their prospective recipients. The cultivated tissues were transplanted into perivascular tissues of patients who had shown signs of parathyroid deficiency after thyroidectomy. In a number of such patients the calcium and phosphorus levels in the blood were rapidly restored to the normal. Success was more common in the younger patients; all the grafts had failed in patients more than thirty-six years old. Dr. P. F. Jones reported that homografts of adrenal cortical tissue from rats, not more than two days old, could survive in mature adrenalectomized rats of a different strain and could keep their hosts alive for many months. The grafts were well vascularized and looked healthy; their hosts died shortly after the removal of the grafts, so showing that the cortical tissue was actively secreting adequate amounts of hormones.

The third session began with a consideration of the storage of blood. The preservation of even the most labile plasma components, Dr. P. L. Mollison (Postgraduate Medical School) said, was relatively simple. Transfused leucocytes soon left the circulation, so that the principal problem was the preservation of red cells. Red cells can be identified by their antigenic properties; their average life-span was about 115 days. Storage in citrated glucose at 4° C. gave poor results after about a month; maintenance of a $p$H of 7·2 improved the results, and sucrose could be used to delay hæmolysis without, however, improving the survival of red cells after transfusion. Dr. Mollison particularly emphasized the fact that the non-occurrence of hæmolysis or visible abnormality after storage did not by any means guarantee the prolonged survival of red cells after transfusion.

The incorporation of glycerol into storage media made possible the use of storage temperatures far below zero, and therefore storage for long periods; but great practical difficulties were introduced by the need for removing glycerol slowly from red cells stored in bulk. Although there was always some loss of cells on storage at very low temperatures, the deterioration did not increase as storage was prolonged. Dr. Mollison said that transfused red cells sometimes failed to survive, and he wondered whether a reaction akin to that provoked by living nucleated cells could be responsible.

The best rates for freezing and thawing tissues to ensure their survival, and the remarkable protective powers of glycerol, were all discovered and worked out by pure empiricism, sometimes (as with the choice of slow freezing in preference to fast) in the face of expert theoretical advice to the contrary. Dr. J. E. Lovelock (National Institute for Medical Research) considered the biophysical aspects of the process of freezing and showed to what a large extent a reconsideration of the theoretical background of the process had justified the empirical choice of methods. The effect of glycerol was to reduce the range of temperature over which cells were particularly susceptible to damage during freezing; its efficacy depended among other things on its complete non-toxicity, its low molecular weight and free passage across cell membranes; very few other compounds, if any, had just the right combination of properties.

Dr. C. M. Pomerat (University of Texas) had been engaged in an attempt to interpret the behaviour of tissues in bulk during changes of temperature into the responses of individual cells. Apparatus had been devised which made it possible to combine continuous thermal and photographic recordings of cultivated cells—particularly those of human nasal mucosa—under various conditions of thermal stress. The forms of mitochondria and the vigour of intracellular movement were sensitive indicators of a cell's well-being under such conditions. Describing the effects of glycerol, Dr. Pomerat illustrated the vigorous cytoplasmic bubbling consequent upon a rapid transition from glycerol to normal saline solutions. Pinocytosis and nuclear rotation were also illustrated; further study would probably show that these also served as delicate indicators of departures from normality of behaviour.

Dr. R. E. Billingham (University College London) began the fourth session by describing the storage of skin. After impregnation with glycerol solutions, skin slowly frozen to − 79° C. did not deteriorate in any way after even ten-months storage; used as a graft, it was indistinguishable from an unstored normal skin graft in fine structure, colour, epithelial growth-rate, and differentiation of glands and hairs. Such criteria of normality were much more rigorous than those based on mere cellular survival. Melanocytes were much more exacting than Malpighian cells in their storage requirements, and showed up the advantages of using glycerol particularly well. Skin did not survive desiccation from the frozen state below a final overall water content of about 25 per cent; claims that mammalian tissues could withstand a higher degree of dehydration had never been supported by actual estimates of residual water. Glycerol, Dr. Billingham pointed out, was negligibly toxic; even dissociated epidermal cells could withstand being suspended in 98·1 per cent glycerol at room temperature for half an hour.

Dr. F. K. Sanders (University of Oxford) described experiments on the use of nerve homografts. Frozen-dried homografts were capable of guiding regenerating nerve fibres across relatively large gaps in the nerve trunks of small laboratory animals, their endoneural collagenous tubes being systematically re-populated by Schwann cells and fibroblast cells deriving from the host. Fresh homografts elicited a typical homograft immunity reaction in which the vascular stagnation was particularly inimical to successful repair. Results with the use of nerve homografts in human beings had been particularly disappointing. Dr. Sanders argued that this was because the absolute size of such gaps was always larger in clinical practice than in experimental animals; since the time relations of the immunity reaction were not much different in the two cases, and the rate of outgrowth of fibres from the central stump much the same, the difference was probably due to the fact that in human beings the immunity reaction became effective before the regenerating fibres reached the peripheral stump.

The next two papers were concerned with the use of arterial homografts, among the most uniformly successful and rewarding of all those in clinical use. Prof. G. C. Rob and Dr. H. H. G. Eastcott, of St. Mary's Hospital, used normal human vessels, removed as quickly as possible after death and stored in the frozen state. Such grafts gave excellent functional results, the success of which depended neither upon the viability of the graft at transplantation nor upon its length; the new endothelial lining was formed as quickly in long grafts as in short, and they accordingly inferred that it was formed by cells derived from the blood stream and not by creeping invasion from the two ends of the graft. Dr. C. A. Hufnagel (Georgetown University) summarized several years experience with vascular grafts in clinical practice and in experiments with dogs. There was no clinical distinction between the success of fresh, frozen, or frozen-dried grafts, and even frozen-dried heterografts from calves and pigs had given clinically satisfactory results. But even frozen-dried grafts had to be removed and preserved aseptically; experiments still in progress suggested that ethylene dioxide was an efficient sterilizing agent which produced no significant alteration in the fine structure of the grafts.

In clinical practice, transplantation of the cornea must always be of necessity homoplastic, and it is now quite widely known to enjoy an encouragingly high expectation of success. Mr. B. W. Rycroft (East Grinstead) analysed the criteria of success. Mere healing, and even the restoration of translucency, were not enough: there must be improvement of vision, if the graft were done for other than purely cosmetic purposes or to prepare the cornea for a later definitive grafting. Lamellar grafts were safer and generally more successful than full-thickness grafts, in which the danger of infection became serious; but he believed that the optical virtues of the latter might be combined with the safety of the former by means of a 'flanged' graft, or full-thickness centrally but with a thinned rim. Mr. Rycroft believed that corneal grafts were replaced by the tissues of the host; but heterografts were generally unsuccessful, and plastic substitutes inefficacious. One of the chief practical difficulties was over supply. The Corneal Grafting Bill of 1952 had now at last made it possible for eyes to be bequeathed after death, and such eyes might be stored for perhaps two weeks under liquid paraffin; but a method of semi-permanent storage would clearly be of the greatest value.

The proceedings ended with Dr. W. R. Strong's (U.S. Naval Medical Centre) description of the working of the U.S. Naval Tissue Bank, instituted in 1949. The Bank made use of tissues aseptically removed after death and stored after desiccation from the frozen state to less than 1 per cent residual water. Skin, bone and blood-vessels were systematically removed in accordance with an exacting routine and stored after drying in sealed glass vessels. Frozen-dried bone, even in the form of coarse granules, had given encouraging clinical results, and so, in their more limited experience, had blood-vessels. Frozen-dried skin was used purely as a temporary physiological dressing: it relieved pain, controlled the loss of tissue fluids, and reduced the risk of infection.

The impressions left in the mind of one participant were these. 'Homovital' grafts (homografts which must be alive on transplantation and must remain so if they are to serve a useful purpose) are a well-defined category. The use of skin homografts in clinical practice must await a fuller analysis of the methods by which their putative recipients can be made to tolerate them. Such methods have already been discovered; but they are not yet clinically applicable, and it is not likely that anything but fundamental research will make them so. Endocrine homografts sometimes succeed, and treatment of endocrine deficiency by hormones has not yet stolen all the thunder their use might one day cause. At the same time, it would be unfortunate if the dispensation which allows them sometimes to survive where homografts of other tissues fail were not made the subject of thorough scientific analysis; the theory of endocrine homografting as such can at present only be pieced together most incompletely from research conducted with only endocrinological or clinical purposes in mind. Tissue storage will become of practical value when the difficulties of transplantation have been overcome. The storage of skin offers no particular difficulty; nor that of certain endocrine tissues—at least if ambitions fall short of storage in perpetuity. The different endocrine tissues may raise their own peculiar storage difficulties.

'Homostatic' grafts are a less well-defined category. Some must apparently be alive on transplantation, but need not remain so; others may be dead from the beginning; some, perhaps all, provide stimuli for regeneration which could not be imparted by plastic replacements; certainly all require that a certain integrity of fine organization should be maintained. The outlook for frozen-dried arterial grafts is most encouraging, and it may not be too rash to say that the practical problems raised by their storage and use are now in principle solved. Bone homografts, even after freeze-drying, show high promise of surgical use. Corneal grafting, from the nature of things, can only approach asymptotically to 100 per cent success: through no fault of the surgeon, it is at present the only tissue for which storage methods are badly in arrears of methods of transplantation. Scientific workers can help the ophthalmic surgeon by devising efficient storage methods and also by attempting to analyse the occasional failure of corneal homografts after promising beginnings: such failures may prove to be of immunological origin.

# RADIO AND THE CORONATION

CORONATION Day, June 2, was marked by the application of the whole of the modern technique of sound and television broadcasting to enable a vast number of people throughout the world to be in constant touch with the proceedings in London during this eventful day. In the first case, the resources of the B.B.C.'s sound broadcasting service were utilized to the full in providing, for a continuous period of seven hours, a direct commentary on the Queen's Procession from Buckingham Palace to Westminster Abbey, the service and ceremony of crowning in the Abbey, and the subsequent State Procession through London. This programme was provided as an integration of the descriptions given by expert commentators at nine points along the route and inside the Abbey and its Annexe. Apart from the radio transmission, this programme was relayed through loudspeakers to the many thousands of people who lined the route, so that in addition to seeing the procession when it passed them, they could follow by verbal description the entire course of the proceedings.

For the home sound broadcasting service, thirty-seven transmitters were used, with an additional forty-eight stations for the B.B.C.'s external services, by reception from which several hundred local stations relayed the programme regionally in many parts of the world. This involved the use of forty-three languages by the B.B.C. during the day: and furthermore, in order to satisfy the needs for world coverage, the Corporation provided about a hundred positions, with suitable 'effects' microphones, in the Abbey and along the processional route, for the use of other commentators. In this way a continuous and very effective sound picture of the Coronation proceedings was made available to countless millions of people in all parts of the world, and the many congratulatory reports received show that it was greatly appreciated.

## Television

But Coronation Day was also a historic event in the development of television in Great Britain. For the first time in history, not only the State Procession but also the whole of the actual ceremony of crowning inside the Abbey could be seen by millions of viewers all over the country through the television service of the B.B.C. With the aid of five cameras inside Westminster Abbey and several others at various points along the processional route, the television audience was enabled to follow the whole of the day's proceedings. All the television transmitters of the B.B.C. were in use, including the supplementary stations recently brought into service in the neighbourhoods of Belfast, Brighton and Newcastle. In addition to private viewing on domestic receivers, many arrangements were made for the benefit of larger audiences in halls, hospitals and other places. These included the Festival Hall in London, where the presentation of the entire seven-hour programme on a full-size cinema screen was described as excellent, and may be taken to record the arrival of television technique at the stage when it is available for the theatre-going public.

## Television to the Continent

The television service was not, however, confined to viewers in Britain. Following the experience gained last July, when for a week the B.B.C. broadcast part of the daily television programme from Paris provided by Radiodiffusion et Télévision Françaises, this time the British programme was transmitted by a series of radio links to the continent of Europe. In Paris the 405-line signals from London were converted to 441 and 819 lines for re-transmission by the television stations at Paris and Lille; and at Breda, in Holland, arrangements had been made by the Philips organization to convert the British video signals into a 625-line signal. This was then taken by additional radio links to the Eindhoven and Hilversum television transmitters in Holland; and also fed into the permanent network recently set up by the Nordwestdeutsche Rundfunk to link up the five or six television stations of that administration in Western Germany, including Berlin. The accompanying sound programme was transmitted independently by cable to the Continental organizations, where either the English language could be used or this could be translated by local commentators. This enterprise for the international relaying of television programmes has met with unqualified success. Tens of thousands of French people saw the Coronation ceremonies on television screens either in private houses or in the many windows and booths in Paris where television receivers had been set up in shops and newspaper offices.

## Service to North America

The technique of the subject has not yet advanced to the state where a direct television service can be established across the Atlantic to the vast potential numbers of viewers in North America on such an occasion as this. Careful examination had been made during the past year or more of proposals to relay the vision signals from high-flying aircraft or over a series of radio links, but even the vast resources of the United States broadcasting organizations could not render this a practical means of getting a direct 'live' view of the Coronation proceedings. An attempt was made in New York to receive the British television signals by direct transmission, but nothing suitable for introduction into the American television service was obtained. Failing this, the most rapid means of letting American viewers see the proceedings in London was by facsimile or photo-telegraphy transmission. Within twenty minutes of the crowning of Queen Elizabeth, pictures of the scene in Westminster Abbey were being sent direct from London into newspaper offices throughout the United States; and these pictures were transmitted over the television networks, so that millions of people throughout the United States could follow the ceremonies with the aid of the service of the B.B.C., which according to *The Times* correspondent "was received with unfailing power and clarity".

Furthermore, as the next best substitute to a 'live' television service, the two major American broadcasting networks (National Broadcasting Company and Columbia Broadcasting System) had Coronation films flown across the Atlantic in a Canberra bomber to Newfoundland, where other aircraft were waiting to take the films on to distribution points in the television networks of Canada and the United States. In this way viewers in North America were, owing to the difference in local times, enabled to have their own view of the Coronation proceedings on the same afternoon as the events took place in London.

### General Appreciation

In one respect only does television technique on a public service basis lag behind the possibilities of the cinematograph film. The pictures are still presented in black-and-white, whereas anyone who witnessed the actual State procession will agree that the pomp and splendour of this could only be given an adequate appraisal by a presentation in full colour. In spite of this limitation, however, the radio correspondents of the daily Press have had nothing but praise and glowing terms of appreciation for the magnificent service given by the B.B.C. and all those connected with this organization, for an outstanding achievement in the history of broadcasting and television.

On the technical side, some thirteen hundred additional sound circuits and more than a hundred vision circuits in and around the London area were provided by the Post Office Engineering Department, working in co-operation with the B.B.C. engineers. It is probable that only those closely connected with the technical and programme sides of broadcasting can appreciate the immense complexity of the circuit and other arrangements necessary to collect together such magnificent programme material and disseminate it to the entire satisfaction of the recipients, public and private, all over the world.

Whatever may be the future of British broadcasting, there is no doubt that, on this occasion, the B.B.C. lived up to the reputation, acclaimed by many, of presenting the best public broadcasting and television service in the world.

# NEWS and VIEWS

### Physical Chemistry at Manchester:
### Prof. Geoffrey Gee, F.R.S.

PROF. GEOFFREY GEE, who has recently been appointed to the chair of physical chemistry in the University of Manchester in succession to the late Prof. M. G. Evans, was born at Disley, Cheshire, and received his early education at New Mills Grammar School under the headmastership of Mr. W. A. Whitton. In 1928 he entered the Honours School of Chemistry in the University of Manchester under Prof. Arthur Lapworth; here he obtained the B.Sc. and M.Sc. degrees and did two years work on electrocapillarity in the Thomas Graham Colloid Research Laboratory. In 1933 he joined the staff of the Dyestuffs Group of Imperial Chemical Industries, Ltd., and for five years he worked in the Department of Colloid Science at Cambridge in association with Sir Eric Rideal and later with Prof. H. W. Melville. During this period, alone or in collaboration, he published more than a dozen papers of a pioneering type on two main topics—oxidation and polymerization reactions in monolayers, and the kinetics of polymerization in the liquid phase. In 1938 he joined the British Rubber Producers' Research Association, and in 1947 he was appointed director of research in the Association. His publications in this period deal with olefin oxidation and, more especially, with the thermodynamics of polymer systems, in which subject, again, he did pioneer work which has led the way to a closer relation of thermodynamic properties to macro-molecular structure. Prof. Gee was elected a Fellow of the Royal Society in 1951 and in 1952 was awarded the Colwyn Medal by the Institution of the Rubber Industry. His return to his old University is warmly welcomed, especially by those who remember him there in his student days.

### Mathematics at Dundee

PROF. A. M. MACBEATH has been installed in the chair of mathematics at University College, Dundee (University of St. Andrews). Prof. Macbeath, who is twenty-nine, was educated at the Royal Academical Institution, Belfast, the Queen's University of Belfast and Clare College, Cambridge. Graduating with first-class honours in mathematics at Queen's in 1943, he served from then until the end of the War as a junior administrative officer in the Foreign Office. At Cambridge he was a Wrangler in Part 2 of the Mathematical Tripos in 1946 and gained a mark of distinction in Part 3 in the following year. After a year's research at Cambridge on the geometry of numbers, he was awarded a Commonwealth Fund Fellowship in 1948. With this fellowship he continued his researches in number theory for two years at Princeton University, obtaining the degree of Ph.D. in 1950. On his return to Cambridge he was elected to a fellowship at Clare, where he worked until October 1951; he was then appointed to a lectureship in mathematics at the University College of North Staffordshire. In the following year he was promoted senior lecturer and played a major part in framing the courses in pure mathematics in the new College. Prof. Macbeath's contributions to pure mathematics are already substantial, and there is no doubt that he will add to them during his tenure of the chair at Dundee.

### Everest

ONE of the great challenges to the spirit of human endeavour in the field of exploration and determination to beat natural obstacles was overcome on May 29, when E. P. Hillary, of New Zealand, and Sherpa Tensing Bhutia, of Nepal, had successfully reached the summit of Mount Everest. This fine achievement by the members of Colonel H. C. J. Hunt's expedition is a noteworthy climax to a long series of attempts dating from the reconnaissance of 1921, and, with the news coming on the eve of the Coronation, the British people can take more than especial pride that their country has engineered this success. However, mountaineering, like science, is not a purely national affair, for it is practised by many peoples and, like science again, builds on the successive experience and knowledge gained by previous generations. First of all, tribute must be paid to the Sherpa porters, without whose courage and endurance this year's expedition—and all the previous ones—could never have started at all; to them, too, falls the honour that one of their number made the final assault. The route followed this year is the comparatively new one from the south, first reconnoitred by Mr. Eric Shipton's party in 1951. The pre-war attempts were all on the northern side by way of Tibet, but that country is now closed to foreigners whereas, paradoxically enough, Nepal, which previously had been a forbidden country, now permits the passage of expeditions. The favourable reports of Mr. Shipton encouraged a Swiss team to make a serious attempt last year, and they were almost successful, for M. Raymond Lambert and the same Sherpa Tensing got within 800 ft. of the summit. It is a great tribute to the Swiss party that, in the true spirit of mountaineering brotherhood and international co-operation, so characteristic of their country, they imparted all the hard-earned details of their climb to this year's expedition.

Finally, mention must be made of the part science and technology have played. It is no belittlement of the prowess of the climbers to say that without oxygen they would never have succeeded, and this year has seen the improvement of the 'open-circuit' oxygen apparatus and the novel development of a 'closed-circuit' apparatus; incidentally, it has been reported that the first assault with the latter type was unsuccessful and that Hillary and Tensing, who were the second pair to make the attempt, used 'open-circuit' masks. Then again, the developments during the past decade and more of synthetic materials, and the experience gained of the physiology of human exposure and acclimatization, together with other recent advances of science and medicine, have all played their part. Nevertheless, any expedition reduces in the end to a battle between man and Nature, and rash indeed would he be who would prophesy that in future man will always be the victor.

It has since been announced that Mr. Hillary has been made K.B.E. and Colonel Hunt has been created a knight; Sherpa Tensing is not a British subject and the question of recognition of his achievement is under discussion.

## The Wiles Lectures at Queen's University, Belfast

THE Queen's University of Belfast has received a gift of £7,500, to be spent over the next 7–10 years, to promote the study of the history of civilization and to encourage the extension of historical thinking into the realm of general ideas. The gift is from Mrs. Austin Boyd, of Cultra, Co. Down. It is to be used to endow an annual series of about four lectures, to be known as the Wiles Lectures, in memory of Mrs. Boyd's father. The purpose of the endowment is not to popularize history, but rather to invite a few historians of distinction to reflect on the wider implications of their work, and to embody their reflexions in the lectures and in a book. It is hoped that the Wiles Lectures will bear fruit in two ways: on one hand by encouraging some younger historians to enter the difficult field of research into the history of ideas; and on the other hand, by broadening eventually the basis of the teaching of history in schools, so that more emphasis is put on supra-national than on national movements. The benefactress hopes to make a further gift to the Queen's University so that the purpose of the endowment may be continued beyond the experimental period of 7–10 years. In administering the endowment the Queen's University will be advised by a committee including its own professor of modern history, together with two scholars to be invited from other universities.

## Natural Gas in Britain

AT a recent meeting of the Institution of Gas Engineers, Sir Harold Smith, chairman of the Gas Council, stated that an intensive, large-scale search for natural gas in Great Britain is to begin in the near future. The supply of good gas-making coal is decreasing and becoming more difficult to win, and therefore every possibility of developing methods of using coals normally considered unsuitable for carbonizing by orthodox means should be considered; further, the efficiency of existing carbonizing processes should be improved. But this is not enough, for the urgency in these matters is dictated by rapidly increasing cost of coal, and it is necessary that investigation into new supplies of gas from natural sources should be undertaken. In co-operation with the Anglo-Iranian Oil Co., Ltd., the Gas Council is proceeding with a scheme of exploration for natural gas in Britain estimated to last about five years. No rosy vista of commercial success can be envisaged, judged by past records, of which Heathfield, Sussex, is the classic example. None the less, a search sufficiently wide and deeply spread in Britain will at least settle once and for all this controversial problem of the occurrences of natural gas, and to this extent the scheme appears justified.

## Glass in Chemical Industry

GLASS has for many years held pride of place in the field of laboratory apparatus, and in recent years its use is being extended to chemical industrial plant where the dimensions are on a very much larger scale. For the supply of laboratory glassware (mainly heat-resistant borosilicate glass) a well-known name is Quickfit and Quartz, Ltd., a firm which has built up a reputation in the manufacture of ground-glass standard interchangeable conical joints, whereby complicated pieces of apparatus can be built up from a relatively small number of standard components. The firm started before the Second World War at King's Norton, near Birmingham, and in 1946 transferred most of its work to Stone in Staffordshire (see *Nature*, 164, 907; 1949). Production at Stone is now in full swing.

The latest developments at Stone are mainly in the field of large pieces of glassware, and one of the most interesting processes that has recently been put into operation is the electric welding of large joints. Though this process is well known in the United States, where electricity is much used and the gas industry is small and, being based on natural gas, is not suitable for glass-working, the method has only been recently introduced into Great Britain. The method is at present only suitable for joints of a simple shape, such as putting on the neck of a flask, but the dimensions can be relatively big (for example, 20–30 cm. diameter). The two parts to be joined are mounted on a glass-working lathe, brought almost together and rotated between electrodes placed at opposite ends of a diameter. The electrodes are hollow and carry small gas-flames which heat up the glass and thereby reduce its electrical resistance from the order of megohms to thousands of ohms. The current is then switched on from a 120-kc./s. generator of 25 kVA. output. The current passes over the small gaps from the electrodes and flows through the glass, heating it uniformly through the body of the work but at the same time over an annular volume that is very narrow. The power factor is usually 0·5–0·8, and when the joint is made and the glass molten the current is about 3 amp. at about 10 kV., some 12 kW. being dissipated in the glass. The frequency of the generator is not critical; but at 120 kc./s. the voltage can only burn and not electrocute in the event of an accident to an operator. The main advantage of this method is the uniform heating through the glass and the small volume of heating as compared with large gas-flames, which heat only on the surface and over a wide area, and for electric-welded joints the subsequent annealing process (which is very time-consuming) is much easier.

## Radiophysics Laboratory, Sydney

One of the Divisions of the Commonwealth Scientific and Industrial Research Organization of Australia is the Radiophysics Laboratory, situated in the grounds of the University of Sydney, and the chief of the Division is Dr. E. G. Bowen. The four main fields of research in the Laboratory are radio astronomy, cloud and rain physics, automatic computation and the development of radio aids to navigation, and in a very attractive and well-illustrated brochure, entitled "Research Activities of the Radiophysics Laboratory" (pp. 36. Melbourne: C.S.I.R.O., 1952), a brief account is given of the Laboratory's current work under these four separate headings. The section on radio-astronomy is mainly concerned with the study of radio noise from the sun and outer space. The design of a new solar radio-spectroscope, now under construction, which is to cover the frequency-range 40–240 Mc./s., and a 32-element interferometer, which will be used at decimetre wave-lengths for the location of sources of solar radio noise, are described. Investigations to determine the positions and characteristics of discrete sources of cosmic noise and the techniques involved are discussed, and an interesting study is outlined of the temperature and structure of the ionospheric *D*-layer by an application of a method first used in radio astronomy to measure the thermal emission from the solar corona. The study by micro-wave radar of rain formation and cloud-seeding experiments for rain-making are the main items in the rain and cloud physics section, and details of the binary type Mk. I digital computer which has now been in use for about a year are given in the section on automatic computation. In the final section, dealing with radio aids to navigation, are described two short navigational aids, the "Distance Measuring Equipment" for aircraft and the "Multiple Track Range" providing a number of flight tracks to and from an airport, and, in addition, a recently developed micro-wave direction-finding apparatus operating at a wave-length of 3·2 cm. The accounts of the work of each section are terminated by a detailed list of scientific papers published by its members during 1948–52.

## Imperial College of Science and Technology, London: Report for 1951–52

The forty-fifth annual report of the Governing Body of the Imperial College of Science and Technology, London, covering the year ended July 31, 1952 (pp. 60; from the College, 1953), refers to the start being made on the new building for the Aeronautics Department, although the steel allocation was at that time being awaited. The creation of laboratories for mineral dressing in the Bessemer Laboratory was nearing completion and a small extension of the Department of Metallurgy was being made in the same building. The space available for expansion in the South Kensington area has been increased by purchase of the freehold of the property at 179 Queen's Gate, and an additional twenty-eight acres of land contiguous to the Field Station at Silwood Park, Sunninghill, have also been purchased. A series of lectures on general subjects for first-year undergraduate students was organized by the Dean of the City and Guilds College during 1951–52, and, with the London School of Economics and Political Science, joint postgraduate studies in technology, economics and administration have been arranged for the session 1952–53. As a further experiment in co-operation between academic staff and students, the College hours are being varied so as to leave two hours (12.30 p.m.–2.30 p.m.) on Tuesdays and Thursdays entirely free from organized College studies. On each of these days a joint committee of staff and students is arranging functions such as discussion talks by outside experts, concerts of chamber music and general entertainments organized by student societies. Besides the statement of accounts and details of teaching and administrative staff changes, appendixes to the report include a list of publications during 1951–52, arranged under departments.

## Dry Rot in Wood

A fifth edition of "Dry Rot in Wood", Bulletin No. 1 of the Forest Products Research Institute, by K. St. G. Cartwright and Dr. W. P. K. Findlay, has been issued under the auspices of the Department of Scientific and Industrial Research (pp. 36+8 plates. London: H.M.S.O., 1952; 2*s*. net). It is said that dry rot has become very much more prevalent during the past decade, though whether this is so has not been proved; nevertheless, there must be many people who are acquainted with the appearance of dry rot in the house in floor-boards and other woodwork. The attack is caused by ***Merulius lacrymans***; moisture is necessary, and strands of the fungus can transport the moisture so that it can rot moderately dry timber once it has got a hold. Dry rot spreads easily. Like the white ant of the tropics in its search for timber, the fungus is said to be able to pass through brick or stone walls via the mortar. As to methods to combat it, the council of perfection is to have no damp spot anywhere in the house. "Leaky gutters, cracked pipes and so on should be repaired immediately. Cellars should be kept dry." Are all these precautions possible these days? There is often a considerable delay before repairs to leaking roofs, pipes, etc., can be effected, and, though it may be feasible to keep a small cellar dry, in country houses where the cellarage may be of fair size it would be very expensive to keep them heated throughout the winter; and, in the case of the wine cellar, the cherished wine would be ruined. Nevertheless, this edition of the bulletin has been thoroughly revised, and in houses of any size it should be regarded as indispensable. No simple practical remedial measure is apparently yet available.

## Metals in the Service of Man

In the ***Museums Journal*** of May 1953, Mr. A. R. Hutchieson describes the modern treatment of the non-ferrous metals at the Royal Scottish Museum, Edinburgh. This has been arranged as a panorama of metals in the service of man. Beginning with a brief survey of their discovery and early uses, this is followed by an attractive introduction to the more technical exposition of modern extraction methods, processing and applications. Bold, colourful maps and diagrams are used, and by an imaginative selection of characteristic three-dimensional material the display has atmosphere and life. Aluminium, magnesium, nickel, copper, tin, lead and zinc have been dealt with, and the growing popularity of the new display with visitors indicates that the method of presentation has been successful.

## Deep-Sea Floor and the History of the Earth

A symposium on the "Deep-Sea Floor and the History of the Earth" has been arranged by the International Joint Commission on Oceanography of the International Council of Scientific Unions and will be held at the University of Liverpool during September 1–2 immediately preceding the meeting of the British Association. The International Union of Geodesy and Geophysics and the International Union of Biological Sciences are represented on this Commission, the constitution of which is as follows: *President*, J. D. H. Wiseman (Great Britain); *Secretary*, C. D. Ovey (Great Britain); *Members*, A. F. Bruun (Denmark), C. W. Correns (Germany), L. Fage (France), Ph. H. Kuenen (Holland), H. Pettersson (Sweden), R. Revelle (United States), Mary Sears (United States); *Advisory Councillors*, F. Bernard (Algeria), F. Koczy (Sweden), J. D. Nares (representing the International Hydrographic Bureau), J. Rouch (Monaco), H. U. Sverdrup (Norway), H. C. Urey (United States) and C. E. ZoBell (United States). The main object of the Commission is to stimulate international collaboration in fundamental research on deep-sea problems, through recent developments in electronics, physics, chemistry and biology, combined with technical advances in detailed surveying and sampling of the deep-sea floor, which have made possible a new level of scientific understanding of the deep sea.

## Merck Fellowships of the Canadian National Research Council

Three post-doctorate research fellowships, endowed by Merck and Co., Ltd., have been awarded by the National Research Council, Ottawa. The awards, which total 11,000 dollars and travel allowances, with an extra 500 dollars to each institution concerned, to help pay for specialized equipment, have been made to the following for research as indicated: Dr. W. G. B. Casselman (Universities of British Columbia and Toronto), cellular physiology, at the University of Oxford, under Dr. J. R. Baker; Dr. G. D. Fasman (University of Alberta and the California Institute of Technology), alkaloids and nucleosides, at the Technische Hochschule, Zurich, under Prof. V. Prelog; Dr. B. A. Gingras (University of Montreal), reactions of free radicals in solution, at the University of Oxford, under Dr. W. A. Waters.

## Association of Applied Biologists

The officers and council for 1953–54 of the Association of Applied Biologists is as follows: *President*, Prof. W. Brown; *Vice-Presidents*, Mr. R. W. Marsh and Prof. J. B. Cragg; *Honorary Treasurer*, Dr. H. F. Barnes; *Honorary General Secretary*, Dr. R. K. S. Wood (Imperial College of Science and Technology, London, S.W.7); *Honorary Programme Secretary*, Dr. L. Broadbent; *Honorary Editor of the Annals of Applied Biology*, Mr. R. W. Marsh; *Honorary Assistant Editor*, Dr. I. Thomas; *Council*, Dr. P. W. Brian, Dr. C. H. Cadman, Prof. J. B. Cragg, Dr. D. W. Fenwick, Dr. R. M. Greenslade, Dr. I. Isaac, Dr. W. F. Jepson, Dr. M. A. Keay, Dr. A. H. McIntosh, Mr. B. D. Moreton, Dr. I. W. Prentice and Dr. A. F. Posnette. The Association celebrates in 1954 the fiftieth anniversary of its founding, and to mark the occasion a series of special meetings will be held during September 13–17, 1954, to which a number of distinguished scientific workers from overseas will be invited. A jubilee fund for the expenses of this meeting was started in December 1952; further contributions to this fund should be addressed to the treasurer of the Association.

## University of London: Appointments

The following appointments in the University of London have recently been announced: Dr. G. O. Jones, reader in experimental physics at Queen Mary College, to the University chair of physics tenable at that College; and Dr. W. B. Pennington, research Fellow at Jesus College, Cambridge, to the University readership in mathematics tenable at Westfield College. The title of reader in mathematics in the University has been conferred on Dr. C. A. Rogers in respect of the post held by him at University College, London.

## Announcements

Sir John Russell, formerly director of Rothamsted Experimental Station, has been elected a foreign member of the Finnish Academy of Science and Letters.

M. Philibert Guinier, director of the École des Eaux et Forêts, Nancy, and *correspondant* for the Section of Rural Economy of the Paris Academy of Sciences, has been elected a member of the Section in succession to the late Prof. L. Lapicque.

The Institute of Fuel has awarded its Students' Medal and Prize for 1952 to B. H. Holland, of the Department of Coal Gas and Fuel Industries with Metallurgy, University of Leeds, for his paper on "The Structure and Stability of Flat Burner Flames".

Dr. David R. Goddard, professor of botany in the University of Pennsylvania, has been elected editor-in-chief of *Plant Physiology*, the journal of the American Society of Plant Physiologists.

The Committee of Privy Council for Agricultural Research and Nature Conservation has re-appointed Lord Rothschild as chairman of the Agricultural Research Council for a further term of five years. It has also approved the appointment of Prof. Stephen J. Watson as deputy chairman of the Council.

Mr. R. C. Worster, who has been a member of the research staff of the British Hydromechanics Research Association since its formation, has been appointed deputy director of research in the Association.

The following have been appointed lecturers in the University of Leeds: F. P. G. Whitaker (industrial administration in the Department of Economics), Dr. F. S. Trippett (organic chemistry), and T. J. Bowen (biochemistry).

The Challenger Society is prepared to consider applications for small grants in aid of research in marine biology or oceanography at a recognized laboratory during the year June 1953–June 1954. Applications, accompanied by details of the proposed research, should reach the honorary secretary, Mr. N. B. Marshall, British Museum (Natural History), London, S.W.7, before the end of June.

Erratum. In the communication "Difference between the Density Distribution of Neutrons and Protons in Atomic Nuclei" (*Nature*, May 30, p. 979), paragraph 2, line 8, for "$1+b(r/r_0)^2$" read "$[1+b(r/r_0)^2]^2$".

# PHYSICS OF THE SOLID STATE

## PHYSICAL SOCIETY SPRING MEETING

THE spring meeting of the Physical Society was held in the Physics Department of the University of Leeds; the president of the Society, Prof. R. Whiddington, was in the chair. The meeting was devoted to several topics under the general heading of "Some Aspects of Solid State Physics" and was well attended, some hundred and eighty people being present.

Introducing the first session, "The Analysis of Magnetization Curves", Prof. E. C. Stoner (Leeds) related such curves with the general characteristics of ferromagnetics and the main processes by which change of magnetization may occur; these latter are changes in intrinsic magnetization, rotation of domain magnetization vectors and movement of domain boundaries. Much is now known of these processes individually, but the statements made about their relative contributions to a change along a magnetization curve of an ordinary polycrystalline material are little more than plausible guesses. By an 'analysis of magnetization curves' is understood a determination of the processes taking place; this can be achieved by a suitable combination of experimental measurements and theoretical reasoning. Measurements of the reversible susceptibility, together with the ordinary magnetization curve, enable the reversible and irreversible contributions to be separately determined. Investigation of the thermal changes accompanying adiabatic magnetization, on appropriate analysis, gives a quantitative indication of the contributions from the various elementary processes. The analysis can be made more nearly complete if that part of the thermal change associated with the reversible processes can be separately determined; this is possible by an indirect method recently developed. Further experimental work will be necessary before complete analyses are possible; but from partial analyses already made it appears that the main thermal effects are usually due to rotations and changes in intrinsic magnetization. The magnetic and thermal changes in moderate and, to a large extent, in low fields can be satisfactorily co-ordinated, but the detailed interpretation of the behaviour in high fields presents greater difficulties.

Prof. L. F. Bates (Nottingham) then gave a description of the method of measuring small temperature changes accompanying the magnetization of ferromagnetic rods in low and moderate fields. Examples were given of earlier measurements and their interpretation in terms of the Stoner and Rhodes theory in which the thermal changes due to the so-called magneto-caloric effect are subtracted from the observed changes and the differences used to calculate an important coefficient. Prof. Bates discussed the values of this coefficient for many metals and alloys, and showed some results for cobalt in which the reversible and irreversible thermal changes had been separated in a simple manner and the coefficient again calculated. Measurements on a 'Ferroxcube' rod were described, and these showed that the thermal changes accompanying magnetization were in this case almost entirely due to changes in intrinsic magnetization. Finally, he compared the results of high field measurements on 'Alnico' with the theory given by Rhodes of the heat changes in an idealized ferromagnetic of high coercivity.

An account was given by Dr. R. S. Tebble (Leeds) of the separation of the processes involved in the magnetization of a ferromagnetic at low fields from measurements on the reversible change in magnetization with temperature. The contributions of rotations of the magnetization vectors, and changes in intrinsic magnetization, have been estimated for annealed nickel, and it is probable that the effect of boundary movements can also be estimated. The agreement in high fields with the measurements of Bates and Davis was shown by Dr. Tebble to be good. He suggested that, if the appropriate measurements can be made on one specimen under carefully controlled conditions, it should be possible to extend this work to a separation of the reversible and irreversible components of the magneto-caloric effect.

Prof. W. Sucksmith (Sheffield) stated that the magneto-caloric effect in high fields probably constitutes the most useful and reliable method for tracing the variation of spontaneous magnetization with temperature and has only been applied fully to the case of nickel. A method of measuring the small rise of temperature with adequate accuracy has been developed. The experimental results for copper–nickel alloys have established a new feature in the non-linear relation between the rise of temperature and the square of the magnetization above the Curie temperature, while the tail of the spontaneous magnetization curve attributed to fluctuations by some writers is certainly not greater than for pure ferromagnetics; in the case of ferrites it becomes almost non-existent.

Mr. K. L. Hunt (Leeds) described a mathematical extension of the collective electron theory of ferromagnetism in which the energy associated with the magnetization is taken not simply as proportional to the second power of the magnetization but as dependent on both the second and fourth powers. A further adjustable parameter is thus introduced. A high degree of co-ordination may then be obtained between all the observed magnetic and thermal properties of nickel and of some nickel alloys. The change of magnetization with field in high fields is the single property for which a qualitative account only is possible. There are indications, however, that this change of magnetization is not entirely that of the intrinsic magnetization, even in high fields.

The next session, on "The Band Theory of Metals", was introduced by Prof. H. Jones (London), who gave a critical survey of the three main assumptions on which the theory is based. These are: (1) the Hartree–Fock self-consistent field method which implies that each electron is in a stationary state, the total wave function being written as a single Slater determinant of the one-electron functions; in consequence the total energy may be written as the sum of the one-electron energies together with an interaction term; (2) the interaction term is independent of the distribution of the electrons over the available states, implying that the electrons may be treated by Fermi–Dirac statistics; and (3) the one-electron functions may be expressed as the product of a space function and a spin function. In conclusion, Prof. Jones stressed the importance of calculations of basic characteristics of particular metals; these would enable the logical consequences of the assumptions to be compared with experiment and the adequacy of the assumptions tested.

Dr. E. P. Wohlfarth (London) gave an account of an approximate treatment to determine the form of the total energy for a metal, the Bloch tight-binding approximation being used for the calculation. For infinite separation of the atoms, this approximation leads to the correct expression for the total energy when the spins of all the electrons are parallel; but when there is zero resultant spin moment, there is a large additional term in the energy expression. Dr. Wohlfarth suggested that, as a first approximation, this large correlation term could be treated as independent of interatomic distance when the dependence of the total energy on the number of electrons per atom and the magnetization could be estimated. He then related the results of this treatment to the analyses of Mr. K. L. Hunt. The applicability of Fermi–Dirac statistics to electrons in metals was also discussed, and he suggested that this provides a good approximation at least for those electrons which can be treated by means of the tight-binding approximation.

Experimental work on the transition elements, directed to the elucidation of their band structures, was then described by Dr. F. E. Hoare (Leeds). Starting with the simple picture of an incompletely filled *d*-band overlapped by an *s*-band, it is to be expected that alloying the appropriate neighbour of higher atomic number should fill the *d*-band at a particular concentration, the alloy then becoming diamagnetic. Alloying with a neighbour of lower atomic number should, on the other hand, create more holes in the band. The height of the band should vary in these alloying processes, and measurements of the electronic heats of the alloys will show the manner of this variation. The experimental results for the susceptibilities of palladium–silver and palladium–rhodium alloys were shown by Dr. Hoare, along with the electronic heats of palladium–silver, and the qualitative agreement with the simple band picture was discussed. The marked difference in behaviour of the electronic heat in the palladium–silver and nickel–copper systems was indicated. Preliminary results for the susceptibilities of the platinum–gold and platinum–iridium systems were shown, and it appears that these may be interpreted in the same general scheme as the former results.

Dr. P. Rhodes (London) discussed the dependence of the temperature variation of paramagnetic susceptibility and electronic specific heat on the form of the density of states relation. He showed how earlier treatments assuming simple band forms have led to the conclusion that the paramagnetic susceptibility is a monotonically decreasing function of temperature, whereas more recent experimental results for palladium and certain of its alloys with silver show that the susceptibility/temperature curves may exhibit maxima. Results for the low-temperature specific heat of the palladium–silver alloys indicate that the band form in palladium is not of the form assumed in the earlier treatments. When the treatment is developed using a band form appropriate to that derived from the experimental results, the calculated susceptibility/temperature curves do, in fact, exhibit maxima. A brief account was also given of some effects of band overlap and band closure.

A short description of the dependence of the steady (field independent) diamagnetic susceptibility of metals and alloys on their electronic structure was given by Mr. E. W. Elcock (Leeds), who indicated how the earlier treatments are inadequate to explain the complicated dependence of susceptibility on temperature and composition for alloys of polyvalent metals. He showed how, by a straightforward extension of these earlier treatments, it is possible to correlate effects of both temperature and alloying on the susceptibility. The alloys of bismuth with small concentrations of lead and tellurium were particularly considered, and the bearing of the treatment on a wider range of metals and alloys was indicated. Finally, Mr. Elcock suggested a possible interpretation of the curious oscillatory character of the temperature variation of the susceptibility of zinc in terms of the treatment developed.

In introducing the final session, on "Luminescence and Ferroelectricity", Dr. J. H. van Santen (Philips Research Laboratories, Eindhoven) reviewed the properties of pure and perfect non-metallic solids in terms of simple band theory. Impurities and imperfections modify these properties by introducing localized energy-levels. In elements such as germanium and silicon the type of semi-conductivity, *p* or *n*, depends on the valency of the impurity relative to that of the host. In alkali and silver halides the introduction of divalent ions leads to increased conductivity through the production of cation vacancies. In oxides, however, the impurity may also produce changes of valency in some of the host cations; for example, $(1-\delta)$ NiO with a small amount, $\delta/2$, of $Li_2O$ can be represented as

$$Li_\delta Ni^{2+}_{1-2\delta} Ni^{3+}_{\delta} O^{2-}$$

and has a *p*-type conductivity. Kröger has shown that gallium in zinc oxide can produce cation vacancies, change of valency of some zinc ions in a reducing atmosphere, leading to *n*-type conductivity or, under oxidizing conditions, to holes trapped near cation vacancies giving *p*-type conductivity. He considers that the blue luminescence of self-activated zinc sulphide is associated with the third kind of centre.

Dr. E. E. Schneider (King's College, Newcastle) gave an account of the mosaic structure of single crystals, citing evidence obtained from optical scattering that the size of the blocks is about 2000 A. He then surveyed the types of defects in crystals, with particular reference to Seitz jogs, which are considered to act as incipient vacancies. Discussing colour centres, he directed attention to the new colour-centre model of Kittel and Kahn in which an electron is regarded as being shared by the six negative ions surrounding the vacancy. This makes the *F*-centre similar to the *V*-centre, in which a positive hole is shared by six anions around a positive ion vacancy. Other *F*- and *V*-centres must exist and probably consist of simple aggregates of simple *F*- and *V*-centres and vacancies. Information on vacancies can be obtained from conduction measurements. Recent work by Cunnell on conductivity and polarization effects gives strong support for the mosaic idea and suggests that at low temperatures the positive ion vacancies are held at or near block boundaries. Coloration must include a mechanism which frees vacancies from boundaries. The build-up of *F*-centres under X-radiation, an initial steep portion with high efficiency followed by a less steep portion leading to saturation, is attributed to an initial easy release of vacancies from boundaries followed by a less efficient release from Seitz jogs. Cunnell's work shows that a coloured crystal displays a small conductivity with increasing temperature, an increase in the temperature-range of bleaching and the maintenance of this increased conductivity on cooling.

Mr. J. Ewles (Leeds) gave an account of investigations, recently completed at Leeds, into the optical and electrical properties of phosphors. He pointed out that luminescence is not a rare phenomenon in solids but is likely to accompany imperfections in crystals whether these are caused by impurities or by thermal treatment. It is, in fact, rarely absent in real crystals, being suppressed only with extraordinary purity and in the absence of thermal strains. It can be intensified by sudden quenching, and reduced or removed by annealing. Recent experiments carried out by Lee have led to a modification of the theory of the large centre first introduced by Ewles in 1930. The modified theory now takes into account the competition of structure centres provided by imperfections, and is in good agreement with experiment. Further, it permits the evaluation of the size of the centre. Mr. Ewles also gave a brief account of the remarkable optical and electrical properties of some new oxygen-activated alkali halide phosphors investigated by Barmby. These phosphors show sharply resolved luminescent bands which must be attributed to oxygen ions adsorbed on the halide. The luminescence is accompanied by very large increases in conductivity. Thermoelectric powers up to some two millivolts per degree indicate that the conduction is electronic, and an interpretation in terms of the effect of the adsorbed oxygen on the band levels of the halide crystals was given.

In the section on ferroelectricity, two papers were presented: the first, by Dr. L. E. Cross, on ferroelectricity in the perovskite type structures; and the second, on the theory of ferroelectrics, by Dr. A. F. Devonshire.

Dr. Cross (Leeds) directed attention to the importance of accurate measurement of electric hysteresis in the ferroelectric state. He described the method normally used for measuring the hysteresis, and examined the limitation imposed by the electric conduction through the ferroelectric. After a brief description of the perovskite structure, he listed the minerals which are of interest electrically and, from them, examined in more detail barium titanate, potassium niobate and sodium niobate. The sequence of symmetry changes which occurs on cooling barium titanate was described by Dr. Cross, and the electric domain structures occurring in the tetragonal room-temperature phase examined, new evidence being produced to confirm the existence of a system of anti-parallel domains within the individual twin unit. Hysteresis figures obtained on untwinned barium titanate crystals above the ferroelectric Curie temperature were shown, and these were compared with previous results in the United States. New measurements of electric hysteresis effects in potassium and sodium niobates were also reported. In the potassium salt, the results were shown to be in reasonable agreement with previous work. Preliminary results on sodium niobate, however, have revealed a linear dielectric up to field-strengths of 20 kV./cm., and clearly this is not a normal ferroelectric.

Dr. Devonshire (Bristol) said that he would consider only the theory of the single domain. This theory can be divided into two parts: first, the purely thermodynamic theory of the relations of the elastic, piezoelectric and dielectric constants to each other; and second, the relation of these to the atomic structure. It is important to carry out a thermodynamical analysis of experimental results, before devising a detailed atomic theory. This analysis shows that all the anomalies observed at the transition temperature are due to the fact that the dielectric stiffness coefficient tends to zero at this point; Dr. Devonshire also suggested that the first-order character of the transition in barium titanate is probably due to the interaction between strain and polarization. The smallness of the dielectric stiffness coefficient is due largely to electrostatic interaction between the different parts of the polarized medium; this is in contrast with ferromagnetic materials, for which magnetostatic interaction is of small importance. The temperature variation is due to the higher entropy of the unpolarized state. The existence of a lower transition in Rochelle salt is probably due to the existence of a stable anti-parallel arrangement of dipoles below this temperature.

The meeting provided a welcome opportunity for an exchange of views among those working in related fields, and full advantage was taken of this in a number of extended informal discussions.

F. E. Hoare

# OXIDATION OF OILS AND FATS

A SYMPOSIUM on "Oxidation" was held by the Oils and Fats Group of the Society of Chemical Industry in the Low Temperature Research Station, Cambridge, on April 24. Prof. T. P. Hilditch, chairman of the Group, presided and welcomed some hundred-odd members and visitors. The programme was divided, after an introductory address, into two sessions of two papers each, one dealing mainly with the oxidative deterioration of fats and the other with the autoxidation of unsaturated fatty acids and esters and other topics related to drying oils and paints. Although the approach to, and aim of, this aspect of the problem are different, the chemical changes which take place have the same common basis, and for this reason the discussion on all the papers was taken together.

Prof. C. E. H. Bawn, in his introductory address, reviewed the fundamental ideas on the mechanism and chemistry of varied classes of organic molecules; for example, hydrocarbons (saturated, unsaturated, aromatic and hydro-aromatic), aldehydes and ketones, etc., which readily undergo autoxidation in the liquid or solution phase at relatively low temperatures. The radical chain theory of these processes has in recent years come to be widely accepted, and it is agreed that the initiation of the reaction requires the production of a free radical either by direct oxygen attack, photochemically or by an added agent. The reaction chain has been established to be of the following type:

$$\begin{array}{rcl} \text{Initiation} & \rightarrow & \text{free radical } R. \\ R + O_2 & \rightarrow & RO_2 \\ RO_2 + RH & \rightarrow & ROOH + R \\ R + R & \rightarrow & \multirow{3}{*}{} \\ R + RO_2 & \rightarrow & \left.\right\} \text{inert products} \\ RO_2 + RO_2 & \rightarrow & \end{array}$$

where $RH$ = hydrocarbon, aldehydes, etc.

The initially formed hydroperoxide ($ROOH$) is of varying stability, and at higher temperatures readily undergoes further decomposition. This decomposition is also a chain mechanism, and many examples conform to the following type:

$$\begin{aligned} &R\mathrm{OOH} \rightarrow R\mathrm{O} + \mathrm{OH} \text{ or } 2R\mathrm{OOH} \rightarrow R\mathrm{O}_2 + R\mathrm{O} + \mathrm{H}_2\mathrm{O} \\ &R\mathrm{O} + R'\mathrm{H} \rightarrow R\mathrm{OH} + R' \\ &R' + R\mathrm{OOH} \rightarrow R'\mathrm{OH} + R\mathrm{O}. \\ &\left.\begin{aligned} 2R' &\rightarrow \\ R' + R\mathrm{O} &\rightarrow \\ 2R\mathrm{O} &\rightarrow \end{aligned}\right\} \text{inactive products} \end{aligned}$$

where $R'\mathrm{H}$ may be parent molecule $R\mathrm{H}$, solvent or added substrate. These secondary chain reactions, together with the direct thermal decomposition of the peroxide to saturated molecules and the decomposition of the radicals $R\mathrm{O}$ and $R\mathrm{O}_2$, give rise to the variety of products—aldehydes, ketones, alcohols, acids and esters—which usually appear when the oxidation is carried to any considerable extent. It is these reactions, to which all unsaturated organic compounds in particular are susceptible, which have important practical consequences, and, as will be seen from the papers discussed, they are responsible for the development of the rancidity of fats, the gelation of drying oils and also the deterioration of rubber and other high polymers.

It is well known that the salts of the heavy metals are good catalysts for autoxidation reactions, and these reactions are of great technical importance particularly in the field of drying oils and 'controlled' oxidation to form selective intermediates, such as the oxidation of aldehydes to acid anhydrides, *cyclo*hexanol to adipic acid and *iso*propyl benzene to its hydroperoxide.

The point of view was expressed that these catalysts function essentially in the ionic form and that their activity resides in their ability to undergo electron-transfer reactions giving rise to free radicals: for example,

$$\begin{aligned} \mathrm{Co}^{++} + R\mathrm{OOH} &\rightarrow \mathrm{Co}^{+++} + R\mathrm{O} + \mathrm{OH}^- \\ \mathrm{Co}^{+++} + R\mathrm{OOH} &\rightarrow \mathrm{Co}^{++} + R\mathrm{O}_2 + \mathrm{H}^+. \end{aligned}$$

Prof. Bawn also referred to the profound effects of oxygen in polymerization mechanisms in which it may initiate and inhibit polymerization, and induce degradation, branching or cross-linking of polymer molecules according to conditions and environment.

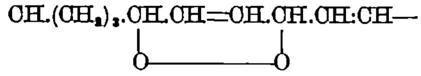
In the opening paper of the first session, Dr. C. H. Lea reviewed some recent studies of the oxidative deterioration of edible lipoids. He said that the degradation products of the primarily formed hydroperoxide, particularly $\alpha\beta$ unsaturated aldehydes and ketones, are largely responsible for the unpleasant odour and flavour of oxidized fats. The relatively rapid autoxidation of poly-unsaturated acids compared with oleic acid emphasizes the deleterious effect of even small proportions of these acids in food fats. These substances not only increase the susceptibility of the whole fat to oxidation, but also the presence of acids containing three or more double-bonds seems to be the cause of the development of the characteristic 'off' flavour, usually described as 'reverted'. The actual mechanism by which these flavours are produced is not fully understood, but the consensus of opinion appears to be that they result from the oxidation of linolenic and more highly unsaturated fatty acids to a substance of unsaturated aldehydic and ketonic structure. Traces of copper and iron favour the development of flavour in fats, and quantities as low as a few parts per million produce appreciable effects in refined oils. In this respect the presence of chelating agents which inactivate trace metals has proved to be of considerable value in improving stability. The composition of animal fat, which is influenced by such factors as diet and rate of growth, affect the susceptibility to the development of oxidative rancidity. Dr. Lea discussed evidence from recent literature that peroxidized fat may be present in the tissues of still living animals which have been subjected to ionizing radiation. This problem is being mainly studied in the United States, and it has been observed that radiation initiates oxidative reactions in many foodstuffs with the consequent development of undesirable flavours. Dr. Lea also referred to the effect of enzymatic catalysts—the lipoxidases—which accelerate the peroxidation of unsaturated fats and fatty acids. These enzymes are very specific in their action towards different types of unsaturated groupings. In the United States much work has been done on antioxidants, and these are used extensively in fats and fat-containing materials. In Britain the whole question of the addition of antioxidants to food, like that of other non-nutrient chemicals, is still under consideration.

In the second paper Dr. Banks described some observations on the autoxidation of linoleic acid. He concluded that the product is a mixture of peroxides, which cannot readily be separated; but after reduction and separation by partition between petrol ether and aqueous methanol two types of linoleic esters (hydroxy acids) are isolated. Investigations of the autoxidation of methyl linoleate in the presence of lauric and palmitic acids at 35° and 55° C. show that esterification does not occur at these temperatures, and this suggests that esters isolated are formed during reduction of the peroxides.

A review of recent work on the oxidation of mono-ethenoid fatty acids and their higher esters catalysed by metallic soaps (uranium, thorium, vanadium, etc.) was presented by Dr. Skellon. This work confirms that the primary product is a hydroperoxide which decomposes to give either epoxy, aldehydic, dehydroxy or keto-hydroxy derivatives. Oleic acid forms hydroperoxide only slowly at low temperatures, but at 85° and 120° C. this process is rapid, and the peroxide concentration passes through a well-defined maximum. Dihydroxy stearic acid, 10-hydroxy stearic acid, and small amounts of scission products have been isolated from the breakdown products of the hydroperoxide. Results were also given for the autoxidation of the *trans* isomer, ethyl, propyl and butyl esters of oleic acid, petroselenic acid, methyl recinoleate, and erucic and brassidic acids.

The drying of oil films and the manufacture of blown oils and linoleum gels are processes which depend on the formation of polymers by autoxidation. The results that have recently been obtained from extensive studies on these problems at the Paint Research Station were summarized by Dr. L. A. O'Neill. Evidence was presented in support of the view that one of the polymer-forming reactions in the autoxidation of non-conjugated drying oils results from the metallic salt-catalysed decomposition of the initially formed hydroperoxide. The main products obtained from the decomposition of the hydroperoxides of methyl linoleate and methyl linolenate are —C—C bonded dimers which retain the full unsaturation of the original esters. Some unsaturation is lost in the process, and conjugated esters are formed by double-bond shift.

The products from the autoxidation of the conjugated drying oil—methyl elaeostearate—are mainly monomeric peroxides (one of which has been isolated in the crystalline form) together with small amounts of polymeric peroxides which do not seem to be bonded by peroxide linkages. A tentative formula was proposed for the crystalline peroxide as



$$CH.(CH_2)_3.CH.CH{=}CH.CH.CH{:}CH{-}$$

Dr. O'Neill also described the results of direct studies of the autoxidation of drying oils in film form. Thus linseed oil takes up eight atoms of oxygen per molecule. Some of this oxygen is lost as volatile products, and only five atoms are retained after fourteen days. The volatiles include water, carbon dioxide, aldehydes and acid (particularly formic acid). Little change occurs in the film after a few days, and it seems necessary to postulate scission of the oxidation polymer in order to explain this high oxygen take-up.

C. E. H. BAWN

# SCIENCE AND GOVERNMENT

IN his address, "Science and Government", to the American Chemical Society at its meeting in Los Angeles on March 16, Dr. L. A. DuBridge suggested that there are three points of contact between government and science. First, the nature, form and operation of the government determine the political, economic and intellectual climate of a nation, and whether the resulting climate is favourable to science or not may be accidental. If science is to flourish, however, that climate must provide for intellectual freedom, progressive change and the recognition and encouragement of intellectual pursuits. Secondly, science and its technological applications produce changes in the way men live, requiring corresponding changes in the operations, and possibly even in the forms of government. Advances in technology are a major source of advances in human welfare. Thirdly, science and government come together most directly and intimately when science affects matters such as national defence, agriculture, industry, transport, navigation, conservation of natural resources, flood control and the weather, which are prime functions of government.

Following this, Dr. DuBridge reviewed the gradual growth in the United States of government interest in science, from the establishment of the U.S. Coast Survey in 1807 and the creation of the Smithsonian Institution in 1846, until in 1952 Federal Government expenditure on research and development in science and technology was about 1,250 million dollars, or more than 40 per cent of the country's total expenditure on research and development. More significant, however, than this increase in Federal expenditure on research, in Dr. DuBridge's opinion, is the increase in non-Federal research expenditure, from 143 million dollars in 1930 to 1,740 millions in 1952. Pointing out that it is almost impossible to distinguish rigidly between expenditure on military and non-military purposes, or even between research and development, Dr. DuBridge classified government activities according to five different management techniques commonly used: government agencies under civilian management; government agencies under military management; government-owned institutions managed privately under contract; contracts for research or development services; and contracts or grants in support of research, usually to colleges or universities.

Dr. DuBridge does not believe that the United States Government is at present getting full value from its vast expenditure on research and development. He thinks that expenditure under the fifth category—research grants—is the most fruitful and valuable. In 1952 this, however, only amounted to about 71 million dollars; and he urged that this should be substantially increased. He is concerned also that 87 per cent of these funds come from the Atomic Energy Commission and the Department of Defence, whereas, in place of the 15 million dollars requested for basic research by the National Science Foundation, the Foundation has only received 3·25 millions in 1952 and 4·75 millions this year. As regards contracts for research services, Dr. DuBridge repeated the warning frequently given by others, that universities and colleges should be chary of accepting too heavy a load of such sponsored research lest their programmes of basic research be endangered.

The opinion was expressed by Dr. DuBridge that the most successful device for development of new ideas, equipment or techniques for the military services is that of government research centres under private management, such as the Los Alamos Scientific Laboratory operated for the Atomic Energy Commission by the University of California. He believes it desirable that any new research facilities—and as many existing ones as possible—should come under the private management contracts rather than military direction. Apart from proving grounds and acceptance or inspection centres, research centres for new military weapons would be more efficient under civilian direction. It is necessary, moreover, not only to give more attention to planning weapon development expenditure but also to consider problems of grand national strategy against the background of recent scientific and technical developments. For this reason, he suggested the appointment of an outstanding scientist or engineer as scientific adviser to the Defence Department, who might also serve as chairman of the Research and Development Board. The chairman of the Atomic Energy Commission should, in his opinion, be a member of the National Security Council, and that Council should be provided with a science advisory council with a full-time chairman.

# U.S. NATIONAL SCIENCE FOUNDATION

## RESEARCH GRANTS

DURING the year ended June 30, 1952*, the National Science Foundation made ninety-six grants totalling 1,073,975 dollars for the support of basic research in the biological, medical, mathematical, physical and engineering sciences at fifty-nine institutions in the United States. Research proposals totalling 13·3 million dollars were received, of which 38 per cent were declined, withdrawn or represented reductions in budgets of approved proposals, and 54 per cent are pending. New proposals submitted in 1953 will exceed the 1952 figure, but the limited Foundation funds for research have discouraged many competent investigators from submitting proposals. Those submitted to date have been marked to an unusual extent by originality in concept, boldness in design and a desire on the part of scientists to explore important but relatively neglected fields. While there appear to be large untapped resources for research in the colleges, universities and other non-profit institutions in the United States, the Foundation has discovered many areas of great scientific interest needing additional support, and nearly 75 per cent of its financial grants went to institutions previously participating least in Federal research support. About 52 per cent of these financial grants was spent on direct assistance to graduate students and other research assistants. Of the sixty-eight grants, totalling 762,675 dollars, for biological and medical research, molecular biology claimed the most, particularly the physical chemistry of proteins and related substances found in living tissues. In this programme the work on photosynthesis is of special interest, and the Foundation, along with other agencies, is supporting photobiological research in various institutions. Much support has also been given to research on regulatory biology and to systematic biology.

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* Second Annual Report of the National Science Foundation, Fiscal Year 1952. Pp. viii+77. (Washington, D.C.: Govt. Print. Office, 1953.) 30 cents.

In the physical sciences, 29 grants, totalling 311,300 dollars, were awarded, and the report stresses the Foundation's obligation to support integrated attacks upon borderline and inter-disciplinary problems. In the engineering sciences, the Foundation's programme places its emphasis on such fields as fluid mechanics, strength of materials, heat transfer, corrosion, and thermodynamics, which are common to several branches of engineering, and it is also encouraging research designed to fill gaps in the basic information at present available to the engineer. Special attention is being given to projects bearing on the extension of the use of strategic materials, their replacement with new, hitherto unknown, materials and the better understanding of the conversion of energy. In the terrestrial sciences, the Foundation's programme is expected to embrace eventually more or less equally studies of the atmosphere, the waters, the surface, and the interior of the earth and their interrelations, and especially microphysical processes basic to the discovery and understanding of geophysical and geochemical principles.

Of the 624 graduate fellowships in the sciences awarded in April 1952 for the academic year 1952–53, 55 were made to post-doctoral applicants. Of the remainder, 169 went to those entering their first year of graduate study, 170 to second-year graduates and the remaining 230 to advanced pre-doctoral students. Biological sciences claimed 158 fellowships, chemistry 140, physics 137, engineering 75, mathematics 62, the terrestrial sciences 36, agriculture 7, astronomy 6 and anthropology 3. While this fellowship programme immediately affects the shortage of scientific men, the Foundation recognizes that the eventual correction of that shortage requires a long-range attack on defects in the educational, social and economic structure of the United States. At present the annual output of trained men of science in the United States is ten per cent or more below demand, and the 3,600 new doctorates in the sciences each year—rather less than 10 per cent of the output of graduates—is too low to meet the expanded current needs of technology; and the situation is expected to become more critical. Meanwhile, the operation of the present National Scientific Register, for which the Foundation assumed financial responsibility after the passage of the National Science Foundation Act of 1950, was to be discontinued after December 31, 1952, when the Register should have completed the initial registration and analysis of data on scientists trained in chemistry, chemical engineering, physics, psychology, agricultural and biological sciences, geosciences, and veterinary medicine. The Foundation has established an office to assist the professional scientific societies in compiling information on scientific workers in various fields on a uniform basis.

Its survey of publications has led the Foundation to believe that no continuing Federal support of scientific periodicals is desirable at present, though in critical cases temporary emergency support may be appropriate. The development of improved methods for compiling scientific information and for its rapid handling, economical storage, and efficient distribution is being followed, and the Foundation is also giving attention to the international exchange of scientific literature, particularly the availability of foreign scientific literature in the United States. A complete survey is being made of the present pattern of distribution and processing of Russian scientific literature in the United States.

# UGANDA FOREST DEPARTMENT

## ANNUAL REPORT FOR 1951

THE annual report of the Forest Department, Uganda, for 1951[*] gives full evidence that the Government of Uganda is intent on putting into force its declared forest policy. This is noteworthy, since during the present century (a forest policy was first laid down in India during the past century) such a policy has been enunciated for several forestry departments of the British Commonwealth and remained a dead letter. The general forest policy in Uganda comprises the maintenance of an adequate forest estate for protective and productive purposes, the management of the estate to fulfil those objects, the teaching to the people of the value of forests, and the encouragement of the practice of sound forestry by local authorities and private enterprise. To carry out these objects the forest officer requires the full support of the civil administration in the district and of the headquarters Government presided over by the Governor. That the Uganda Forest Department has the full support of the civil administration is evidenced by its present position in professional matters and the great strides that have been made in recent years.

To a considerable extent this progress must have been aided by the statement on "Land Policy of the Protectorate Government in Uganda", issued by the Government in 1950. This reaffirms that rural lands are being held in trust for the use and benefit of the African population; it further goes on to state that, while the Protectorate Government retains the forest rights, the Governor may, at his discretion and regard being had to the circumstances of each case, make an *ex gratia* payment to the African local government concerned of a portion of the income derived from Crown forest rights.

That good professional administration is possible under the present régime is shown by the progress made in the enumeration of the growing stock in the forests, the preparation of working plans and the striking sylvicultural investigations being undertaken by the research staff, the plantation work being carried out for both the people and for industrial use such as tobacco, etc. The great trouble being experienced is the want of labour, and some provisions of the working plans have had to be modified for this reason. Arrangements have been made, through longer leases of forests being granted, for improvement in milling and extraction. An important part of the work is connected with the conservation and protection of forests, especially in catchment areas of rivers and streams, and on the maintenance of this work so much of the future progress and prosperity of the people will depend.

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[*] Uganda Protectorate. Annual Report of the Forest Department for the Year ended 31st December 1951. Pp. iv+38. (Entebbe: Government Printer, 1952.) 2s.

The report was written by Mr. C. Swabey, the recently appointed conservator in Uganda, and Mr. Swabey has written a letter to me in which he takes exception to certain remarks I have made in the reviews of Uganda forest reports for 1949 and 1950 (see *Nature*, 168, 507 (1950) and 169, 1005 (1952)). In the 1949 report it was stated that local African governments were being encouraged to take over forestry work in areas where there was sufficient forest estates and that the district forest officer would act less and less in his official and trained capacity in those forests. In the report for 1950 it was stated that during the year the proposed devolution of the management of local forest areas was further developed. Past experience has shown time and again that, in the ultimate resort, the forest authority has no power to enforce regulations made by the civil authority. When the people become dissatisfied with the restrictions inevitable in good forest management, they commence to ignore them, with the result that friction arises which may easily go further. To avoid this in the past, the methods of forest management have had to be modified, at the instance of the civil authority. Improvements in the forest area and its usefulness may then disappear in a very short time. This will be the final test for a Department which, as the present report demonstrates, is making magnificent progress with the full support of the Governor and civil administration behind it.

E. P. Stebbing

# STRYCHNINE AS A DEPRESSANT OF PRIMARY INHIBITION

By K. BRADLEY and Prof. J. C. ECCLES, F.R.S.

Departments of Physiology, University of Otago, Dunedin, New Zealand, and the Australian National University, Canberra

THERE have been many investigations on the convulsive action of strychnine[1-7]; but it has hitherto not been possible to determine the essential nature of the action. For example, it would still be possible to hold that strychnine transforms inhibitory synaptic action into excitatory action, or alternatively that it merely intensifies excitatory synaptic action. No decisive experimental test has been possible because the testing reflexes have always been evoked by afferent volleys composed of admixtures of excitatory and inhibitory impulses. Even a pure group I afferent volley from a muscle nerve will exert, by virtue of its group I*a* and I*b* components respectively, excitatory and inhibitory actions on homonymous motoneurones and inhibitory and excitatory actions on antagonist motoneurones[8-10]. Perhaps the only significant evidence is that in subconvulsive doses strychnine has little or no effect on the monosynaptic reflex discharge, while there is a great increase in polysynaptic discharges[1,2,5,6]. Since the monosynaptic discharge evoked by group I*a* impulses would occur before the complicating disynaptic inhibitory effect of the group I*b* impulses[9], this evidence indicates that strychnine does not appreciably intensify the monosynaptic excitatory action of group I*a* impulses.

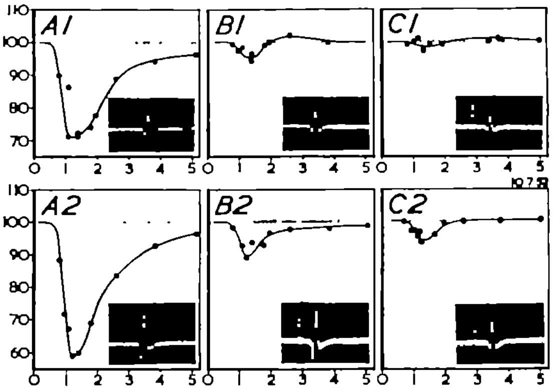

Fig. 1. Height of test reflex spike resulting from a single maximal afferent volley on biceps-semitendinosus nerve. Recorded from $S_1$ ventral root, and preceded at various intervals by an inhibitory volley in quadriceps nerve. Ordinates, heights of test reflexes as percentages of control height. Each point is mean of twenty observations as determined by method of superimposed tracings. Abscissae, interval in milliseconds between inhibitory and test afferent volleys as recorded by an electrode in contact with the $L_7$ dorsal root close to its entry into the spinal cord

The present communication is principally concerned with the effect produced by strychnine on the direct inhibitory action which group I*a* impulses in the quadriceps nerve exert on the antagonist biceps-semitendinosus motoneurones. The initial requirement of this investigation was to distinguish between group I*a* and I*b* impulses in the afferent volley. In some, but not all, low spinal cat preparations under nembutal anaesthesia, a group I afferent volley set up in the quadriceps or biceps-semitendinosus nerves gives a double spike potential when it is recorded triphasically by a surface lead from a dorsal root as it is about to enter the spinal cord (cf. Fig. 3 and the lowest two inset records of Fig. 2). The second spike has a higher threshold than the first, and often it is possible to have the first spike more than half maximal with no detectable contamination by the second, as is shown in Fig. 3, in which the first stimulus was varied in strength from just above group I*a* threshold to about three times this strength, while the second stimulus was about three times

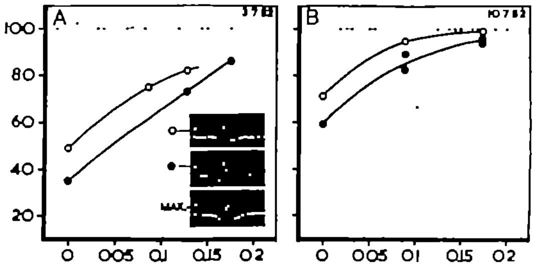

Fig. 2. Plots of test reflexes taken at the interval after the inhibitory afferent volley giving maximal effect (cf. Fig. 1), and expressed as percentages of control test reflexes (ordinates) against dosage of strychnine (mgm./kgm. body-weight: abscissae) in two experiments. In each experiment two sizes of inhibitory volley have been used. In graph *A*, the smaller inhibitory volley (open circles) contained little, and the larger (filled circles) considerable group I*b* contribution (see in inset dorsal root spikes for corresponding symbols). In graph *B* the two inhibitory volleys are those used in Fig. 1

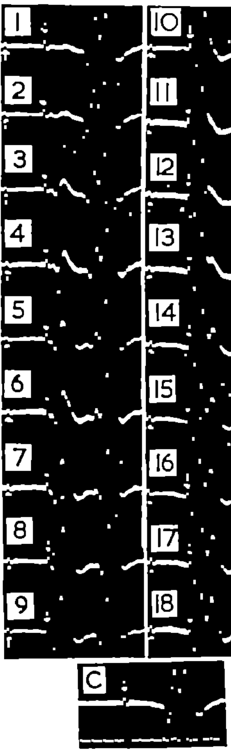

Fig. 3. Triphasic records of two group I afferent volleys from quadriceps nerve and recorded by a surface electrode on $L_6$ dorsal root close to its entry into the cord. Each record is formed by superposition of twenty faint traces in order to minimize random noise *C* gives control response to second stimulus alone with two spikes (I*a* and I*b*) 0·17 m sec. apart

threshold and 0·68 m.sec. later, so that it failed to excite any fibres that were excited and made refractory by the first. In records 7 and 8 there is virtually no group I*a* spike in the second response, that is, the first stimulus excited almost all I*a* fibres and yet virtually no I*b* fibres. Appreciable I*b* excitation only occurs from record 9 onwards. In this way it has been shown that the afferent impulses represented by the earlier spike cause monosynaptic excitation of homonymous and inhibition of antagonist motoneurones, whereas impulses of the second spike have no detectable monosynaptic action, that is, the first and second spikes are identifiable as group I*a* and I*b* respectively.

Fig. 1 (*A*1) shows the time course of the inhibitory effect of a group of I*a* afferent volley with no significant contamination by group I*b*. A subconvulsive dose of strychnine (0·09 mgm./kgm.) diminishes and shortens the inhibition (*B*1) and a further dose (0·08 mgm./kgm.) virtually abolishes the inhibition (*C*1). In *A*2, *B*2, *C*2 the quadriceps afferent volley is larger but still contains few, if any, fibres of group I*b*. The control inhibitory curve resembles that of *A*1, but the inhibition is larger, corresponding to the larger size of the group I*a* volley. There is likewise a corresponding diminution of the inhibition by the two doses of strychnine. Note that this diminution is much larger than the relatively small decrease in the dorsal root volley.

The effect of strychnine in diminishing the direct inhibitory action of group I*a* afferent impulses has been observed in all our experiments (eleven in all). Typical dose-response curves are shown in Fig. 2. Strychnine has also been observed to depress the polysynaptic inhibitory effect of cutaneous afferent volleys. Thus strychnine would seem to have a specific depressant action on synaptic inhibition, for this action is observed with doses which have no significant action on synaptic excitation as tested by the monosynaptic reflex.

Two alternative explanations of this specific action may be suggested: that strychnine acts competitively to reduce the bonding of an inhibitory transmitter substance with the subsynaptic membrane, much as curare is believed to depress the action of acetylcholine at neuro-muscular junctions and ganglionic synapses; or that strychnine interferes with the inhibitory action further downstream, for example, by depressing the hyperpolarizing action of the postulated inhibitory transmitter substance[11,12].

Finally, this specific effect of strychnine gives rise to the question: How far is it possible to explain its convulsive activity solely by its depressant action on inhibition? At least it is the simplest initial postulate that depression of the inhibitory synaptic action on interneurones causes the great apparent increase in polysynaptic excitatory action[1,6] which is so characteristic a feature of the strychninized nervous system. [Sept. 24.

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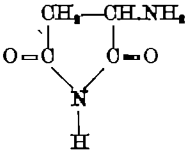
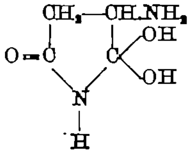
# STRUCTURE OF ASPARAGINE

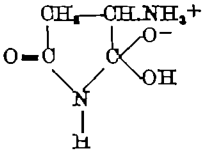
STEWARD AND THOMPSON have recently discussed the properties of glutamine and asparagine and proposed a new cyclic structure for asparagine[1].



(1)



(2)



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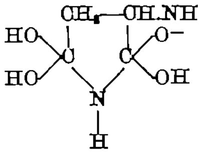
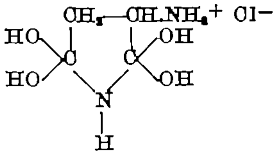


(4)



(5)

In the accompanying formulæ, (1) represents the (hypothetical) parent structure used by Steward and Thompson, amino-succinimide. (2) and (3) represent the uncharged and zwitterionic forms of anhydrous asparagine respectively, whereas (4) is their formulation of the monohydrate. The authors apparently consider asparagine in solution as a tautomeric system in which the cyclic form is in equilibrium with the conventional straight chain, but with the former very much preponderating.

It seems to us that there are many difficulties associated with this view. Since Steward and Thompson regard the straight-chain formulation as correct for glutamine, their arguments based on different chemical properties of asparagine and glutamine lose force in view of the postulated tautomerism of asparagine. An equilibrium of this type could explain additional properties of asparagine and slower rates of reaction through the straight-chain form compared with non-tautomeric amides. It could not, however, explain the complete failure of nitrous acid to react with the asparagine amide group, since other reactions of the straight-chain form (for example, with acid, alkali or ninhydrin) take place at a measurable rate. Furthermore, many of the arguments advanced by Steward and Thompson in favour of a cyclic structure for asparagine apply with equal force to *iso*-asparagine, which also exists in the form of a hydrate. However, the analogous structure for *iso*-asparagine hydrochloride would be formula (5), which also represents asparagine hydrochloride. The two substances should therefore be interconvertible in solution, whereas they are, in fact, quite distinct chemically.

Our view is that the straight-chain formulation, possibly modified by hydrogen bonding, adequately represents the structure of asparagine, and that most of the differences in behaviour between asparagine and glutamine represent anomalies in the behaviour of glutamine rather than asparagine. Thus it is definitely glutamine which is anomalous in its behaviour towards nitrous acid, since its amide group reacts very readily. Other amide groups do not normally react with nitrous acid under the conditions of the van Slyke estimation, but require prolonged reaction in the presence of mineral acid[2]. Moreover, in proteins where, as Steward and Thompson admit, only the straight-chain formulation is possible for the combined asparagine, it is known that amide groups react with nitrous acid only very slowly if at all, even in the presence of mineral acid[3]. In its ease of hydrolysis to liberate ammonia, glutamine has been described as a "unique amide"[4], whereas investigations we have just completed show that the rate of hydrolysis of asparagine by acids is similar to that of acetamide under comparable conditions and gives normal values for the energy and entropy of activation. It should also be noted that substitution of the amino group of glutamine, as, for example, in leucylglutamine, slows down the rate of hydrolysis of the amide group to a rate of the same order as that of asparagine[5] and also causes the amide group to become unreactive towards nitrous acid[6]. On the other hand, it is of interest that N-methylation of the amide group of glutamine does not affect the reaction with nitrous acid[7], and in glutathione, a γ-glutamyl peptide, this reagent also reacts with some of the peptide nitrogen[8].

More conclusive evidence against the cyclic structure of asparagine has emerged from our kinetic studies on the rate of hydrolysis of the amide group of asparagine peptides. Inspection of Steward and Thompson's cyclic structure shows that it cannot be maintained for peptides of the type asparaginylglycine, whereas glycyl- or leucyl-asparagine could still possess a cyclic structure. If the hypothesis of ring structure is correct, therefore, one could expect similarities of behaviour between the amide groups of asparagine and peptides of the glycylasparagine type, but contrasting behaviour from peptides of the asparaginylglycine type. Kinetic data on the acid hydrolysis of the amide group show the converse of this relationship. The hydrolysis of the amide group of L-asparagine and L-asparaginylglycine by acid are both second-order reactions, being first order in amide and hydrogen ion. Moreover, the rates of both reactions are similar, and derived thermodynamic data are reasonably comparable for both compounds. Glycyl- and L-leucyl-L-asparagine, however, both show behaviour contrasting sharply with that of asparagine on acid hydrolysis. For these peptides the reaction is first order only in the molecular species of the type glycylasparagine hydrochloride, and the rate of hydrolysis is independent of hydrogen ion concentration at *p*H values where this ionic form preponderates. Under comparable conditions the amide groups of these peptides hydrolyse much more rapidly than those of asparagine and asparaginylglycine, the greater rate being due to a more positive entropy of activation.

Full data on these kinetic experiments will be published shortly.

January 6. Since submitting this communication, we have read the letter by Katz *et al.*[9] on the three-dimensional X-ray analysis of the structure of glycyl-L-asparagine crystals. This provides additional direct evidence against the cyclic structure proposed for asparagine by Steward and Thompson.

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Wool Textile Research Laboratory,
Commonwealth Scientific and
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Melbourne.
Jan. 5.

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THROUGH the courtesy of Drs. Leach and Lindley, we have seen their communication on the structure of asparagine, prior to its publication. This and numerous other comments that we have received testify to the interest which our article[1] aroused. In that sense, part of our purpose was achieved, since we wished to direct attention to the problem. Other recent and relevant communications are those of Katz, Pasternak and Corey[2] and of Cochran and Penfold[3], and a paper by Davies and Evans sent to us prior to its submission to the Chemical Society in London.

These communications may be summarized as follows.

(1) In the form of its peptides and even in certain cases where asparagine occupies a terminal position, the evidence of crystal structure is consistent with the combined asparagine existing in the conventional open-chain form[2].

(2) Cochran and Penfold[3] have published their evidence, referred to by us as communicated privately

from Dr. Pepinski, which shows crystalline glutamine has the open-chain form.

(3) Davies and Evans[4] have re-examined the infra-red absorption spectra of asparagine and glutamine and, as a result of this, they prefer the alternative structure for asparagine which was suggested to us by Dr. M. L. Huggins.

(4) Leach and Lindley refer again to the general problem, and from evidence derived from the rates of hydrolysis of peptides they now question whether there is any major structural difference between asparaginyl-glycine and glycyl-asparagine. Since the latter could contain asparagine in the ring form, this is interpreted by Leach and Lindley to mean that the ring form of asparagine does not exist.

(5) Leach and Lindley also state that their evidence indicates that asparagine is decomposed by acid at a rate more comparable to that of acetamide than to that of glutamine.

It should be recognized that we were concerned to explain certain stated differences in both chemical and physiological properties of *free* asparagine and glutamine in solution. It is of interest, as indeed we suggested, if these differences extend to situations in which the asparagine and glutamine are present in the form of their compounds. On the other hand, the fact that the compounds of glutamine and asparagine, or even their crystals, do not exist in the stipulated form does not necessarily disprove the postulated structure for free asparagine. We are still left with the problem of explaining the marked differences between these two compounds as they occur in the *free* state and in solution.

Leach and Lindley refer to the fact that *iso*-asparagine exists and that this compound also might occur in a cyclic form. Of this we were well aware; but since we had no data on which to base comparison of the relevant properties of *iso*-asparagine and asparagine, it did not seem helpful to refer to this interesting compound, which does not apparently occur in Nature. So far as we can tell, Leach and Lindley have not compared *iso*-asparagine with asparagine and/or glutamine. Until this is done, any speculations on *iso*-asparagine are scarcely relevant. It is true that in the ring form *iso*-asparagine and asparagine would not be distinguishable; but the position of the amino group may greatly affect the relative stability of the respective open-chain forms compared with the supposed ring. Since *iso*-asparagine seems to react blue with ninhydrin under the conditions in which asparagine reacts brown, it would seem to resemble glutamine more than asparagine in this respect.

With respect to the contrasted behaviour of asparagine and glutamine to nitrous acid, the definitive thing is that in the one compound (glutamine) both nitrogen groups react, whereas in the other (asparagine) only the amino group reacts. Leach and Lindley have in no way explained this difference. It still seems reasonable to us that, if the ring form exists, the equilibrium might be far in this direction and, this being so, and in the absence of special evidence to the contrary, this could be consistent with the virtual failure of nitrous acid to react with the amide group.

Leach and Lindley re-discuss the decomposition of the amides, asparagine and glutamine. They treat this as though hydrolysis alone were involved. It is, however, evident that on one hand (asparagine), hydrolysis and, on the other (glutamine), cyclization by loss of ammonia may be involved. This complicates comparisons with other amides. When the glutamine is substituted in the amide group, this precludes cyclization by loss of ammonia, and therefore the decomposition of such compounds by acid should resemble that of asparagine more than that of free glutamine. While we again recognize that this problem is a difficult one to resolve conclusively, we also believe that the arguments of Leach and Lindley have not yet led to finality.

The evidence of infra-red absorption spectra, as it was available to us through Dr. Gore, seemed to indicate a difference of structure between crystalline glutamine and asparagine. It is this evidence which Davies and Evans[4] now call in question from their re-examination; but they make significant reference to the fact that the spectrum of crystalline asparagine is somewhat variable from sample to sample in certain of the critical regions. A re-examination of an anhydrous specimen of asparagine, as carried out for us by Dr. Gore, still indicates a difference in absorption between asparagine and glutamine in the general region of 1,420 cm.$^{-1}$. We now recognize that the absorption of asparagine at 1,530 cm.$^{-1}$, which is still evident, should not be described as 'strong' (ref. 1), though it is not present in glutamine and we believe is not due to water as Davies and Evans suggest.

However, the cumulative evidence to which we referred[1], together with the new evidence which we were able to derive by the use of the ninhydrin reagent as applied to asparagine containing carbon-14, still seems to us to be in favour of a ring configuration for free asparagine as it exists in solution.

Although all these papers are of interest, they are scarcely conclusive. As we said earlier, the determination of the structure of asparagine by X-ray methods could be unequivocal for crystalline asparagine, whereas a synthesis of amino succinimide would also be conclusive according as it proved to be, when hydrated, identical or different from asparagine.

*Note added in proof.* Evidence bearing on the properties of asparagine and glutamine also comes through the work of Meister[5] on their α-keto acid analogues. Asparagine yields two separable keto compounds (*A* and *B*). One of these (*B*) readily gives a 2-4 dinitrophenyl hydrazone, readily decarboxylates and has an ultra-violet spectrum similar to that of a β-keto acid (cf. oxaloacetic). The other (*A*) does not give a phenylhydrazone, lacks the ultra-violet absorption and decarboxylates with more difficulty: this compound may be either cyclic or a polymer. Glutamine may also yield two keto analogues, though only one (*A*) has been isolated (as its barium salt) free from the other (*B*). Compound *A* gives a phenyl hydrazone; the amide group is easily hydrolysed giving α-keto glutaric acid. Compound *B*, which is less stable, has not yet been isolated. The further outcome of this work will be awaited with considerable interest.

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# LETTERS TO THE EDITORS

*The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications*

## Incorporation of 8-Azaguanine into Nucleic Acid of Tobacco Mosaic Virus

THE guanine analogue, 5 amino-7-hydroxy-1-v-triazolo(*d*) pyrimidine (guanazolo; 8-azaguanine), delays or inhibits the development of infection in the case of several plant virus diseases[1]. The activity of the compound is reversed by adenine, guanine and probably hypoxanthine, but not by several other naturally occurring purines. On current views of the action of antimetabolites, these facts would suggest that 8-azaguanine acts by blocking an enzyme system involved in the utilization of guanine and perhaps adenine by the virus. There is, however, the possibility that 8-azaguanine is sufficiently like guanine to be incorporated into the virus nucleic acid, replacing some of the guanine, but different enough to make a virus particle containing it incapable of further multiplication. With tobacco mosaic virus in inoculated tobacco leaves, 8-azaguanine causes a delay in the production of virus (measured by infectivity, by particle counts using electron microscopy, or by yield of extractable virus[2]). The results described here show that 8-azaguanine is incorporated into the nucleic acid of tobacco mosaic virus.

Tobacco plants, inoculated with a highly infective preparation of a 'type' strain of tobacco mosaic virus, were sprayed twice weekly, on all leaves, with 0·01 *M* 8-azaguanine in 0·1 per cent sodium bicarbonate, commencing the day after inoculation. Batches of treated and untreated plants were harvested at various times between three and thirty days after inoculation. Preparations of tobacco mosaic virus were obtained by the usual ammonium sulphate precipitation procedure. The method for isolation of virus nucleic acid and the analytical procedures used were those of Markham and Smith[3]. The method of printing chromatograms by the fluorescence of the spots[4] has proved particularly useful, since 8-azaguanine fluoresces strongly under both acid and alkaline conditions, while guanine compounds fluoresce strongly under acid conditions only. In addition, with 8-azaguanine the fluorescence method is about ten times as sensitive as printing by absorption. About 0·3 μgm. of 8-azaguanine can be detected on No. 1 Whatman paper printing on Grade 1 bromide paper.

On analysis, the virus nucleic acid from treated plants was found to contain less guanine (by approximately 3·5 per cent) than that from untreated plants. This deficiency was accounted for entirely (within the limits of experimental error) by an increase in adenine (Table 1). In the *iso*propanol–hydrochloric acid solvent used, 8-azaguanine would run with and be estimated as adenine.

Table 1. MOLAR RATIOS OF BASES IN NUCLEIC ACID OF TOBACCO MOSAIC VIRUS FROM CONTROL AND 8-AZAGUANINE-TREATED PLANTS

| Base | Molar ratios (means of 7 determinations) | | Difference control-treated | Difference required for significance at 0·01 *P* |
|---|---|---|---|---|
| | Control | 8-Azaguanine treated | | |
| Guanine | 0·979 | 0·943 | − 0·036 | 0·024 |
| Adenine | 1·103 | 1·134 | + 0·031 | 0·031 |
| Cytosine | 0·817 | 0·815 | − 0·002 | 0·021 |
| Uracil | 1·101 | 1·110 | + 0·009 | 0·058 |

When acid-hydrolysed nucleic acid (*N* hydrochloric acid, 1 hr., 100° C.) was run on two-dimensional chromatograms (first solvent: *iso*propanol–hydrochloric acid; second solvent: *iso*propanol–ammonia) an additional small fluorescent spot was present behind adenine in the second solvent system in the hydrolysate from treated virus, in the position expected for 8-azaguanine. The fluorescent material isolated by this procedure had an electrophoretic mobility on filter paper in borate buffer at *p*H 9 corresponding to that of 8-azaguanine.

In attempting to isolate 8-azaguanylic acid from alkaline hydrolysates of nucleic acid, advantage was taken of the fact (determined by paper electrophoresis) that the *pK*'s of the hydroxyl and amino groups in the triazolopyrimidines are lower than those for the corresponding purines. In the case of 8-azaguanine, the *pK* of the hydroxyl group is about 3 *p*H units lower than that of guanine. When nucleic acid from virus from 8-azaguanine-treated plants was hydrolysed with 1 *N* sodium hydroxide (at room temperature for 24 hr.) and subjected to electrophoresis on filter paper in borate buffer at *p*H 9, a fluorescent band was found, running in a positive direction slightly ahead of uridylic acid, the fastest-moving of the naturally occurring nucleotides at this *p*H. This band, which was absent in control preparations, moved about 1·4 times as fast as 8-azaguanine—approximately the mobility to be expected for 8-azaguanylic acid. This procedure was used to isolate the fluorescent compound free from other absorbing material except traces of uridylic acid. This was removed by chromatography in *iso*propanol–ammonia. Table 2 gives the approximate $R_F$ values of the fluorescent material and other compounds in two solvent systems.

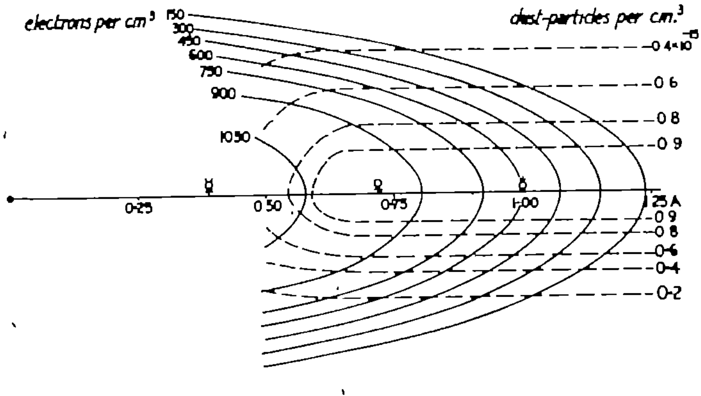
Table 2

| Compound | Approximate $R_F$ in . | | |
|---|---|---|---|
| | *Iso*propanol–ammonia | Ammonium sulphate–water | |
| Guanine | 0·33 | | 0·16 |
| Guanylic acid | 0·08 | *a* | 0·33 |
| | | *b* | 0·42 |
| 8-Azaguanine | 0·27 | | 0·17 |
| 8-Azaguanylic acid | 0·05 | *a* | 0·33 |
| | | *b* | 0·40 |

In the ammonium sulphate solvent, the fluorescent material divided into two spots running in the expected positions for 8-azaguanylic acids *a* and *b*. This is strong evidence for the production of 8-azaguanylic acid from polynucleotides through the cyclic phosphate[5].

The fluorescent compound contains phosphorus and had a base / phosphorus ratio of 1·4 / 1·0 (on one determination on only 0·5 μgm. of phosphorus). From the above we conclude that the fluorescent compound in alkaline hydrolysates is 8-azaguanylic acid, and that therefore 8-azaguanine is incorporated into the nucleic acid of tobacco mosaic virus. In two previous claims for the incorporation of 8-azaguanine into nucleic acids[6], since the material was isolated only as 8-azaguanine, the possibility that it was present as a contamination in the nucleic acid preparations was not eliminated.

In view of the large errors in infectivity measurements, it may be very difficult to prove whether, in fact, 8-azaguanine incorporated into the nucleic acid renders a virus particle 'sterile'.



Lines of equal density for electrons and dust particles in the planetary system in a plane perpendicular to the ecliptic. Position of sun and inner planets marked by their symbols

The incorporation of 8-azaguanine suggests more directly than did reversal experiments that at least some plant viruses can utilize free guanine for synthesis.

In young pea embryos, most of the 8-azaguanine absorbed is fairly rapidly deaminated to give 8-azaxanthine, a compound which is inactive against all plant viruses that have been tested. If this deamination occurs in leaves of more mature plants, then most of the 8-azaguanine is rendered inactive. It would be in accordance with much recent evidence[4] suggesting the primary role of nucleic acids in virus infectivity to assume that 8-azaguanine has its effect through being incorporated into the nucleic acid and thus rendering the particle 'sterile'. If these assumptions be correct, it may prove profitable to search for a compound that will not be subject to deamination and that will lead to an increased incorporation of 8-azaguanine into the virus nucleic acid. From work on the biosynthesis of the natural purines into ribonucleic acids in other systems[7], two compounds that may have these properties in some degree are 8-azaguanylic acid itself (particularly the *b*-isomer) and the triazole equivalent of 4-amino-5-imidazole carboxamide.

I wish to thank Mr. P. R. Fry for some of the tobacco mosaic virus preparations, and Dr. Roy Markham for much useful discussion. This work was carried out while I was on leave from the Plant Diseases Division, Auckland, New Zealand.

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## Photoelectric Observations of the Zodiacal Light

It has been generally accepted that the zodiacal light comes from the scattering of solar light by dust-particles in the planetary system, which are concentrated towards the earth's orbital plane. On the other hand, it is known that the sun emits continuously a variable number of charged particles, principally protons and electrons. The possibility that the free electrons give some part of the luminosity of the zodiacal light has been discussed by F. L. Whipple and J. L. Gossner[1], who derived maximum values of the possible electron densities in the space between sun and earth. For the following discussion of the density of electrons and dust particles in the planetary system we use the results of photoelectric registrations of brightness and polarization in the zodiacal light with a 1 *P* 21-multiplier. These were obtained during February/March and October 1952 and in the recent winter at the Hochalpine Forschungsstation Jungfraujoch (altitude 3,600 m.). Details of the apparatus and the observing and reduction methods are given in a paper by A. Behr and H. Siedentopf[2].

The spatial densities of electrons and dust particles were derived from the observed values of brightness and polarization on the assumption that the polarized part arises only from the scattering by free electrons, whereas the dust-particles give no appreciable polarization. This supposition can be justified by the Mie theory of scattering by small particles. Since for dust particles with radii less than $10^{-4}$ cm. the radiation pressure of the sun is greater than the gravitational attraction, the main effect comes from particles with radii about $10^{-5}$ cm. (the number of particles per unit volume $n(r)$ decreases with radius $r$ nearly as $n(r) \sim r^{-3.5}$). For a mixture of particles with different radii it can be shown[3] that, for the angles of scattering encountered, there results no appreciable amount of polarization. Only if the particles are of oblong shape and if their axes are aligned, for example, by an interplanetary magnetic field, might a certain amount of polarization by the particles be possible. If this should be really the case, the number of electrons given in the accompanying diagram must be considered as an upper limit.

The diagram shows the mean distribution of electrons and dust particles as derived by solving numerically the integral equations connecting the brightness and polarization at the sphere with the density of electrons and particles in space. Whereas the observed polarization, and therefore the electron distribution, is symmetrical about the ecliptic, there is a distinct asymmetry in the distribution of brightness, also found by other observers. This asymmetry can be represented by a steeper decrease of particle numbers on the southern side of the ecliptic than on the northern side. We are not yet sure of the amount of this asymmetry, since the elimination of the ground brightness on the northern side of the evening zodiacal light is difficult because of the neighbourhood of the Milky Way and the increase of the air-glow towards the northern horizon. The numbers of dust particles given for the southern side of the ecliptic are therefore more reliable.

The resulting electron-density of about 600 per cm.$^{-3}$ near the earth's orbit gives a gas-density of about $10^{-21}$ gm.cm.$^{-3}$, since for electrostatic equilibrium one proton or other positive ion is necessary for each electron. The density of the dust—$10^{-15}$ particles cm.$^{-3}$—comes out to about $10^{-23}$ gm.cm.$^{-3}$ near the earth, or only a hundredth of the density of the gas. The decrease of density of dust towards the sun as shown in the diagram may be the result of evaporation of dust particles near the sun, as is similarly found in the nuclei of comets.

The brightness of the light-bridge connecting the morning and the evening zodiacal light is correctly represented by the above dust density (the contribution of the electrons to the light-bridge is small since their number decreases rapidly outwards). The luminosity near the counterpoint of the sun, the so-called counterglow (*Gegenschein*) with a diameter of about 20°, is 30 per cent higher than in the light-bridge. If the counterglow is explained as the result of a cloud of dust-particles near the outer libration-point in the system sun–earth[4], this cloud is situated at a distance of 0·01 astronomical units from the earth and has a density about thirty times higher than the mean density of dust near the earth's orbit.

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## Action of Cortisone on the Polymerization of Actin

In adrenalectomized animals maintained on an adequate diet, the work capacity of skeletal muscle, as shown by the response to prolonged repetitive stimulation, is greatly diminished[1]. This effect is apparently not due to a direct failure of energy supply as could be expected from hypoglycaemia, but to an alteration in the metabolic or contractile system of the cell.

It has been shown by Horvath *et al.*[2] that the cardiac glycosides enhance the polymerization of actin prepared from cardiac muscle but do not affect actin from skeletal muscle. These observations have been confirmed in this laboratory, and the possibility that cortisone might act in a similar manner on skeletal muscle actin alone has been investigated.

Actin was prepared from skeletal muscle of the dog by the method of Straub *et al.*[3]. Solutions obtained by the extraction of 1 gm. of dry powdered muscle residue with 20 ml. of carbon dioxide-free distilled water had an actin content of 5–6 mgm./ml. Polymerization was followed by viscometry measurements at 10° C. using the Ostwald viscometer.

Our results show that cortisone in a concentration of 25 μgm./ml. added as a solution in propylene glycol increased the rate of polymerization twofold compared with a control preparation containing the solvent alone and of identical ionic constitution. This effect is apparent throughout the range of concentration of cortisone 0·25–50 μgm./ml. The polymerization was carried out at the physiological ratio of potassium to calcium (potassium, 0·054 *M*; calcium, 0·001 *M*) with a trace of magnesium (0·0005 *M*) and in the presence of veronal-acetate buffer of *p*H 7·4. All salts were present as chlorides.

Under identical conditions, actin prepared from the cardiac muscle of the dog showed no alteration in polymerization-rate when cortisone was present in a concentration of 25 μgm./ml.

The globular to fibrous transformation of actin effected by ions *in vitro* is an extreme case of small changes occurring in the actin particles in the intact cell and gives a good indication of these reactions. It would seem that steroid substances have a role in the regulation of contractile force through an influence on actin particles.

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## Serum as a Source of Growth-factors for *Trichomonas fœtus*

Cailleau[1] concluded that cholesterol, ascorbic acid and a third unidentified factor were essential for growth of *Trichomonas fœtus*. Ascorbic acid, however, may only have been required because of its reducing properties[2]. The object of the present study was to investigate the nature of the factors in serum required by *T. fœtus* when grown in bacteria-free culture.

Stock cultures of the organisms were grown in 2 per cent glucose-broth over an inspissated serum slope, the medium being covered with a layer of liquid paraffin. Experimental cultures were grown in broth containing 2 per cent glucose and 7 per cent liquid horse serum. The inoculum gave an initial count of 200,000 organisms per ml. Without serum no significant multiplication took place; but when present in the medium a population of up to ten millions per ml. was obtained.

Preliminary investigations led to the preparation of a water-soluble extract of inspissated serum which would support growth when added to glucose broth. It was prepared by steaming together for 45 min. equal volumes of inspissated serum and distilled water. The final *p*H was 8. After steaming, the extract was cleared in a Seitz filter and then freeze-dried. The extract could be dialysed without loss of activity. When added to 2 per cent glucose-broth to give a concentration of approximately 0·15 per cent in terms of its protein content, optimum growth was obtained which could be serially subcultured. The extract contained a considerable amount of protein which could be precipitated by trichloracetic acid or by heating at *p*H 5.

The following analyses on a sample of the freeze-dried extract were kindly carried out by Dr. Winifred Watkins, who reported the material to contain total nitrogen, 10·5 per cent; total phosphorus, 0·6 per cent; inorganic phosphorus, 0·005 per cent; reduction and hexosamine (after hydrolysis for 8 hr. at 100° with 0·5 *N* hydrochloric acid), 4·6 per cent and 2·4 per cent respectively. The substance gave a positive biuret and Liebermann–Burchard (cholesterol) reaction.

The method of preparation suggested that the extract might contain seromucoid, and the results of the analysis support this possibility. The total carbohydrate content is 4·6 per cent compared with a content of 10·7 per cent in seromucoid; but the ratio of hexose to hexosamine is approximately the same as that recorded for seromucoid³. The low carbohydrate value may be due to the amount of precipitable protein present.

The growth-promoting activity of the serum extract was not due solely to its cholesterol content, since by itself cholesterol would not support growth.

The essential components of serum for *T. foetus* have thus been shown to be water-soluble, non-dialysable and stable to heating at *p*H 8. It is considered possible that one of the factors required may be seromucoid. The work is being continued, and it is hoped to elucidate further the nature of the growth-factors required by this organism.

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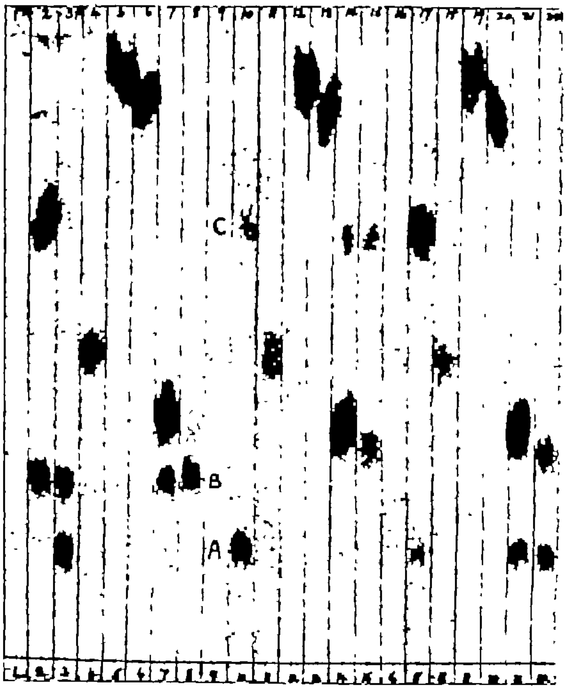
## A New Transamination Reaction

THE isolation of γ-methylene-glutamine and γ-methylene-glutamic acid from groundnut plants has been described¹. More recent studies, in which an attempt has been made to obtain information regarding the metabolism of the compounds, have indicated that transamination processes may be largely responsible for the breakdown of the γ-methylene-glutamic acid in groundnut plants.

The first experiments were of a qualitative nature only. Seeds germinated for four days at 25° in the dark were ground with half their fresh weight of *M*/5, *p*H 7·4, phosphate buffer solution and a little acid-washed sand until a smooth paste was obtained. The paste was squeezed through fine muslin and the filtrate centrifuged for 5 min. at 3,000 r.p.m. to remove finely divided debris. The supernatant was then enclosed in a collodion bag and dialysed against a stream of *M*/5, *p*H 7·4, phosphate buffer for 24 hr. at 3° in order to remove most of the free amino-acids found in the original extract. After dialysis the extract was used directly in the transamination experiments to be described.

The efficiency with which the α-amino-group of γ-methylene-glutamic acid was transaminated to three α-keto-acids (α-keto-glutaric, pyruvic and oxalacetic acids) was compared with that of certain other *l*-amino-acids previously found to participate in transamination systems in plant materials². The reaction mixtures consisted of one volume of *M*/35 α-keto-acid solution (titrated to *p*H 7·4), one volume of *M*/35 *l*-amino-acid solution and two volumes of the extract. The amino-acids used were *l*-aspartic acid, *dl*-alanine, *l*-valine, *dl*-leucine, glycine and γ-methylene-glutamic acid (concluded to be the *l*-form from unpublished experiments). Synthetic γ-methyl-glutamic acid (presumably a *dl*-form) was also used. Transamination was allowed to proceed for 4 hr. at 38°, and then the enzymes were inactivated by the addition of absolute alcohol to a final concentration of 70 per cent followed by warming. After the precipitated proteins had settled, aliquots of the supernatants from each reaction mixture were applied as spots to a chromatogram later developed in the usual manner for 24 hr. in phenol – ammonia. The relative amount of the products of the transaminations (glutamic acid, alanine and aspartic acid) can be estimated approximately from the sizes and intensities of the ninhydrin-developed spots on the chromatogram. The photograph of the chromatogram produced here shows that when α-keto-glutarate was used, the maximum and approximately equal amounts of glutamic acid were produced from γ-methylene-glutamic and γ-methyl-glutamic acids, alanine and aspartic acid. When pyruvate or oxalacetate was used, the maximum amounts of alanine or aspartic acid appeared to be produced when γ-methylene-glutamic and γ-methyl-glutamic acids were employed. The reactions between α-keto-glutarate and the three amino-acids, alanine, aspartic acid and natural γ-methylene-glutamic acid, when studied at intervals of 0·5 *p*H units between 5·0 and 8·5, all had *p*H optima of about 7.



Chromatogram prepared from 100 µl. amount of the following reaction mixtures. Nos. 1–8 contained 2 parts of extract, 1 part of *M*/35 α-keto-glutarate and 1 part of *M*/35 *l*-amino-acid as (1) water, (2) alanine, (3) aspartic acid, (4) glycine, (5) leucine, (6) valine, (7) γ-methyl-glutamic acid, (8) γ-methylene-glutamic acid. Nos. 9–15 contained 2 parts of extract, 1 part of *M*/35 pyruvate and 1 part of *M*/35 *l*-amino-acid as (9) water, (10) aspartic acid, (11) glycine, (12) leucine, (13) valine, (14) γ-methyl-glutamic acid, (15) γ-methylene-glutamic acid. Nos. 16–22 contained 2 parts of extract, 1 part of *M*/35 oxalacetate and 1 part of *M*/35 *l*-amino-acid as (16) water, (17) alanine, (18) glycine, (19) leucine, (20) valine, (21) γ-methyl-glutamic acid, (22) γ-methylene-glutamic acid. Spots found at level *A* are aspartic acid, at level *B* are glutamic acid, and at level *C* are alanine

The experiments in which α-keto-glutarate was used were repeated, the glutamic acid produced being determined quantitatively after separation from the other amino-acids on chromatograms developed for 40 hr. in phenol – ammonia³. Similar experiments were performed in which the seed extract was replaced by an equal volume of an extract prepared

| | Per cent of the α-keto-glutarate converted to glutamic acid | |
|---|---|---|
| | Leaf extract | Seed extract |
| Alanine | 10·4 | 38 9 |
| Aspartic acid | 17·2 | 37·7 |
| γ-Methylene-glutamic acid | 8 8 | 56·5 |
| γ-Methyl-glutamic acid | 9·1 | 55 5 |
| Leucine | 4·0 | 9·6 |
| Glycine | 0·8 | 2·2 |
| Valine | 1·4 | 2·0 |

The leaf extract contained 0·49 mgm. total nitrogen per ml.; the seed extract contained 7·9 mgm. total nitrogen per ml.

in the same manner from the leaves of 20-day old plants. The percentages of α-keto-glutarate converted to glutamic acid in the presence of various amino-acids are given in the accompanying table.

The larger amounts of glutamic acid formed in the presence of the seed extract are probably only an indication that it contains higher concentrations of enzymes than those present in the leaf extract. The total nitrogen contents of the extracts give support to this idea. The transaminase system responsible for the conversion of the naturally occurring γ-methylene-glutamic acid is presumably also acting on the non-natural γ-methyl-glutamic acid, and since the rates of transamination are not significantly different for the two compounds, the affinity of the enzyme for the two substrates would appear to be unaffected by the differences in the groupings on the γ-carbon atom.

Our thanks are due to Miss A. E. Wright for technical assistance during part of this work.

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## Effect of Enforced Exercise on Myoglobin Concentration in Muscle

For many years it has been widely accepted that active muscles are generally redder than those which are little used. Such differences might be regarded as fortuitous, however, and unconnected with the state of activity. The red colour is principally due to the presence of the pigment myoglobin[1]. To secure a convincing indication that myoglobin is increased as a result of muscular activity, its concentration has been compared in the muscles of forcibly exercised and of inactive rats. In addition, the effects of enforced inactivity on myoglobin concentration has been studied in the pectoral and leg muscles of domestic fowls.

Myoglobin was estimated by a method previously described[2] and *p*H by the glass electrode.

Table 1. Myoglobin in Relation to Enforced Exercise in Rats (mixed muscles of hind limbs)

| Group | No. of rats | Treatment | Myoglobin (% wet weight) | Sig. of diff. between means |
|---|---|---|---|---|
| *A* i | 6 | Unfed—exhausted | 0·094 ± 0·003 | nil |
| ii | 2 | Unfed—controls | 0·094 ± 0·009 | |
| *B* i | 3 | Fed—heavy exercise (1½ hr. 30 r.p.m.) | 0·097 ± 0·009 | nil |
| ii | 3 | Fed—heavy exercise (3 hr. 30 r.p.m.) | 0·105 ± 0·013 | |
| iii | 3 | Fed—controls | 0·096 ± 0·003 | |
| *C* i | 7 | Fed—trained (17 days, 2 hr./day) | 0·131 ± 0·006 | i > ii* |
| ii | 6 | Fed—controls | 0·104 ± 0·007 | |
| *D* i | 11 | Fed—trained (2 months, 2 hr./day) | 0·138 ± 0·006 | i > ii* |
| ii | 11 | Fed—controls | 0·111 ± 0·006 | ii > iii† |
| iii | 11 | Fed—'immobile' | 0·096 ± 0·006 | i > iii‡ |

* Significant at 5 per cent level. † Significant at 1 per cent level. ‡ Significant at 0·1 per cent level.

The effects of short bouts of exercise of varying severity were first considered. Female albino rats six months old of uniform breeding were made to run on mechanically driven drums at 30 r.p.m., corresponding to a running speed of 120 ft./min. In Table 1 (*A* i, ii), values are given for myoglobin levels in the mixed hind-limb muscles after the rats had been exhausted by 1½ hr. of this treatment. To accentuate the shock arising under these conditions, the animals were starved for 24 hr. prior to being placed in the machine. It may be seen that the pigment concentration in the muscles of the exhausted rats was not significantly different from that in the control animals, which were in cages. Nevertheless, the treatment had greatly lowered the glycogen reserves of the muscles in the exhausted rats, as their ultimate *p*H was 7·24 ± 0·04, whereas that in the controls was 6·46 ± 0·02. (The ultimate *p*H derives from the conversion to lactic acid of all the glycogen remaining in the muscle at death[3].) When well-fed rats were subjected to moderate exercise, there was again no change in myoglobin-levels (Table 1, *B* i, ii and iii). It was once more evident, however, that the enforced exercise had affected the muscles, as the ultimate *p*H in the controls was 6·20 ± 0·03, and in the exercised rats 6·90 ± 0·21 (1½ hr.) and 6·94 ± 0·15 (3 hr.).

As a stress of short duration apparently produced no change in myoglobin concentration, the effect of moderate exercise every day over an extended period (17 days) was considered. Seven rats were exercised for 2 hr. a day at about 10 r.p.m. A similar number were retained as controls. In Table 1 (*C* i and ii), it may be seen that this procedure led to an increase in myoglobin-levels in the treated animals which was significant at the 5 per cent level. In the hope of accentuating this trend, a further batch of female albino rats six months old were subjected to treatment. One-third of their number were trained for two months, again for 2 hr. a day and at 10 r.p.m. (Table 1, *D* i): one-third were retained as controls (*D* ii); and the remaining third were kept 'immobile' in a confined space (*D* iii). It is readily seen that myoglobin concentrations in the trained group were higher than those in both the controls and the 'immobile' animals, the significance of the difference being high—at the 0·1 per cent level. Furthermore, the values for the controls were also higher than those in the 'immobile' group, although the significance of this difference was not so great (1 per cent level).

The ultimate *p*H values of the muscles from the trained group (6·07 ± 0·04) were significantly lower than those in the controls (6·18 ± 0·03) and in the 'immobile' animals (6·16 ± 0·05), suggesting a building-up of glycogen during training. Changes of *p*H of this magnitude have been reported before in

Table 2. MYOGLOBIN IN RELATION TO 9 MONTHS ENFORCED INACTIVITY IN FOWLS

| Group | No. of fowls | Treatment | (% wet weight) | |
|---|---|---|---|---|
| | | | Myoglobin gastrocnemius | Pectoralis major |
| *A* | 10 | Normal activity | 0 177 ± 0·016 | 0·086 ± 0·001 |
| *B* | 10 | 'Immobile' | 0·116 ± 0·011 | 0 084 ± 0·001 |
| Significance of difference between means, at 0·1 per cent level | | | *A* > *B* | nil |

exercised rats, and the degree of acidity has been correlated with the quantity of lactic acid produced in the muscles[4].

The pectoral and leg (gastrocnemius) muscles of a group of fowls which had been allowed considerable freedom to forage, and of a comparable group closely confined in a battery over a period of nine months, were also analysed (Table 2).

Myoglobin concentrations in the gastrocnemius muscles of the normally active control group were significantly higher (0·1 per cent level) than those of the 'immobile' birds. It is interesting to note, however, that the pectoral muscles, which were not exercised by either group, showed no difference in pigment content.

It is concluded from these results that an increased myoglobin content represents one of the responses of muscle tissue to the influence of enforced activity, provided the latter continues over an extended period ('training'). Over a short period, even the most severe exercise elicits no such response, although it profoundly diminishes the glycogen reserves of the muscle.

I am indebted to Dr. D. G. Gilmour and Mr. R. W. Pomeroy, of the School of Agriculture, Cambridge, for making available the fowl muscles. The statistical analysis of the data in Tables 1 and 2 was carried out by the Statistical Laboratory, Mathematics Department, Cambridge. The interest shown in these experiments by Prof. D. Keilin and by Dr. E. C. Bate-Smith is gratefully acknowledged. The work described in this communication was carried out as part of the programme of the Food Investigation Organization, Department of Scientific and Industrial Research.

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## Hyaluronidase as an Adjuvant to Methylene Blue in staining of Nerve Fibres

IT is notoriously difficult to produce consistent and uniform results in the vital staining of nerve fibres with methylene blue. Using Weddell's methods[1,2], both local and intravenous methylene blue in rabbits have given unsatisfactory results, with patchy and inconsistent staining.

Very considerable improvement in uniformity of staining of the nerve plexuses of the ear in rabbits has been achieved by adding hyaluronidase to the solution of the dye immediately before injection, in the proportion of 1,000 'Benger' units to 20 ml. of the dye solution. After local injection, diffusion of the dye throughout the corium and subcutis of the ear is rapid, particularly if the ear is lightly massaged. In other particulars, Weddell's method[1] has been followed.

Similarly, better staining is obtained after intravenous injection of methylene blue to which hyaluronidase has been added. Given intravenously, the enzyme appears to be relatively non-toxic; 6,000 units were added to the injection fluid in the case of a 2-kilo rabbit without apparent toxic effect. In all experiments the ordinary B.D.H. preparation of methylene blue was used as a 2·5 per cent solution in isotonic glucose. To prevent any possibility of saline over-dosage, the glucose solution has been used in preference to physiological saline as a vehicle for the dye. 20–30 ml. of the solution plus hyaluronidase were injected slowly over a period of 2–4 hr. The time factor is not significant. For examination of the nerve plexuses of the ear injection is made into one of the hind limb veins, as injection into the dorsal vein of the ear produces gross non-specific staining of the tissues around the site of injection from local diffusion of the dye.

Weddell[1] has pointed out the value of vasodilatation of the skin area being investigated, and certainly less uniform results in the ear are obtained when there is vasoconstriction. The induction of an acute inflammatory vascular reaction of the dorsal skin of the ear by rubbing with xylol during the injection period has produced the most consistent and uniform staining. This would suggest that uniformity of staining follows widespread capillary dilatation which reduces the need for tissue diffusion of the dye to the minimum.

The addition of hyaluronidase to the solution of methylene blue in supravital staining of nerve plexuses in human skin has also given promising results. An alternative to this method would be the injection of the enzyme locally into the skin before excision and supravital staining, since Bywaters *et al.*[3] have shown that the dermal barrier to the spread of dye after hyaluronidase injection is not reconstituted for 24 hr.

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## The X-Organ of Crustacea

INTEREST in the location and identity of the *X*-organ of decapod crustaceans has been renewed with the discovery of its neurosecretory nature, for it is one of the major sources for the secretory material of the sinus gland[1-3]. The total endocrine complex formed by these two organs strikingly resembles the brain – corpora cardiaca complex of insects. The appearance of the *X*-organ varies in different species; but apparent homologues have been located in the nervous system of the eye-stalk of decapods by either of two methods: (*a*) from the original observation of Hanström[4,5] that it is usually associated with the innervation of the sensory pore

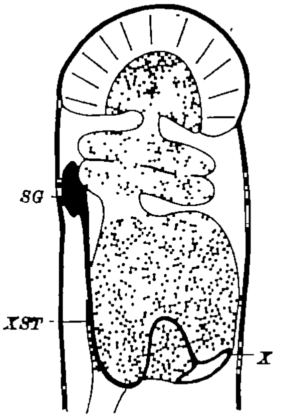

Fig. 1

or sensory papilla ; or (*b*) from the recent discovery[1–3] that the *X*-organ is linked to the sinus gland by the *X*-organ sinus gland tract, otherwise called the sinus gland nerve.

By examining a number of species of Crustacea (Stomatopoda : *Squilla mantis* ; Decapoda : Brachyura : *Carcinides* (= *Carcinus*) *maenas*, *Pachygrapsus marmoratus*, *Maia squinado*, *Uca pugilator*, *Portunus corrugatus*, *Dromia vulgaris* ; Anomura : *Calocaris macandreae* ; Natantia : *Crangon* (= *Crago*) *vulgaris*, *Lysmata seticaudata* ; Reptantia : *Palinurus vulgaris*) we have found that the *X*-organ in most forms contains at least three types of cell. In Brachyura, where the sensory pore is poorly developed or wanting, these different types of cells are commonly found together, usually at the proximal ventral corner of the medulla terminalis (Fig. 1) ; but in *Squilla* (Fig. 2) and in Natantia (Fig. 3) especially, the *X*-organ may be separated into two parts connected by a nerve.

In Brachyura, the most abundant cell type seems to be a big (30–40 µ diameter), pear-shaped, monopolar neuron, with a conspicuous nucleus and one to several nucleoli. The axon of this cell body is large, unbranched and leads to the sinus gland (Fig. 1). Secretory granules or droplets can be demonstrated by appropriate histological methods in both cell body and axon. These cell types are termed 'giant β neurosecretory cells'[2] or simply '*X*-organ neurosecretory cells'[1–3].

The second, and less-abundant, cell type in the Brachyura is a spherical cell (*c*. 15 µ in diameter), the nucleus of which lies against the cell wall, while most of the perinuclear space is usually filled by a single inclusion which stains uniformly. Sometimes several smaller inclusions are present instead. No axon can be seen. A third, and least abundant, cell type consists of oval or irregular 'concretions of concentric structure'[5] lying adjacent to both the cells types already described. No clearly defined nucleus can be seen in these bodies, which may be products of secretion rather than cells.

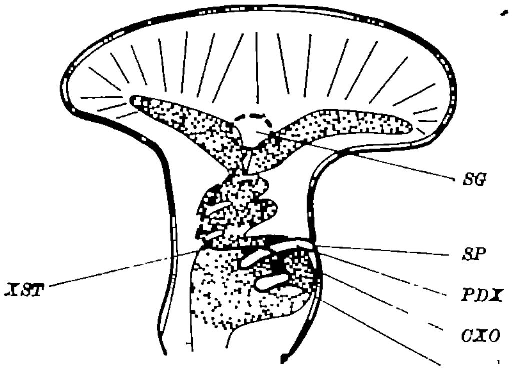

Fig. 2

In the Natantia examined, the two latter types of cell have been found close to the sensory pore. Cells of the second, spherical, type appear to be more numerous here than in the Brachyura, and they are characteristically ". . . shaped like a cluster of grapes surrounding the nerve from the medulla terminalis"[4]. These cells may form a syncytium. Cells of the first type (*X*-organ neurosecretory cells) are also present but are isolated from the other two kinds ; they occur in the medulla terminalis close to the point where the sensory pore nerve enters it. Fibres connect these two groups of cells.

In Natantia as well as Brachyura, the sinus gland is innervated by (and presumably receives secretory product from) the *X*-organ, but not from that portion of the *X*-organ close to the sensory pore. We propose that the two portions of the gland, where they are separated, should be termed ***pars distalis X-organi*** and ***pars ganglionaris X-organi*** (Figs. 2 and 3, *PDX* and *PGX*), while the nerve connecting them should be termed *connexio X-organi* (*CXO*), that is, *X*-organ connective.

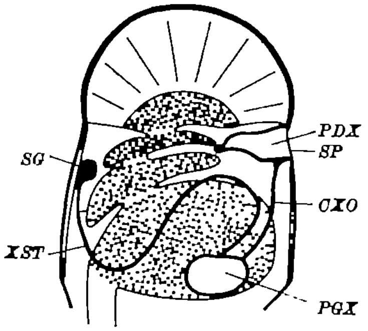

Fig. 3

*Dromia* and *Calocaris* show a degree of separation of these two portions of the *X*-organ intermediate between the extremes shown in crabs and shrimps.

We feel that these findings confirm the identification of the brachyuran *X*-organ by recent workers[1,2,6] and may explain why compatible results have not previously been obtained after *X*-organ extirpation in Natantia[7].

We wish to thank Dr. P. F. R. Dohrn for the *Calocaris* material placed at our disposal. One of us (D. B. C.) is aided by a grant from the Browne Fund of the Royal Society, and the other (L. M. P.) at present holds a National Science Foundation (U.S.A.) fellowship.

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## Extension of the Salivary Chromosome Method to *Anopheles claviger, quadrimaculatus* and *aquasalis*

The cytogenetic method of investigation in malaria mosquitoes, based on morphological comparative study of salivary chromosomes, has been fruitful in the analysis of the *maculipennis* group. The results obtained are in good agreement with those of taxonomic studies based on egg morphology and larval chetotaxis; moreover, they permit systematic diagnosis also where such morphological differential characters vary too much or are altogether lacking. For example, where mixed *A. typicus* and *messeae* occur in a larval breeding place, no larval character is sufficient for their discrimination, whereas cytological examination shows different structures in the *X*-chromosome which are absolutely constant and characteristic of each species. The method of examination is both easy and rapid.

Hitherto, only species of the *maculipennis* group have been thoroughly investigated in our laboratory by this method, although we could foresee a much wider field of application. Preliminary researches in *A. claviger* showed this species to be a suitable one for cytogenetic studies.

Last year we received from Dr. L. E. Rozeboom a strain, easy to rear in laboratory conditions, of *A. quadrimaculatus*; the species, which is widespread in North America—middle and eastern States—is considered to be one of the chief malaria vectors. Cytogenetic study of this species, based on the structure of the salivary gland chromosomes, also appears possible and promising.

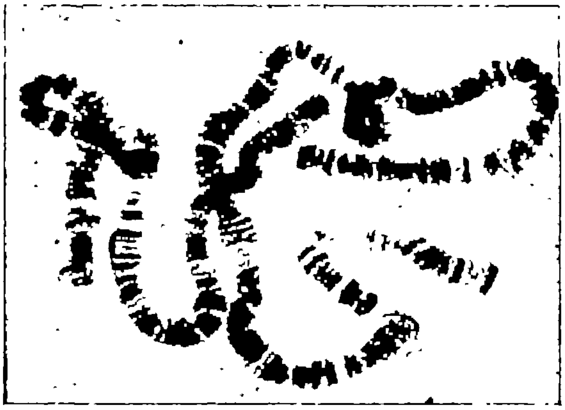
The mitotic chromosome picture consists of two mediocentric and one acrocentric, dot-like chromosomes, resembling those of *A. claviger* in somatic cells. Thus a preliminary investigation of the chromosomes of *quadrimaculatus* shows that the tip of one of them is similar to the end of the right arm of the third chromosome of the Italian *A. maculipennis*.

The end of the *X*-chromosome of *A. quadrimaculatus* also appears to be somewhat similar to that of *messeae*.

Any hypothesis on phylogenetic relationship between palearctic and nearctic forms of the *maculipennis* group has little foundation at present; but this cytogenetic approach is the most promising one for such investigation. The banding pattern of *freeborni* and *aztecus* is almost identical with that of *atroparvus*; there are, however, rather extensive inverted regions.

According to Freeborn, *quadrimaculatus* is a member of the *maculipennis* group, filling up a niche, in the United States, and completing "the globe encircling holoarctic distribution of this variable and versatile species". My preliminary results support this point of view. It must be admitted that the chromosomic set of *quadrimaculatus* resembles more closely that of *claviger* than *maculipennis*, in ordinary mitotic or meiotic cells; but I think the difference between *maculipennis* and *quadrimaculatus* could be referred to the heterochromatic part. As a matter of fact, the *X*-chromosome in the salivary gland cells is almost the same in the two species, although it appears rather different in the mitotic set. The phylogenetic relationship between nearctic and palearctic species, however, is a problem requiring much further investigation and close co-operation between many research workers.

What is unquestionable is the possibility of extending to the American species of the *maculipennis* group the same method of investigation as that applied to the Italian species. Comparing *freeborni*, *aztecus* and *occidentalis*, differences can be found in the chromosomic structures which make differential diagnosis easier in larval breeding places (for example, between *freeborni* and *punctipennis* in regions where these species are co-breeders).



Salivary gland chromosomes of *A. aquasalis* (subgenus *Nyssorhynchus*)

The species mentioned belong to the subgenus *Anopheles*. We believe that the method can be applied fruitfully also to species of the subgenus *Nyssorhynchus*. Dr. Ivan Ricciardi, of the Malariological Institute of Rio de Janeiro, has recently come to this Institute, and brought with him eggs and larvæ of *aquasalis*. Both in larvæ collected in Nature and in larvæ reared in the laboratory, the structure of salivary chromosomes appears with a clarity quite comparable to that characteristic of the most suitable species of *Drosophila* and *Chironomus* (see photograph).

We hope that complexes like *tarsimaculatus* and others of the subgenus *Nyssorhynchus* will offer suitable material for the application of the cytogenetic method.

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## Probable Relationship between the *Rhodometopa* Group of Cercariæ and the Trematode Genus *Renicola* Cohn

During the past year, a study of the trematodes of the genus *Renicola* from birds in British zoos has been carried out and certain interesting points concerning the genus have come to light.

Among other features to which particular attention was given is the excretory vesicle in a species which has been found on several occasions in the kidneys of various penguins. This species was first reported by Campbell and Sloane[1] from king penguins in the Edinburgh Zoo. The fact that they had found specimens in birds hatched in the menagerie, and certain other features of infections observed in London, seemed to indicate that this is not a normal parasite of penguins, but is more likely to be found in British sea-birds. With this in view, a search was started and, after several unsuccessful examinations about ten specimens, similar to those from the penguins, were found in the kidneys of a common guillemot (*Uria aalge*).

An examination of the literature on larval trematodes from British marine gastropods showed almost at once the very marked similarity between the excretory vesicle of young adults of this species of *Renicola* and that of the *Rhodometopa* group, of cercariae, particularly *C. pythionike* Rothschild[2]. In both cases the vesicle is *Y*-shaped with numerous lateral branches and with a connecting channel joining the two arms of the *Y* immediately behind the ventral sucker.

Evidence of this kind seems fairly strong, and further work is being carried out in the hope that a knowledge of the larval stages may help to establish more definitely the true systematic position of this somewhat disputed genus.

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# Relationship between the Oxidative and Fermentative Phases during Adaptation to Galactose in *Saccharomyces cerevisiae*

Aerobic adaptation to the utilization of galactose in *Saccharomyces cerevisiae* occurs in two phases: an oxidative phase in which the respiratory quotient is 1, and a fermentative phase which follows it[1]. Further experiments have now demonstrated that during the oxidative phase of adaptation to galactose, the yeast cells are capable of fermenting galactose if anaerobic conditions are introduced. The degree of fermentation which resulted when anaerobic conditions were instituted was found to be correlated with the degree of adaptation during the oxidative phase as measured by the $Q_{CO_2}$.

These results confirmed previous ones which indicated that adaptation to the utilization of galactose is not concerned with oxidation or fermentation as such, but rather with an enzyme or series of enzymes which make galactose available to the cell for subsequent oxidation or fermentation[1]. Since the oxidative phase of aerobic adaptation was always followed by the onset of fermentation, provided the concentration of galactose was sufficiently high, it was of extreme interest to determine the factors involved in this shift from oxidation to fermentation under aerobic conditions.

It was found that, during the early stages of adaptation long before fermentation started, carbohydrate was being stored, some as glycogen and some as glycolytic intermediates, and pyruvate did not accumulate appreciably until storage of glycolytic intermediates was close to maximum. Therefore, it appears that storage occurs as soon as adaptation starts, and that only a relatively small amount of galactose is initially metabolized to pyruvic acid and oxidized through the tricarboxylic acid cycle. However, when storage is at a maximum and adaptation has proceeded sufficiently, galactose is metabolized at a greater rate to pyruvate until the oxidative mechanisms are apparently saturated, and pyruvate and acetaldehyde accumulate. It is at this point that fermentation starts. These conclusions are in agreement with previous results which demonstrated that, at low concentrations of galactose, adaptation occurred readily (as indicated by increase in $Q_{O_2}$, disappearance of galactose, and accumulation of glycogen) but that fermentation did not occur[1].

An important implication of these results is that fermentation is not a valid criterion for measuring the synthesis of the galactose-adaptive enzyme. The onset of galactose fermentation in yeast appears to be dependent upon the preliminary accumulation of reserves and intermediates, and only in a superficial way related to the kinetics of adaptive enzyme formation. Therefore, experiments using this method which purport to show that the synthesis of galactokinase is autocatalytic in nature are invalid[2], and theories which postulate the existence of extrachromosomal hereditary factors in order to explain the kinetics of galactokinase formation in yeast[2] are premature.

I wish to thank Dr. Carl C. Lindegren for encouragement during the progress of the work. This work has been supported by grants from the American Cancer Society, administered by the Committee of Growth, National Research Council, National Cancer Institute of the National Institutes of Health, Public Health Service and Anheuser-Busch, Inc.

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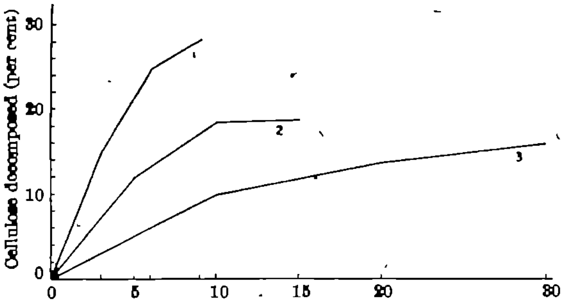
# Purification and Cellulolytic Activity of *Cellvibrio*

In recent years, several workers have paid a great deal of attention to the purification and the cellulolytic activity of aerobic cellulose-decomposing bacteria, especially *Cytophaga* and *Cellvibrio*. Isolations have generally been carried out by direct plating of soil suspensions on precipitated cellulose agar, and by enrichment cultures on silica-gel filter paper or on filter paper partly immersed in a liquid mineral medium. With the former method, most of the dishes are invaded by moulds and generally the formation of lytic zones is not very obvious.

In order to isolate *Cellvibrio*, a first enrichment was effected on silica-gel filter paper. After tenfold subculturing on the same medium, impurities in the form of other bacteria were still present. The impure strains were plated out on precipitated cellulose agar containing the common minerals, 0·1 per cent farmyard manure extract and 0·2 per cent cellulose. After seven days incubation at 26° C., different types of colonies were obtained. Some were surrounded by clear lytic zones while other colonies were not. All the *Cellvibrio* colonies that produced lytic zones on this medium showed a luxuriant growth when subcultured on filter paper agar. The strains obtained in this way were again plated on cellulose agar until only one type of colony with clear lytic zones was present. These strains were considered to be absolutely pure.

Not all strains of *Cellvibrio*, after enrichment on filter paper, produced lytic zones on precipitated cellulose agar to which farmyard manure extract was added. Some strains need other growth factors in addition to those present in the farmyard manure extract. More work will be done on the role of these factors in the formation of lytic zones by *Cellvibrio* on cellulose agar.

The pure cultures already have been maintained during four months by alternate subculturing on agar filter paper and precipitated cellulose agar provided with farmyard manure extract.



Vibrio 14: (1) pure strain on agar cellulose; (2) impure strain on agar cellulose; (3) impure strain on cellulose and mineral liquid medium

Impure strains, after many subcultures on silica-gel paper medium, and pure strains obtained by using the technique mentioned above, were tested for cellulolytic activity. We used two methods: growth in square-section bottles on a liquid mineral medium to which filter-paper strips were added, and a mineral agar medium covered with filter paper. Farmyard manure extract was not present in either media. The cellulose decomposition was measured by loss of dry-weight of the filter paper. The accompanying graph shows the results with an impure and a pure strain of *Cellvibrio* 14 on the two media.

It seems clear that the cellulose is more rapidly decomposed in the early stage of growth on the agar filter medium. The pure strain is also more active than the impure one.

Further results with other pure strains of *Cellvibrio* will be published elsewhere.

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## Some Factors affecting Heat Tolerance of Cattle and Buffaloes

EGYPTIAN cattle, buffaloes and high-grade shorthorns were used for studying the effect of age, lactation and fattening on heat tolerance coefficients. The method developed by Rhoad[1] was used in estimating the heat tolerance, and the test was carried out twice during July 1952. The atmospheric temperature during test days ranged between 91° and 98·6° F., and relative humidity between 42 and 68 per cent. The average body temperatures of animals during March 1950 were taken as normal body temperature[2].

It was found that calves one year old had the lowest adaptability coefficient (see table). As young calves are sensitive organisms, probably their heat-regulating mechanisms are not as efficient as that of older animals.

HEAT TOLERANCE COEFFICIENTS OF EGYPTIAN CATTLE, BUFFALOES AND SHORTHORN GRADES AT DIFFERENT AGES

| Animals | Age | No. of animals | Heat tolerance coefficient | |
|---|---|---|---|---|
| | | | Rhoad's test | One reading |
| Egyptian cattle | Mature (lactating) | 4 | 80·4 | 80·3 |
| | 2 years | 8 | 84·1 | 83·5 |
| | 1 year | 8 | 78·5 | 77·9 |
| Buffaloes | Mature (lactating) | 10 | 69·5 | 66·0 |
| | 2 years | 9 | 71·8 | 67·7 |
| | 1 year | 10 | 64·1 | 59·2 |
| Shorthorn grades | Mature (lactating) | 9 | 72·0 | 71·0 |
| | 2 years | 8 | 74·8 | 73·5 |
| | 1 year | 10 | 62·0 | 61·2 |

Our results show that lactating animals are less tolerant than animals two years of age. It should be noted that mature animals used in this work were during their first month of lactation. Such animals consume more food than two-year old heifers and consequently their heat increment is increased; moreover, the endocrine and mammary glands of lactating animals are more active than non-lactating ones. These factors are responsible for increasing the body temperature of lactating animals and lead to a lower heat tolerance coefficient. The heat tolerance coefficients of non-lactating Egyptian cows, buffaloes and shorthorn grades have been found[3] to be 91·5, 75·7 and 89·2 per cent respectively; these are higher than those reported here for lactating animals and heifers two years of age.

To study the effect of fattening on the heat tolerance coefficient of buffalo calves, a group of three calves were given a rich ration of concentrates after weaning until they were eleven months of age. These calves gained about 1·5 lb. daily, while the control group gained only 0·7 lb. The average heat tolerance coefficient of the fattened group was 60 per cent compared with 64 per cent for the non-fattened ones. This difference may be attributed to the fact that fattened calves consumed three times as much food as that taken by the control animals, and consequently their heat increment should be greater than that of the controls. Deposition of more fat under the skin of fattened calves may be another factor in decreasing their heat tolerance.

The Iberia heat tolerance reported by Rhoad[1] requires that the body temperature of tested animals be recorded at 10.00 a.m. and 3.00 p.m. for three hot days (atmospheric temperature close to 90° F.). During the course of this experiment, body temperatures of animals were taken at 12.30 p.m., and heat tolerance coefficients were calculated using this reading only. It is interesting to note that the two estimates obtained are very close except in the case of buffaloes (see table). Work carried out in this department has shown that the body temperature of buffaloes increased with increasing the period of exposure to summer sun; whereas Egyptian cattle and graded shorthorns were not significantly affected[2]. This is probably the explanation of the discrepancy between the estimates obtained for buffaloes.

When individual heat-tolerance tests were calculated for each animal, it was found that there were significant differences between individuals of the same age. Some of the buffalo one-year old calves had to be removed during hot hours on test days. Highly tolerant animals should be selected for breeding, as such animals are more efficient in food utilization and production.

This work was carried out at the Animal Breeding Department, Faculty of Agriculture, Giza, Egypt.

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[2] Ghany, M. A., M.Sc. thesis, Faculty of Agric., Giza (1951).

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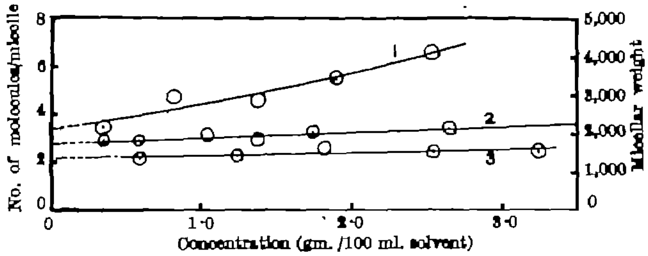
## Dipole Moments of Metal Oleates

Banerjee and Palit[1] have reported a value of 0·29 D. for the dipole moment of zinc oleate in contrast to values of 1·20 and 1·66 D. for the oleates of copper and magnesium. A possible reason for this anomaly has been found in the course of an ebullioscopic investigation of the micellar weights of some of the metal soaps in benzene and other solvents.

The dipole moments reported by Banerjee and Palit were evaluated by measuring the molar polarization of the oleates in benzene solution, using a heterodyne beat method. This procedure is based on the fundamental assumption that the solute is either molecularly dispersed or is approaching molecular dispersion in the concentration range in which the polarization measurements are made. Micellar weight data for zinc oleate, however, are shown in the accompanying graph.



Micellar weight and degree of association of zinc oleate in organic solvents: (1) benzene; (2) toluene, (3) $p$-xylene

These results demonstrate the presence, in all the solutions, of aggregates at concentrations well below those at which Banerjee and Palit made their polarization measurements. Further, the shape of the micellar weight-concentration curves provides no justification for the assumption that extrapolation of the polarization data to infinite dilution is likely to give a reliable value for the polarization of the molecularly dispersed solute. Aggregation was also detected ebullioscopically in solutions of the copper and magnesium compounds; but, in these cases, the accuracy obtainable did not warrant extrapolation of the micellar weight data to infinite dilution. The fact hat aggregation occurs in all these solutions even at low concentrations suggests that the absolute values of the moments reported by Banerjee and Palit may be in error, although there is little reason o doubt that their measurements place the oleates in the correct order of polarity.

It should be noted that Banerjee and Palit's measurements were made at room temperature, whereas the micellar weight measurements now eported are at the boiling points at atmospheric ressure of the respective solvents. However, a omparison of the micellar weights of zinc oleate in enzene (boiling point 80·1° C.) and $p$-xylene (boiling point 138·4° C.) indicates clearly that, at room emperature in benzene, aggregates even larger than hose observed at the boiling point are to be expected. The measured micellar weights are average alues, and a high average micellar weight in solution does not therefore exclude the presence of some micelles of smaller size, or even of some molecularly dispersed solute. The measured polarizations are hus mean values for the different sizes of particles resent in the solutions. Since the larger aggregates ight reasonably be expected to be much less polar, he relatively high polarization values recorded by Banerjee and Palit provide evidence for the existence in the solutions of some particles considerably smaller than the average and possibly also for a small proportion of the monomeric solute. The ebullioscopic apparatus used in these experiments has been described elsewhere[2].

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[1] *J. Indian Chem. Soc.*, **27**, 385 (1950).

[2] Nelson and Pink, *J. Chem. Soc.*, 1744 (1952).

## Optical Exaltation in Aromatic Compounds

It is known that the molecular refraction, as defined by Lorenz–Lorentz, of liquid (non-aromatic and non-conjugated) organic compounds may be calculated with fair accuracy by summation of the atomic refractions and the contributions to structural influences which may play a part (for example, olefinic double bonds). For aromatic compounds this additive character of the molecular refraction does not apply. Here the value measured is nearly always greater than the sum of the atomic refractions and contributions due to double bonds.

In determining the molecular refraction, the difficulty is encountered that, under normal conditions (20° C.), most of the aromatic compounds with three or more rings are solids, some of which have a very high melting point. This difficulty may be avoided by dissolving compounds the molecular refraction of which is required in a solvent with a known molecular refraction, determining the refractive index and the density of the solution, and afterwards calculating the molecular refraction of the solution from these results. The molecular refraction of the dissolved substances as a hypothetical liquid is denoted by:

$$R_{M_{\rm I}} = \frac{R_{M_{\rm I\,II}} - f_{\rm II} \cdot R_{M_{\rm II}}}{f_{\rm I}}, \qquad (1)$$

where $R_{M_{\rm I}}$ and $R_{M_{\rm II}}$, $R_{M_{\rm I\,II}}$ are molecular refractions of the dissolved substance, the solvent and the solution respectively; and $f_{\rm I}$ and $f_{\rm II}$ are molecular fractions of the dissolved substance and the solvent respectively. The molecular refractions of a number of aromatic compounds in the hypothetical liquid state at 20° C., calculated in this manner, are given in the accompanying table.

With the help of the values of the molecular refractions determined, we derived the corresponding refractometric exaltations (see table). Here the exaltation of an aromatic $C_pH_qO_rN_sS_t$ molecule is defined as:

$$E = R_M - (p.R_C + q.R_H + r.R_O + s.R_N + t.R_S), \qquad (2)$$

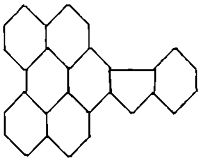
where $R_M$ is the measured molecular refraction of the compound; $R_C$, $R_H$, $R_O$, $R_N$ and $R_S$ are the atomic refractions of C, H, O, N and S, as derived from non-aromatic compounds. For the atomic refractions we used those which may be calculated from the bond refractions given by Vogel *et al.*[1]. $p$, $q$, $r$, $s$ and $t$ are the number of C, H, O, N and S atoms.

| Compound | Formula | *RM* | *E* | *E/A* |
|---|---|---|---|---|
| Acenaphthene | $C_{12}H_{10}$ | 52·0 | 10·6 | 1·06 |
| Fluorene | $C_{13}H_{10}$ | 54·7 | 10·7 | 0·89 |
| Acridine | $C_{13}H_{9}N$ | 63·8 | 18·4 | 1·31 |
| Anthracene | $C_{14}H_{10}$ | 65·6 | 18·9 | 1·35 |
| Phenanthrene | $C_{14}H_{10}$ | 62·2 | 15·5 | 1·10 |
| Pyrene | $C_{16}H_{10}$ | 72·5 | 20·7 | 1·29 |
| Fluoranthene | $C_{16}H_{10}$ | 71·5 | 19·7 | 1·23 |
| Brazan | $C_{16}H_{10}O$ | 75·8 | 22·3 | 1·31 |
| 2,3 Benzfluorene | $C_{17}H_{12}$ | 77·2 | 20·8 | 1·22 |
| Chrysene | $C_{18}H_{12}$ | 83·4 | 24·4 | 1·36 |
| 1,2 Benzanthracene | $C_{18}H_{12}$ | 82·6 | 23·6 | 1·31 |
| Hexahydroperylene | $C_{20}H_{18}$ | 90·0 | 17·6 | 1·26 |
| 1,2,5,6 Dibenzanthracene | $C_{22}H_{14}$ | 104·9 | 33·5 | 1·52 |
| Coronene | $C_{24}H_{12}$ | 107·2 | 32·7 | 1·36 |
| Difluorenyl | $C_{26}H_{18}$ | 108·0 | 22·1 | 0·92 |
| β Truxene | $C_{27}H_{18}$ | 114·9 | 26·4 | 1·10 |

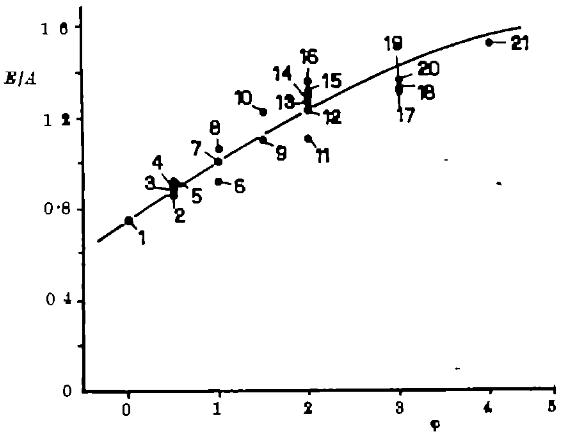
Now it appeared that the optical exaltation per aromatic atom (*E/A*) is far from constant, it being a function of a structure parameter Φ, which we define as:

$$\Phi = r_{ar} - \frac{3}{2} i_{ar} + \tfrac{1}{2} j, \qquad (3)$$

where $r_{ar}$ is the number of aromatic joint bonds between aromatic 6-rings, $i_{ar}$ is the number of buried carbon atoms (completely enclosed by aromatic 6-rings), and $j$ is the number of direct covalent bonds between aromatic 6-rings (non-condensing). For example, the parameter Φ for the molecule



is given by $\Phi = 9 - \frac{3}{2}\,4 + \frac{1}{2}\,.\,1 = 3{\cdot}5$ because $r_{ar} = 9$, $i_{ar} = 4$ and $j = 1$. The value of the structure parameter Φ is linked up with the geometrical asymmetry of the molecule. The correlation between the exaltation per aromatic atom *E/A* and the structure parameter Φ is given in the accompanying graph. This correlation has been given a theoretical foundation.



1, Benzene; 2, 2,3′ dimethylbiphenyl; 3, fluorene; 4, 3,4′ dimethylbiphenyl; 5, 1 methyl 2 phenyl 4 isopropylbenzene; 6, difluorenyl; 7, naphthalene; 8, acenaphthene, 9, β truxene; 10, 2,3 benzfluorene; 11, phenanthrene; 12, fluoranthene; 13, hexahydroperylene; 14, pyrene; 15, acridine; 16, anthracene; 17, 1,2 benzanthracene; 18, brazan; 19, chrysene; 20, coronene; 21, 1,2,5,6 dibenzanthracene

With the help of this correlation, it is possible to draw conclusions as to the structure of mineral fuels. Particulars about this correlation and about the method followed in the structural investigation will be published elsewhere.

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[1] Vogel, A. I., Cresswell, W. T., Jeffery, G. H., and Leicester, J., *J. Chem. Soc.*, 514 (1952).

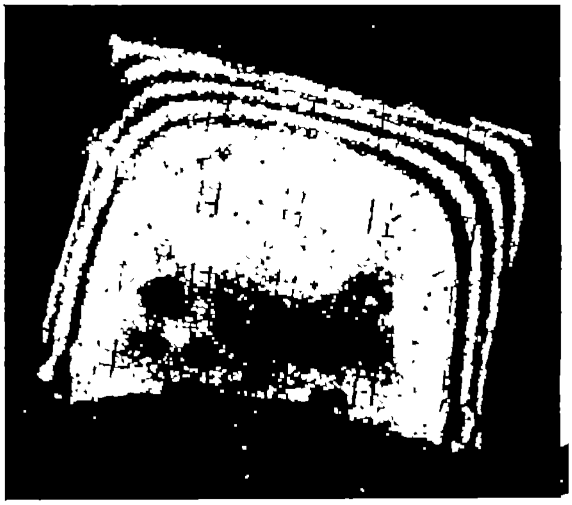
## A New Method of making Electron Microscope Specimen Support Films

It has been found that a thin film, suitable for specimen mounting, is formed over the mesh squares of an electron microscope specimen grid when dipped into a 1 per cent solution of 'Formvar' in chloroform, and allowed to dry in air. Very thin films, which are stronger than those wet-stripped from glass, can easily be obtained.

In each grid square, the film is uniformly thin over the central 70–80 per cent of the total area, thickening abruptly at the edges.

The accompanying photograph was taken by Mr. J. Dyson of this laboratory on an interferometer microscope[1] at a magnification of 500 diameters. The interference fringes can be regarded as contour lines of equal thickness. To make the photograph possible, it was necessary to cut across a grid in order to leave half the field free for the interfering beam. This required a thicker film than is usually made for the electron microscope; consequently, the uniform area is somewhat reduced. The loss in usable area is offset by the advantages that the films are easily and quickly made, entirely free from dirt and very rigid on the supporting grid.

A disadvantage arises when metal shadowing at small angles, because the vertical position of the film lies between the top and bottom of the grid bars; hence part of the area of each grid square is not shadowed. At angles of $\tan^{-1} \frac{1}{2}$ and $\tan^{-1} \frac{1}{3}$, shadowing generally covers the entire film.



Interference photograph of cut 'Formvar' film

To make the film, the specimen grid is held at the extreme edge in a fine-pointed pair of forceps, and immersed in the solution. On withdrawal, it is held horizontal and allowed to dry; this takes only a few seconds. The formation of the film is easily observed during drying, and best results are obtained when up to about one-third of the grid squares remain covered. If the whole grid is covered, the film is usually found to be too thick. To achieve this, two factors can be varied. The strength of solution can be between 0·5 and 1 per cent, and the amount of liquid remaining on the grid can be varied by the manner in which it is withdrawn from the solution. With practice, good thin films can be made without difficulty. It is important to remove the grid from the forceps immediately after the drying of the film is complete, otherwise any solution remaining on the forceps will form a thick blob of 'Formvar' on the grid which is liable to charge up electrically in the microscope. It is convenient to transfer the grid quickly to a second pair of forceps and remove any small drops of liquid which may remain at the point where it was previously gripped.

The method has been used over a period for routine work and has proved to be very satisfactory.

I wish to thank Dr. T. E. Allibone for permission to publish this note.

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[1] Dyson, J., *Nature* [171, 743 (1953)].

## Frictional Electrification of Polar Polymers

IT does not appear that any single mechanism suffices to explain frictional electrification completely[1,2]. The electrolytic mechanism of charge transfer has been discussed by Freundlich[3], but is generally taken to presuppose the existence of thin aqueous films on the surfaces, and to have only limited application to 'dry' solids[3]. Further, the conductance of even the thinnest of aqueous films is likely to suppress electrification on separation[4]. Nevertheless, electrolytic action accounts very satisfactorily for the behaviour of solids with polar properties. Thus Knoblauch[5] demonstrated the tendency of a large range of acids and bases to become electrified negatively and positively respectively, and obtained the best results with organic acids and bases. One concludes that the polar nature of these substances facilitated ionic processes in the presence of sorbed water molecules (not necessarily forming a separate phase), and that the acid donated excess positive ions (proton) and bases excess negative ions (hydroxyl). The results no doubt depend on the relative mobility of the ions, the larger ions tending to aggregate in both cases and were therefore less mobile than H$^+$ and OH$^-$ ions.

Excellent conditions for investigating electrolytic charge separation obtain with polar polymers, and in particular textiles and ion-exchange resins. The presence of the acid or basic groups promotes water sorption and consequent ionic dissociation and mobility even at low humidities[6]. One ion is, however, firmly bound to the polymer matrix and the other is free to take part in the charge transfer. For example, consider the strongly basic resin 'De-acidite *FF*', and the strongly acid 'Permutit' sulphonated polystyrene. We have:

$$R.\mathrm{NOH} \rightarrow R\mathrm{N}^+ + \mathrm{OH}^-$$
$$R.\mathrm{SO_3H} \rightarrow R\mathrm{SO_3}^- + \mathrm{H}^+,$$

with the respective positive and negative ions firmly bound; the resins donate freely diffusible OH$^-$ and H$^+$ ions respectively. This was indeed found to be true at about 30 per cent relative humidity, when the resins in powder form were shaken from a filter paper; the basic resin showed consistent positive charges and the acid resin negative charges.

Weak bases and acids were found to behave in a similar manner provided they were carefully neutralized (for example, 'Amberlite' *IR 4B* and 'Zeo-Karb' 216). It would seem that a similar mechanism also contributes largely to the electric charge acquired by wool keratin, which becomes positively electrified against filter paper; this is characteristic of polypeptides, which contain both basic and acidic groups against cellulose. Acidified horn keratin also becomes positively electrified against filter paper, while after treatment with dilute caustic soda it becomes negatively electrified. Similar reversals may be obtained with the resins, and in all these cases the direction of charge transfer is given by the sign of the boundary potential as deduced from the Donnan theory.

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## A New Precision Method for the Measurement of Ultrasonic Velocities in Liquids

SEVERAL methods[1] are available for the determination of ultrasonic velocities in liquids, of which the liquid film method[2] offers many advantages. The new method presented here enables a rapid determination of ultrasonic velocities with a high degree of accuracy.

The experimental arrangement consists of the usual apparatus for observing the Debye–Sears diffraction pattern in liquids. A quartz *X*-cut wedge of 1–3 Mc./sec. range is mounted in the crystal holder with *X*-axis vertical and the tapered edge parallel to the direction of the light beam, and is excited by a Hartley shunt-fed oscillator. The ultrasonic waves generated by this wedge are communicated to the liquid contained in a glass cell mounted on a levelling stand. The levelling is then adjusted so that the bottom of the glass cell is truly parallel to the surface of the wedge in contact with the liquid. A stationary ultrasonic diffraction grating can now be set up in the liquid column only at those frequencies for which the liquid column is in resonance.

Intense diffraction patterns are observed at a large number of these frequencies, which are very closely spaced. Using a slow-motion gear on the oscillator condenser and a length of liquid column of 4 cm., the frequencies of a number of these diffraction maxima have been measured and found to be exactly equally spaced, the frequency difference being in the range of 0·01–0·03 Mc./sec. for various liquids. The frequency difference $\Delta f$ between any two consecutive maxima is obtained by measuring the frequency interval for about a hundred maxima. The ultrasonic velocities are then evaluated by using the relation

$$V = \Delta f \times 2L,$$

where $L$ is the length of the liquid column and $V$ is the velocity of ultrasonic waves in the liquid. Results thus obtained for the velocities of ultrasonic waves in some liquids are shown in the accompanying table.

| Liquid | $L$ (cm.) | $\Delta f$ (Mc./sec.) | $V$ (m. per sec.) (20° C.) |
|---|---|---|---|
| Amyl alcohol | 3·3 | 0·0202 | 1,333 |
| Benzene | 4·0 | 0·0162 | 1,296 |
| Carbon tetrachloride | 3·9 | 0·0117 | 913 |
| Toluene | 3·7 | 0·0176 | 1,302 |
| Water | 5·0 | 0·0151 | 1,510 |

These values for the ultrasonic velocities are found to be in good agreement with those obtained by other methods. The accuracy of the results obtained is about 0·2 per cent. A higher accuracy of 0·02 per cent can be achieved with a precision wavemeter and thermostatic control of temperature of the liquid.

Though the method is simple, accurate and rapid, it is limited to transparent liquids and is not suitable for measurements at very high frequencies.

Further investigations are in progress. An interferometric modification of this method with a movable layer of mercury in the bottom of the ultrasonic cell as reflector is also under investigation.

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[1] *Phil. Mag.*, 5, 1177 (1928); *Proc. U.S. Nat. Acad. Sci.*, 18, 409 (1932); *Nature*, 133, 176 (1934); *J. Chem. Phys.*, 14, 606 (1946).

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## Structure of Magnesium–Lithium β-Phase Alloys

During work on magnesium–lithium–silver alloys, Hume-Rothery, Raynor and Butchers[1] examined X-ray powder photographs from binary magnesium–lithium alloys containing the body-centred cubic β-phase, or a mixture of this phase with the close-packed hexagonal magnesium-rich α-phase. Diffraction patterns from (α + β) alloys showed, in addition to fundamental reflexions, extra lines which were provisionally identified as derived from an $Fe_3Al$ type of superlattice in the β-structure. The extra lines persisted on annealing at temperatures up to 300° C. and were also present in diffraction patterns of thin rods quenched from 420° C., but were not observed in photographs from homogeneous β-alloys. It was suggested that the β-phase develops an $Fe_3Al$ type of superlattice very near to the (α + β)/β boundary. The existence of such a structure in a system of two components of such similar atomic size and electrochemical characteristics is surprising, but no further examination of the phenomenon was possible. More recently, however, the original diffraction patterns became available for re-examination; inconsistencies in the development of the suspected superlattice at various temperatures were noted, while identification of the extra lines with $Fe_3Al$-type ordering appeared uncertain. The appropriate region of the binary diagram has therefore been re-investigated.

| Alloy No. | Atomic % lithium | Annealing treatment | Phases present | Remarks |
|---|---|---|---|---|
| 1 | 34·0 | Quenched after 24 hr. at 400° C. + 24 hr. at 200° C | β | Cast from under lithium chloride flux |
| 2 | 23·0 | 14 days at 420° C. followed by slow cooling to room temperature at 50 deg./day | α + β | Cast in argon, using the method of Hume-Rothery, Raynor and Butchers (ref. 1) |
| 3 | 32·7 | | α + β | |
| 4 | 22·1 | Quenched after 14 days at 400° C. + 21 days at 200° C. | α + β | Cast in argon with improved technique, using iron crucibles |
| 5 | 27·7 | | α + β | |
| 6 | 31·86 | | β | |
| 7 | 33·62 | | β | |
| 8a | 49·4 | Quenched after 48 hr. at 400° C. + 24 hr. at 300° C. | β | Cast from under lithium chloride flux |
| 8b | 49·4 | As for alloys 2 and 3 | β | |

The alloys used in the structural investigation are described in the accompanying table.

Exploratory experiments were carried out with alloy 1. The diffraction pattern, obtained in a 19-cm. powder camera with copper $K_\alpha$ radiation, showed a number of weak lines additional to the fundamental reflexions. The photograph could not be satisfactorily indexed in terms of an ordered structure of the $Fe_3Al$-type. Measurement of nineteen of the extra lines ($\theta = 8°$ to $\theta = 32°$) indicated, however, that they could be indexed on the basis of an ordered cubic structure of lattice spacing $a_0 \simeq 9·7$ kX. Further reference to this is made below. Alloys 2 and 3 both gave rise to diffraction patterns containing extra lines which, however, did not correspond with those from alloy 1, and could not be indexed in terms of any simple structure, or with any simple ordered arrangement based on either the α- or β-phases.

From this lack of consistency it was suspected that the extra lines in alloys 2 and 3 might be associated with the presence of contaminants introduced during the preparation of the reactive alloys. The most likely cause of contamination is reaction of the molten metal with the atmosphere or with residual atmospheric impurities in the argon. A deliberately contaminated specimen was therefore obtained by heating a binary alloy in air until a considerable amount of reaction product (oxide and nitride) had accumulated. By comparison of this material, using monochromatized copper radiation in conjunction with a Geiger-counter spectrometer, with alloy 3 it was shown that the extra lines in the diffraction pattern of the latter from $\theta = 10°$ to $\theta = 35°$ corresponded exactly to the stronger lines in the pattern of the oxidized specimen. Further comparison showed that the extra lines on films obtained during the original work also corresponded with the stronger diffraction lines of the oxidized alloy. These experiments indicated that the apparent coincidence of the diffraction patterns in the original work with an $Fe_3Al$ type of structure was fortuitous, and that the extra lines were due to contamination.

To test this conclusion, alloys 4–7 were prepared under more stringently controlled conditions. Since the use of alumina crucibles leads to contamination

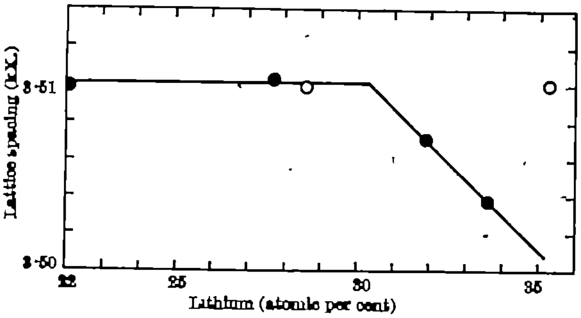

Fig. 1. ●—●—, iron crucible; O—O—, alumina crucible

by aluminium, the metals were melted in iron crucibles under argon which had been passed through a considerably enlarged purifying train to remove oxygen, nitrogen and water. Minimum preparation times were employed; the crucible was raised to the casting temperature before inserting the magnesium, and the lithium was added to the molten metal from a wire cradle without opening the apparatus. Casting also took place in the same enclosed apparatus, and the alloys were adequately protected from the atmosphere at all stages. The diffraction patterns showed only a few extra lines, of intensity considerably less than those observed for alloys 1–3. The few extra lines corresponded exactly with the strongest lines in the pattern of the oxidized specimen; their intensities did not vary with the amounts of α and β present. The striking reduction in the number and intensity of the extra lines by greater care in alloy preparation confirms that the effects arise from contamination, and not from superlattice formation.

Fig. 1 shows the lattice spacings (kX. at room temperature) obtained from the second series of alloys. For comparison, two measurements made on alloys prepared in alumina crucibles are included; one of these is clearly inconsistent with the results for alloys 4–7. The (α + β)/β boundary at 200° C. deduced from Fig. 1 lies at 30·3 atomic per cent lithium, which is not consistent with the extrapolation of the boundary reported at higher temperatures by Catterall[2].

As noted above, the diffraction pattern for alloy 1 indicated the presence of both the β-phase and a cubic structure of unit-cell side approximately 9·7 kX. The systematic absences and the relative line intensities may be accounted for by a structure with hirty-two atoms per unit cell as illustrated in Fig. 2. t is significant that the lattice spacing is nearly equal to $2\sqrt{2a}$, where $a$ is the lattice spacing of the body-centred cubic β-structure. In the basal plane (001) the atomic sites and distances are closely imilar to those in the (001) plane of the β-structure; thus the new structure may be regarded as formed by an expansion of the [001] direction in the cubic structure by a factor of $\sqrt{2}$, accompanied by ordering.

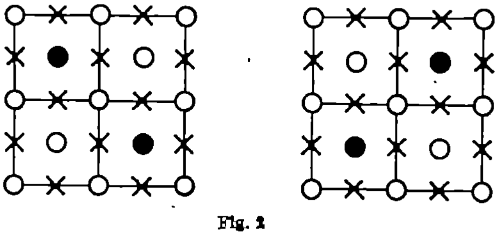

Fig. 2

○, Li } at heights 0 and $a$
●, Mg }
×, Mg at heights $a/4$ and $3a/4$

○, Li } at height $a/2$
●, Mg }
×, Mg at heights $a/4$ and $3a/4$

It is thus equivalent to a body-centred cubic arrangement, in which cube corners and two cube centres out of every eight are occupied by magnesium and the remaining sites by lithium, which has been stretched out vertically. This structure was not observed in the slowly cooled alloys 2 and 3, nor in the uncontaminated alloys 4–7, and is probably to be regarded as a transitional structure due to relatively short annealing times, and stabilized by impurities (oxygen and nitrogen).

It is of interest to note that alloy 8*a*, after comparably short annealing times, also showed a number of extra lines, which were almost completely absent from the diffraction pattern of alloy 8*b*. Such extra lines as were observed gave no indication of ordering near the equiatomic composition.

The new evidence available suggests strongly that no ordered structures exist at equilibrium in (α + β) alloys, or in alloys of composition in the range 30–34 atomic per cent of lithium, while no evidence for ordering at 50 atomic per cent lithium has been obtained.

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## Vesicular Laterite

Mr. G. Ap Griffith's contribution to the long-debated problem of the origin of vesicular laterite is welcome[1].

I am well acquainted with laterite beds and pavements in Ceylon and eastern and southern Africa, and I am aware of no case in which organic agency need be considered in the production of this very distinctive deposit. An up-to-date study of the subject is provided by Prescott and Pendleton[2].

More than forty years ago I watched Africans in the Mozambique Territory using laterite pellets, washed out of river banks by ephemeral streams, as shot for muzzle-loaders.

One might here record that both mature and semi-formed laterite can be found in certain places beneath the Kalahari sand in Bechuanaland. Stone implements may be found lying upon it, or otherwise associated with it, and examples of artefacts with fragments of the ironstone adhering to their worked surfaces are not wanting. The laterite so found is pre-Kalahari sand in age, and thus provides striking evidence of the pre-desert climate.

I have no doubt that Mr. Ap Griffith's solution of this laterite problem is correct, so far as it goes. Laterite pellets and nodules can be seen in process of formation to-day; but in many places optimum conditions for the production of vesicular laterite no longer obtain.

E. J. Wayland

The Athenæum,
Pall Mall,
London, S.W.1.

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[1] *Nature*, 171, 530 (1953).

[2] Prescott, J. A., and Pendleton, R. L., "Laterite and Lateritic Soils". Comm. Bureau Soil Sci., No. 47 (1952).

# FORTHCOMING EVENTS

*(Meeting marked with an asterisk * is open to the public)*

## Saturday, June 13

Association of Clinical Biochemists, Southern England and South Wales Region (at the Courtauld Institute of Biochemistry, Middlesex Hospital Medical School, London, W.1), at 1.30 p.m.—Demonstrations and Papers.

## Wednesday, June 17

Royal Meteorological Society (at 49 Cromwell Road, London, S.W.7), at 5 p.m.—Sir Charles Normand: "Monsoon Seasonal Forecasting" (Presidential Address).

University of London (in the Anatomy Theatre, University College, Gower Street, London, W.C.2), at 5.30 p.m.—Prof. S. R. K. Glanville: Flinders Petrie Centenary Lecture.*

## Thursday, June 18

Royal Society (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Messrs. A. W. Hanson, H. Lipson and C. A. Taylor: "Application of the Principles of Physical Optics to Crystal Structure Determination"; Messrs. J. Dutton, S. C. Haydon, F. Llewellyn Jones and P. M. Davidson: "Photo-ionization and the Electrical Breakdown of Gases".

London Mathematical Society (at the Royal Astronomical Society, Burlington House, Piccadilly, London, W.1), at 5 p.m.—Dr. E. S. Barnes: "Isolation Problems in the Geometry of Numbers".

Royal Society of Tropical Medicine and Hygiene (at Manson House, 26 Portland Place, London, W.1), at 7.30 p.m.—Annual General Meeting.

## Friday, June 19

Institute of Navigation (at the Royal Geographical Society, 1 Kensington Gore, London, S.W.7), at 5 p.m.—"The Accuracy of Wind Forecasts for Aviation".

## Saturday, June 20

Biochemical Society (in the Department of Biochemistry, The University, South Parks Road, Oxford), at 11 a.m.—Scientific Papers.

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# APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Entomologist in the Tsetse Fly Operations Branch, Department of Agriculture—The Secretary, Southern Rhodesia Government, Rhodesia House, 429 Strand, London, W.C.2 (June 20).

Laidon Foundation Fellowship in Organic Chemistry—The President, University College, Dublin (June 20).

Lecturer in Inorganic or Physical Chemistry, and a Lecturer in Civil Engineering—The Secretary, Queen's University, Belfast (June 20).

Lecturer in Microbiology (with special qualifications in microbiological chemistry or cell biochemistry, and have undertaken independent research in some branch of these subjects)—The Registrar, The University, Reading (June 20).

Lecturer in Psychology—The Secretary, The University, Aberdeen (June 20).

Senior Lecturer in Mathematics—The Registrar, College of Technology, Birmingham 1 (June 20).

Assistant Lecturer in Physics, and a Lecturer in Electrical Engineering—The Registrar, College of Technology, Manchester 1 (June 22).

Physicist (with honours degree in physics) for radio-isotope work in the University Department of Medical Physics—The Registrar, The University, Leeds 2 (June 22).

Psychologists in the Admiralty, Air Ministry, Civil Service Commission, and Prison Commission—The Secretary, Civil Service Commission, Burlington Gardens, London, W.1, quoting 76/53 (June 25).

Assistant (temporary) in the Department of Agriculture (Animal Husbandry)—The Registrar, University College, Aberystwyth (June 26).

Hospital Biochemist (with degree in chemistry or A.R.I.C.), and a Research Assistant (biological) (with degree in physiology or zoology)—*The Professor of Chemical Pathology*, Westminster Medical School, 17 Horseferry Road, London, S.W.1 (June 26).

Assistant Lecturer in the Department of Agricultural Economics—The Registrar, University College of Wales, Aberystwyth (June 27).

Lecturer or Assistant Lecturer in Geography at University College, Ibadan, Nigeria—The Secretary, Inter-University Council for Higher Education in the Colonies, 1 Gordon Square, London, W.C.1 (June 27).

Physicist (with *first- or second-class* honours degree or equivalent in physics) in the Metallurgy Department, Royal Aircraft Establishment, Farnborough, for work on X-ray diffraction of solids and liquids—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting A.186/53A (June 27).

Research Assistant in the Department of Botany—The Secretary, Birkbeck College, Malet Street, London, W.C.1 (June 27).

Assistant Experimental Officers in the Entomology an Weed Ecology Sections, and a Scientific Officer in the Irrigation Section—The Secretary, National Vegetable Research Station, Wellesbourne, Warwick (June 29).

Lecturer and an Assistant Lecturer in the Department o Leather Industries—The Registrar, The University, Leeds (June 29)

Assistant Agricultural Economist (with a degree in economics agricultural economics or agriculture) in the Eastern Province o the Provincial Agricultural Economics Service—The Secretary, Schoo of Agriculture, Downing Street, Cambridge (June 30).

Assistant Lecturer in Animal Physiology—The Secretary and Registrar, The University, Southampton (June 30).

Colville Fellowship in the Department of Chemistry—Th Professor of Chemistry, Royal Technical College, George Street Glasgow (June 30).

Graduate Students in Physics, Chemistry or Engineering for Research Scholarships (5) tenable at the Universities of Oxford Cambridge, London, Birmingham and Glasgow—The Secretary, Th Gas Council, 1 Grosvenor Place, London, S.W.1 (June 30).

Lecturer in Physiology, and a Demonstrator in Physiology—The Registrar, King's College, Newcastle-upon-Tyne (June 30).

Nuffield Research Studentships and Fellowships for experimental and theoretical research in nuclear and elementary particl physics—The Professor of Natural Philosophy, The University Glasgow, W.2 (June 30).

Senior Lecturer or Lecturer in Parasitology at the University of Malaya, Singapore—The Secretary, Inter-University Counci for Higher Education in the Colonies, 1 Gordon Square, London, W.C. (June 30).

Lecturer in Mining—The Registrar, King's College, Newcastle upon-Tyne (July 1).

Lecturer in Chemistry (with special qualifications in physica chemistry)—The Registrar, University College, Cathays Park, Cardi (July 4).

May and Baker Research Fellowship, for research on plan growth-regulating substances—The Registrar, Wye College, Wye Ashford, Kent (July 4).

Assistant in Experimental Physics—The Secretary, Th University, Aberdeen (July 8).

Senior Experimental Officer in the Ministry of Supply, Londo headquarters, for research and development of natural and syntheti aircraft textile materials in all forms, technical consultations wit industry and research organizations concerning selection of material manufacturing and user problems, and the preparation of specification —The Civil Service Commission, Scientific Branch, Trinidad House Old Burlington Street, London, W.1, quoting S.4216/53 (July 8).

Assistant in Statistical Research—The Secretary, Facult Board of Economics and Politics, The Marshall Library, The University, Downing Street, Cambridge (July 15).

Lecturer or Senior Lecturer in Philosophy at Canterbury University College, New Zealand—The Secretary, Association o Universities of the British Commonwealth, 5 Gordon Square, London W.C.1 (July 15).

Senior Research Awards for investigations on the followin aspects of locust physiology: (*a*) nutrition, with a view to developin a fully sufficient artificial diet, (*b*) vision and visual responses, (*c*) hea and/or water metabolism—The Director, Anti-Locust Research Centre c/o British Museum (Natural History), Cromwell Road, London, S.W. (September 1).

Plant Pathologist (with a wide knowledge of plant patholog in all its branches and, preferably, with tropical experience; an some aptitude for, and interest in, taxonomic work) in the Commonwealth Mycological Institute—The Secretary, Commonwealth Agricultural Bureaux, Farnham Royal, Bucks (September 15).

Assistant (Grade A) in Physics—The Principal, Technical College Queen Street South, Huddersfield.

Assistant Lecturer in Agricultural Chemistry (with specia qualifications in animal nutrition), and a Demonstrator in Agricultural Chemistry, in the Department of Agricultural Science School of Agriculture, Sutton Bonington—The Registrar, The University, Nottingham.

Biochemist or Clinical Biochemist interested in human biology to assist Dr. J. M. Tanner in investigation of metabolic and endocrinological differences in man, their genetical bases, and their development during childhood—Prof. H. Barcroft, Sherrington School o *Physiology, St. Thomas's Hospital, London*, S.E.1.

Chemist at a Ministry of Supply Research Establishment nea Sevenoaks, for inorganic analysis—The Ministry of Labour an National Service, Technical and Scientific Register (K), Almac House, 26 King Street, London, S.W.1, quoting F.228/53A.

Educational Psychologist (woman)—The Director of Educatio County Education Office, Castle Street, Worcester.

Investigator (with degree in metallurgy, physics, or engineerin or equivalent qualification) in the Department of Industria Metallurgy, *for research on elastic properties of spring materials*—The Registrar, The University, Birmingham 15.

Metallurgist (with first- or second-class honours degree or equivalent in metallurgy, and at least three years postgraduate researc experience) in the Ministry of Supply, London Headquarters—Th Ministry of Labour and National Service, Technical and Scientif Register (K), Almack House, 26 King Street, London, S.W.1, quotin F.245/53A.

Principal of Bhavsinhji Polytechnic Institute, Bhavnag (Bombay Region), *India*—The Ministry of Labour and Natio Service (A.S.12), Almack House, 26 King Street, London, S.W. quoting A.12/I.84B/53.

Scientific Assistant (with good knowledge of physics and rad maintenance) for service in the Antarctic with the Falkland Islan Dependencies Survey—The Crown Agents, 4 Millbank, London, S.W. quoting M3B/33763/TA.

Senior Geneticist (with good honours degree in botany or oth natural science, with some years experience of plant breeding a *genetics*) at the West African Institute for Oil Palm Researc —The Director of Recruitment, Colonial Office, Great Smith Stree London, S.W.1, quoting CDE.37/11/03.

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# SCIENTIFIC INSTRUMENTS IN RESEARCH AND INDUSTRY

THE recent Exhibition of the Physical Society is still a lively memory and it will be followed by the second British Instrument Industries' Exhibition, which is to be held at Olympia, London, during June 30–July 11. These two Exhibitions, while necessarily having a considerable amount of common ground, have essentially different backgrounds, and it is the two Exhibitions in combination which furnish a complete picture of the functions of scientific instruments at the present time and of the revolutionary changes which have taken place in those functions during the past two or three decades. While some users of instruments may feel that their interests lie entirely in the Physical Society's Exhibition and while others may feel that the British Instrument Industries' Exhibition, with its more utilitarian atmosphere, is more likely to be of value to them, yet a better spirit of understanding between the users and manufacturers of instruments might well be fostered if visitors to the recent Physical Society's Exhibition were to complement their experience by visiting the Exhibition to be held at Olympia.

In the application of science to utilitarian purposes, the use of scientific instruments has always played a major part; and it is therefore not surprising that the technological developments which have taken place during recent years in almost every sphere of human activity and endeavour have been accompanied by very drastic changes in instrument design and by a very considerable expansion of the field of instrument use. The original purpose of the founders of the Physical Society's Exhibition was to give Fellows of the Physical Society, and others interested in physics, an opportunity of seeing the current impact on instrument design of established principles of physics and of advances in physical knowledge. At that time the scientists, for the benefit of whom the Exhibition was staged, were, in fact, the main users of scientific instruments. This main purpose of the Physical Society's Exhibition still provides the guiding principle governing its organization, and although the field of use of instruments has extended far beyond the confines of the scientific world, and although the main user of instruments is no longer the man of science, yet a demonstration of the impact of scientific knowledge on instrument design is still clearly to be discerned at the Physical Society's Exhibition. On the other hand, the main purpose of the British Instrument Industries' Exhibition is to indicate the impact which the use of scientific instruments can make on the carrying out of industrial processes, on the precision of engineering and, in fact, on every department of life on which the hand of technology has been firmly placed in this present age. In other words, the Physical Society's Exhibition still, to some extent, reflects the old scientific use of instruments: the Exhibition to be held at Olympia reflects the new use of instruments, which is now far more widespread than the old.

A survey of the whole field of instrument manufacture would reveal that the accurate measurement of physical quantities is no longer the sole function of a very large proportion of instruments, although they may well be capable of making such measurements. The main function of these instruments is to utilize this property of precise measurement for some ulterior purpose; an example coming immediately to the mind is the continuous recording or control of temperature. With the conversion of instruments from measuring devices to controlling mechanisms, the border-line between instrument making and engineering has become very obscure. It is, however, still true that the most fruitful source of ideas which may eventually be incorporated in some new form of instrument is the science research laboratory; and one of the difficult problems of instrument manufacture to-day is to provide investigators in the various fields of science with the particular and peculiar instruments required by them, while at the same time meeting the demands imposed by the adoption of the scientific instrument as a major tool in industry.

It should be remarked that the research worker has himself reaped considerable advantage from the great demand which exists for instruments in the new fields of use. The character of academic research laboratories has been subject to changes no less striking than those which have occurred in the instrument and technological spheres. The urgency of research and the increased complication of the apparatus used in research have combined to limit the possibility of relying, for the building of research gear, mainly on internal mechanical resources and the skill of the researcher's hands. One characteristic of modern research laboratories is the great use made of commercial scientific instruments, and it is largely true that it is the demand for instruments from outside the scientific world which has given to the instrument industry the resources for the creation of development and research facilities, without which the almost bewildering variety of types of instruments, capable of use in so many directions, would never have been produced. To that extent the research worker has gained by the changes which have occurred in the use of instruments; but, nevertheless, the clamant demand for instruments outside the laboratory makes it difficult to produce the instruments, often of a very special character, required inside the laboratory, and presents to the instrument manufacturer a problem to which a completely satisfactory solution is difficult to find.

From the commercial point of view, it is probable that the demand of the science research worker for instruments is of less importance than the demand for instruments from utilitarian sources. Since, however, the basic raw material of scientific manufacture is scientific knowledge, it is of the highest strategic importance that the research worker should not be handicapped by having to use instruments not specially relevant to his purposes. It should be remarked that the effort given within the industry to the making of what are known as 'research instruments' is very considerable; but the problem of supplying on an economic basis instruments o very special character for which the demand can, the nature of the instrument, only be very small, a very real one and demands that the maximu degree of adaptability and flexibility should be fou both in the user and in the manufacturer. To t end a common knowledge of the problems of bo user and producer cannot but be helpful, and c tainly the British Instrument Industries' Exhibitic taken in conjunction with the Physical Societ Exhibition, should give the man of science an insig into the breadth of the commitments of the instrume industry.

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# TRIALS AND TRIBULATIONS OF CYTOCHEMISTRY

## Cytochemistry

A Critical Approach. By Prof. J. F. Danielli. (Wil
Biological Research Series.) Pp. ix+139+12 plate
(New York: John Wiley and Sons, Inc.; Londo
Chapman and Hall, Ltd., 1953.) 32s. net.

CYTOCHEMISTRY, even enzyme cytochemistr is not as recent a development as many peop seem to imagine; Nadi oxidase and Dopa oxida reactions demonstrate that. The specific chemic delineation of cellular constituents is, in fact, mo than a hundred years old, and before the developme of aniline dyes investigations of this type were bei actively pursued. The introduction of a vast ne series of dyestuffs and the ease with which they ma possible the delineation of structure led to a co centration on cell morphology and the introductic of a spurious chemical nomenclature for cell co stituents, and the older work was discontinued. I the past thirty years, however, the development new techniques, new apparatus, new chemicals a new ideas has led to a rebirth and intensification cytochemical research. At the beginning of th Second World War the development by Gomori a by Takamatsu of a new technique for histo- and cyt chemical localization of phosphorolytic enzymes le to an amazing burst of interest in, and work c phosphatase, and resulted in a spate of publicatio on this subject. It was fatally easy to obtain resul with a technique like that for alkaline phosphatas and it became obvious that some of the publishe work had been carried out by those who thought the phosphatase reaction simply as just anoth cytological staining technique without appreciati the chemistry and physics of what they were doing.

In the past few years a number of workers ha sought to remedy this fact and in some cases th themselves have reacted too far in the opposi direction and brought the phosphatase technique in a state of undeservedly ill repute. So far has th gone that statements have even been made that th phosphatase technique gives no indication at all the intra-cellular distribution of the enzyme.

The time was obviously ripe for a careful a detailed consideration of this and other histochemic techniques, and the appearance of a work of th nature by J. F. Danielli is timely. His work divided principally into four main studies: alkaline phosphatase, on aldehydes, on proteins, a on nucleic acids. These studies are prefaced by introductory chapter and by one on fixation, a they are followed by a consideration of quantitative cytochemistry and a forecast of the cytochemical future.

There is no doubt that Prof. Danielli has produced a critical and balanced account which is of great value. The work in general is free of bias and all points of view are given fair treatment and comment. However, it is not surprising if the reviewer does not agree wholeheartedly with the statement on p. 2 that "A good training in histology is one of the worst backgrounds possible for cytochemical work". The same comment would apply with equal force to many other specialities, and many of the cytological contributions of biochemists make it quite obvious that a thorough study of Wilson's "The Cell in Development and Heredity" should be compulsory for them as well as for histologists, and also for others who seek to embark lightly and untrained on a voyage into a region which is fraught with the most peculiar dangers and bristles with traps for the uninitiated and the unwary. It seems likely, however, that Prof. Danielli, in making his statement, is really referring to those who think that "anyone who can cut a tissue section and make up a standard solution is competent to carry out cytochemical investigations", and if this is the case the reviewer would agree with him. He also utters a particular word of warning against the too facile acceptance of the results of differential centrifugation of cell homogenates, and although recent cytochemical results have supported some of this work such a warning at this stage is highly desirable. The discussion on the phosphatase reaction is comprehensive and critical, but the section on aldehydes, although valuable, could have been expanded with advantage. There is also, for the first time to the reviewer's knowledge, a useful evaluation of Caspersson's work—apart, of course, from those which deal with it from an optical point of view. Prof. Danielli's explanation of the significance of phosphatase for cell penetration in which he postulates that phosphatase acts as an enzymic centre of a contractile protein is most ingenious, and one looks forward to further experimental support or this idea.

From the date of the preface and from the dates of the references it is obvious that the manuscript of his work has spent an unusually long time in the press, which is a pity. Nevertheless, Prof. Danielli has produced a readable, critical work on a subject which badly needed a critical approach, and no person arrying on histo- or cyto-chemical investigation hould fail to read it. Geoffrey H. Bourne

## DESCARTES

**The Scientific Work of René Descartes (1596–1650)**

By Dr. J. F. Scott. Pp. x+211. (London: Taylor and Francis, Ltd., 1952.) 21s. net.

DESCARTES, like his contemporary Pascal, enjoys a great dual reputation, though only a few of those who study his work are aware that he has the right to more than one. An enigmatic personality, because much of his life-story is obscure, his character is rendered even more puzzling by what we know of it. Paradoxically, the man who, in the Discours de la Méthode" and its accompanying treatises on physics, geometry and algebra, gave to the world a synthesis of scientific principles and a isplay of their application comparable to the great medieval compilations, was in temper and outlook far removed from both the equably minded philosopher and the modern scientist. It is perhaps understandable that he should have avoided controversy and defended his priority by making "La Géométrie" too difficult for most of his contemporaries to comprehend—a method superior to Newton's, which consisted in merely withholding publication; but it is curious, to say the least, that he could find no merit in Galileo, Fermat or Pascal, and that he invariably denied all credit to his predecessors, even when his indebtedness to them was obvious and considerable.

However, what is more relevant to an estimate of Descartes's scientific contributions is the specific point of view of their author. By the time that Descartes was composing his first great work, Renaissance thought had made its mark upon mathematics; fundamental advances in algebra were nearly a century old, and Galileo had already formulated his ideas on dynamics. Yet although Descartes may justly be described as one of the founders of modern mathematics, he is more strikingly a child of the past, and especially of the Schoolmen. Thus, while he sought for mechanical explanations of natural phenomena—and in the field of optics actually found them—his scientific procedure was rational chiefly in Whitehead's sense of the word; according to Descartes (and also to some of our contemporaries) the function of experiment is not to provide a basis for theoretical superstructure, but to confirm notions already conceived *a priori*. It can only have been by this route that Descartes arrived at his theory of vortices, which at once became enormously popular as an all-embracing explanation of the universe, and for more than a century resisted all attempts to dislodge it: as late as 1730, no less a person than Jean Bernoulli published an essay denouncing Newton's theory in its favour.

Such misjudgments in a realm where, as the history of astronomy seems to show, one man's guess is almost as good as another's, are, however, to be found in other branches of Descartes's work. Thus his treatise on analytical geometry, which initiated the modern approach to the subject, only partially aimed at reducing geometrical problems to algebraic form: Descartes was equally concerned to reverse the process, in the true spirit of the Greeks. Again, his solution of the problem of drawing a tangent to a curve—one of the foremost questions of the day—began by constructing the normal. His companion treatise on algebra, which effected great improvements in notation, suggests at the same time that the author himself was scarcely ready for all of them: although he employed literal coefficients and enunciated the rule of signs for algebraic equations, it is evident that he was even less happy with negative numbers than were some of his forerunners.

All things considered, it seems fair to say that Descartes's work has achieved importance despite the obscurantism, intentional or otherwise, of its expositor. The present account of it by Dr. J. F. Scott, who is already known for his interesting book on John Wallis, treats the subject sympathetically while not attempting any unjustifiable defence. It begins with a sketch of Descartes's life and a general survey of his work, and then proceeds to analyse each of the treatises in detail. These cover such a wide range that there is something for every scientific taste; mathematicians, in particular, will be fascinated by the descriptions of Descartes's methods in geometry and algebra, which include a welcome account of the problem of the *locus ad quatuor lineas*, from which, it is believed, co-ordinate geometry was born.

The book is copiously illustrated; and the author has had the happy idea of including brief biographies of all the minor personalities mentioned in the text. Printing and binding are excellent. L. ROTH

# CRYSTALLOGRAPHICAL STRUCTURE REPORTS FOR 1949

Structure Reports for 1949

Vol. 12. General Editor: A. J. C. Wilson. (Published for the International Union of Crystallography.) Pp. viii+478. (Utrecht: A. Oosthoek's Uitgevers Mij., 1952.) 45 Dutch florins.

THE format of Vol. 11—as the prototype of the new series of "Structure Reports" published by the International Union of Crystallography—excited almost as much interest at the time of its publication as the structural data it contained, for with it there reappeared a valuable series of reference works upon which one may confidently rely.

With the appearance of Vol. 12, one can turn directly to the contents, since it was prepared by the same editors more-or-less concurrently with Vol. 11 and is strictly isomorphous with it, being strongly bound, well printed, adequately illustrated and extremely comprehensive; the arrangement within individual reports is, as before, name, formula, papers reported, unit cell, space group, atomic positions and parameters, interatomic and intermolecular distances, material, discussion, details of analysis and references. Happily the editors have been entirely successful in providing this wealth of detail without that sacrifice of clarity which makes the extraction of information from some reference books almost a kind of parlour game.

It is a striking indication of the potentialities of structural crystallography that the work reported in this volume represents the output of but a single year—a prodigious quantity even after allowance has been made for the publication of work carried on during the War, such as the investigation of penicillin and of many of the compounds of the trans-uranium elements. Current trends are everywhere discernible; for example, in the organic section, there are reports on the increasingly accurate determinations of the structure of aromatic hydrocarbons now available for comparison with quantum mechanical calculations, while in the inorganic section are some of the first-fruits of the neutron diffraction experiments, such as the structure of $UH_3$—a most unpromising substance for a crystallographer equipped only with X-rays. There are also reports of structure determination from single-crystal electron diffraction patterns.

One striking thing is the steady increase of symmetry from the frequently monoclinic or even triclinic crystals of organic compounds through the mainly orthogonal lattices of the inorganic section to the predominantly cubic structures of the metals section. This high symmetry is a valuable asset when one realizes how much of the work on alloys is done with powders. Occasional references to as yet unindexed patterns of high complexity remind us that a really satisfactory generalized solution of powder patterns of any symmetry is still required, in spite of some recent advances. As regards technique, however, one wonders whether the statement on p. 231, that "Absences, observed on Laue and oscillation photographs, show the above space group" ($P2_12_12_1$), indicates an unusually ingenious experimenter, or merely a tired abstractor.

The fullness of these structure reports makes the volumes particularly useful for rapid surveys of special topics in which one is currently interested—such as carbon–sulphur bond-lengths, or the frequency of polymorphism among organic crystals. Since useful ideas can be quickly substantiated in this way, and unprofitable speculations as rapidly deflated, such books are a constant challenge to review the data from some novel point of view, and thus a powerful stimulus to us all to avail ourselves of the rich diversity of experimental material now available as a starting-point for new adventures into the unknown. H. J. GRENVILLE-WELLS

# STRUCTURAL LINGUISTICS

Methods in Structural Linguistics

By Zellig S. Harris. Pp. xv+384. (Chicago: University of Chicago Press; London: Cambridge University Press, 1951.) 56s. 6d. net.

THE basic concept of structural linguistics is substitutability, and the nature of the subject may be explained by the two following examples. First, in the English word ***kingcup***, the two [k]-sounds are well known to be different (I write $k_1ingk_2up$); if, now, the philologist, interchanging them, says $k_2ingk_1up$ to a native English speaker, he is told that the interchange is immaterial; if, however, he substitutes the initial sound of ***man*** for $k_1$, producing $mingk_2up$, he is told that the interchange is not immaterial (for a ***Ming cup*** is not a ***kingcup***). By this procedure the philologist has learnt that there is an essential difference between the distinction $k_1/k_2$ and the distinction $k_1/m$; he therefore makes one 'phoneme' [k], materializing in at least two forms $k_1$ and $k_2$, and another, different phoneme [m]. Secondly, the informant will allow the substitution of *from* for *to* and will not allow that of *dog* for *to* in the phoneme-block *Come to London*; in this way the philologist learns that *to* and *from* are 'morphemes' of the same kind and that *dog* is a different kind of morpheme from *to*.

Prof. Z. S. Harris's long and complicated book is essentially devoted to the problems indicated by the above two examples. He describes how the phonemes and morphemes of a language may be set up by the sole aid of a native informant (as an example of the first procedure, he sets up the phonemes of Swahili). His account of the concepts and methods is entirely lucid; regrettably, the book lacks an index of authors cited—were such an index made, many philologists might feel that it contained an undue proportion of American names.

Structural linguistics appears, rather refreshingly, to have little theory underlying it; it is a purely practical discipline, and it therefore stands or falls solely according to whether it does or does not accomplish what it purports to—that is, to extract the phonemes and morphemes of a hitherto unstudied language. With regard to phonemes, the 'cross-word puzzle' method which Mr. J. Josephs and I advocate is undoubtedly greatly superior to the structural linguistic method, but our method suffers from the grave disadvantage that it can only be applied to languages which possess at least one speaker who appreciates, or who can be trained to appreciate, the nature of the concept 'phoneme'; of the world's languages, approximately ten thousand in number, perhaps not more than five hundred possess such a speaker. The structural-linguistic method depends entirely upon getting the 'right' response to a substitution from a native informant; presumably, the latter can make three different responses: 'immaterial' (*$k_2$ingk$_1$up* for *$k_1$ingk$_2$up*); 'not permissible' (*hingk$_2$up* for *$k_1$ingk$_2$up*)—[k] and [h] are different phonemes in English; and, 'it alters the meaning' (*Ming cup* for *kingcup*). Can we really be sure that native informants will always distinguish clearly between these three responses? The structural-linguistic method *could* be tested against the cross-word puzzle method (though, so far as I know, it has not yet been); Lappish, with its highly complex phoneme-system, would be an excellent language for the test; we could use the structural-linguistic method on a 'primitive' kind of Lapp and see if the results agreed with those obtained, on the cross-word puzzle method, by a Lapp of, say, Ph.D. standard (at least one such exists).

ALAN S. C. ROSS

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Josephs, J., and Ross, A. S. C., "Triangular Tables for the Phonemes of English", *Archivum Linguisticum*, 1, 41 (1949).

# FLORA AND VEGETATION OF IRELAND

Die Pflanzenwelt Irlands (The Flora and Vegetation of Ireland)

Ergebnisse der 9 Internationalen Pflanzengeographischen Exkursion durch Irland 1949. Redigiert von Werner Lüdi. (Veröffentlichungen des Geobotanischen Institutes Rübel in Zürich, Heft 25.) Pp. 421. (Bern: Hans Huber, 1952.) 26.50 francs.

THE International Phytogeographical Excursion of 1949, held in Ireland under the leadership of Prof. D. A. Webb and Mr. G. F. Mitchell, was attended by twenty-three botanists of some twelve different nationalities, and was the ninth of a series of meetings of specialists in plant ecology which have done much to promote international understanding in a field where opinions tend more than usually to differ.

The present volume begins with a narrative of the Excursion and a report on the "Second Conference of Pollen Workers" which took place afterwards in Dublin; these are followed by short but authoritative accounts of Irish geology and the Irish flora, by Mr. Mitchell and Prof. Webb respectively, then by ten original contributions by K. Jessen, Max Welten, J. Heslop-Harrison, I. Markgraf-Dannenberg, F. Markgraf, H. Gams, F. Firbas, J. Braun-Blanquet, R. Tüxen and W. Lüdi (who edited the whole volume).

Among the topics dealt with are the pollen analysis of Irish peat, Irish dactyloid orchids, oceanic bryophytes and Irish woodlands. In an interesting account of Irish *Festuca* races, I. Markgraf-Dannenberg records an interesting addition to Ireland's Mediterranean flora, *F. ovina* ssp. *indigesta* (Boiss.) Hack., previously known only from the French Pyrenees and the Iberian Peninsula. In another paper Dr. Braun-Blanquet refers to a distinct race of *Antennaria dioica* found on the Irish eskers, which he has described elsewhere as *A. hibernica*.

Dr. Lüdi has some interesting comments to make on the different habitats, in Switzerland and Ireland respectively, of *Empetrum nigrum*, *Calluna*, *Sedum roseum* and other plants. In an article mainly concerned with the well-known problem of the occurrence of the usually basiphilous *Schoenus nigricans* in ombrogenous Irish bogs, Prof. Firbas refers to the view, originally proposed by Nilsson-Ehle, that the xeromorphy of bog plants is related to mineral starvation rather than to water shortage.

The history of the Irish flora is a constantly recurring theme in many of the contributions. Dr. Jessen, in a paper summarizing his own researches on the late Quaternary deposits, points out that in Zone III of the Late Glacial, Ireland was to the north of the polar timber line; nevertheless he thinks it possible that the American and most of the Lusitanian species (except woodland plants such as *Arbutus*) may have been able to survive the last glaciation in favourable places, an opinion with which several other contributors seem to agree.

By far the longest chapter in the book is the description by Dr. Braun-Blanquet and Dr. Tüxen of the plant communities met with during the Excursion. Since a very representative fraction of Ireland was traversed, almost every plant community above the tide-mark is dealt with. This contribution will be greatly appreciated by British ecologists, since communities with which they are familiar (those of Ireland being in the main similar to those of Great Britain) are classified here according to Dr. Braun-Blanquet's well-known system; thus for the first time we have an excellent basis for forming an opinion on its much-debated merits. It is impossible to discuss this question here, but it is perhaps worth directing attention to the extreme artificiality of a scheme which names one of its major divisions ('*Potentilletalia caulescentis*') after a species which does not occur within some seven hundred miles of Ireland, and divides into several widely separated categories the communities which are normally found successionally connected and spatially contiguous on sand-dunes. On the other hand, it must be freely admitted that Dr. Braun-Blanquet's clear and methodical procedure represents something still missing in British ecology. May we hope that a method of classifying vegetation may yet be developed which will retain this desirable feature without the artificiality?

British ecology has been insular for too long, and in Britain we have much to gain by realizing that our plant communities are for the most part impoverished versions of those better and more extensively developed on the Continent. It is as a help towards this end that this report of the Excursion is valuable, and we may be particularly grateful for the comparisons with France, Spain and other countries which the unrivalled experience of Dr. Braun-Blanquet and Dr. Tüxen enables them to make. Naturally, the hurried impressions of three weeks are not always accurate: several contributors stress as peculiarly Irish features which are equally well displayed in western Scotland and Wales—for example, it is not only in Ireland that the two species of *Hymenophyllum* grow together. Nevertheless, the British ecologist will be grateful to the contributors to this volume, for helping him to see his own vegetation as others see it.

P. W. RICHARDS

# THE ROYAL BOTANIC GARDENS, KEW

## CENTENARY OF THE HERBARIUM AND LIBRARY

THE modern history of Kew began in 1841 when the Royal Gardens became a government institution and William Jackson Hooker, professor of botany in the University of Glasgow, was appointed director. There was then neither herbarium nor library at Kew and the new director brought with him his own collections and books. In 1853 Miss E. Bromfield presented to Kew the Herbarium and Library of her late brother, Dr. W. Arnold Bromfield, and these formed the nucleus of the present Herbarium and Library. In 1854 George Bentham gave his valuable collections to be added to the Bromfield Herbarium and Library, and in 1866 the Government purchased the private collections of Sir W. J. Hooker. The Bentham and Hooker Herbaria, together with new collections that quickly began to be sent to Kew, led to the rapid growth in size and importance of the preserved botanical collections and the essential library. To these early donors or collectors Kew owes a double debt: the richness of the Herbarium in early types and the complete runs of many valuable periodicals in the Library. In addition, the Hookers and Bentham, by the excellence and number of their published researches, made Kew the world centre of botanical, and especially of botanical systematic, studies. The Herbarium now contains some six million 'specimens' and the Library more than fifty thousand volumes.

Since it was in 1853 that the Bromfield collections were presented, it is appropriate that the centenary of the Herbarium and Library at Kew should be celebrated in 1953. To mark the occasion an exhibition of specimens, books, manuscripts, diagrams, photographs, drawings, etc., was arranged in the three wings of the Herbarium and in the Library. Official guests, individual scientists, university students, and members of many scientific societies visited the exhibition during the period May 7–9. The theme of the exhibition was the research carried out at Kew during the past hundred years, and particularly that in connexion with the systematics of plants. About fifty separate but interconnected series of exhibits, some of them extensive, were staged by members of the staff, who ably demonstrated their special subjects.

The early period of Kew, and of the Herbarium and Library in particular, was illustrated by photographs, plans, drawings, and original items of historical interest. The unbroken sequence of administration could be followed through the periods of directors from Sir W. J. Hooker to the present director, Sir E. J. Salisbury, and of keepers from Prof. Daniel Oliver to the present keeper, Dr. W. B. Turrill. It was clearly shown that, in addition to carrying the burden of administration, now greatly increased, both the directors and keepers contributed considerably to botanical knowledge by their own researches.

The work of the Herbarium is divided into departments on a double basis, purely systematic and phytogeographical. The systematic divisions were well illustrated by the work done at Kew on the cryptogams. Collections of Algæ dating from the voyages of H.M.S. *Erebus and Terror* and of H.M.S. *Challenger* were on view as well as those used by well-known algologists. The taxonomy of fungi has received much attention at Kew during the past century, and the collections and work of Cooke, Massee, Wakefield, and others attract many mycologists to study, often for long periods, in the Herbarium. Selections from types of W. J. Hooker to recent additions illustrated the rich material of liverworts and mosses preserved in the Herbarium and now being revised. The pioneer investigations of W. J. Hooker and J. G. Baker on the ferns and fern allies greatly enriched Kew in type specimens. Examples of their materials and the results of their researches were contrasted with a fine collection of living plants of twenty-six genera of ferns recently gathered in Ceylon and now being grown at Kew. This was only one of many exhibits showing the facilities existing, and utilized, at Kew for linking together the study of living plants with the examination and comparison of numerous preserved specimens of diverse origins.

There are at Kew specialists for the orchids and grasses, but most of the work carried out on the seed-bearing plants is divided on a geographical basis. Monographic studies have not been neglected; but, partly because of the need for development of what are now Dominions, Colonies, or Protectorates, a major item in the policy at Kew has been, and still is, to prepare Floras of areas usually with political boundaries. These sometimes coincide closely with phytogeographical divisions, but are sometimes more or less artificial. The practical advantages of having accounts complete to date of publication, with descriptions, keys to determination of taxa, summaries of known range and distribution, etc., for this or that portion of the Commonwealth, needs no emphasis. Their preparation should naturally be a British enterprise and, moreover, involves no competition with either the preparation of floras for other parts of the earth's surface or with that of systematic monographs such as those of the "Pflanzenreich".

In preparing the centenary exhibition, members of the staff had a wealth of material from which to select subjects to illustrate the contributions of their predecessors and themselves to floristic research. A tabulation based on a map of the world listed forty-one Floras prepared entirely or largely at Kew. These ranged from single volumes, as those of Bentham and Hooker "Handbook of the British Flora", or the 'Flora Simlensis", to the many volumes of the 'Flora of British India" or the "Flora of Tropical Africa". A complete survey of the floristic and phytogeographical interests of past and present members of the Kew staff, and of other botanists who have carried out much of their work at Kew, would occupy much space, and here only a brief account of some of the collections and of work published as a result of investigations conducted at or in connexion with Kew can be given. Since the time of Bentham and Hooker, many members of the Herbarium staff have carried out field studies on the British flora as a recreation, mainly concentrating on a few special families such as those of the orchids, sedges, and grasses or detailed investigations of smaller groups. The Herbarium, in fact, contains valuable special collections of British plants such as those of Bromfield, Lightfoot, Borrer, and Watson. It happens that three or four species new to the British flora have quite recently been first recorded from material sent or brought to Kew. Specimens of these were exhibited. The flora of Europe and the Orient (Nearer East) is well represented in the collections, and researches, especially on the plant life of the Balkan Peninsula and Cyprus, have been published in book form and in series of papers. The rich harvest of plants from China garnered by Henry, Wilson and other famous collectors must be consulted by students of plants of the Far East, and its importance is enhanced by the many species introduced into horticulture. The "Index Florae Sinensis" is based almost entirely on material at Kew. The service of J. D. Hooker to our knowledge of Indian plants must always be acknowledged since it culminated in the classic "Flora of British India". This was followed by the publication of a series of more local floras, many of which were prepared at Kew. The plants of Siam were largely worked out by a former member of the Kew staff, and the "Flora of the Malay Peninsula" is indissolubly linked with Kew.

The greater part of the continent of Africa has been covered botanically by Kew publications, including the "Flora of Tropical Africa", the "Flora Capensis", the "Flora of West Tropical Africa" (now under revision), Hooker and Ball's work on Morocco, and numerous other books and papers. Publication of the "Flora of Tropical East Africa" has recently begun. Exhibits connected with these and other floristic researches consisted of dried specimens, living plants (many illustrating special morphological features or peculiar physiological behaviour), statistical tables, drawings and paintings, methods of collecting, and of printed books and papers.

Bentham's "Flora Australiensis" and J. D. Hooker's Floras of the southern hemisphere together form the foundation of all subsequent studies of the flora of Australasia. Much of the later floristic research has been carried out by Australian and New Zealand botanists at their own institutions; but Kew has always maintained the happiest relations with them and a great interest in their work, and they continually add new specimens to the extensive representation. Samples of the collections recently made in the Montebello Islands were exhibited.

Apart from early researches on the floras of temperate North America and Central America, relatively less work has been done at Kew on American botany than on the plants of other continents. Exceptions to this generalization are the continued investigations concerning the botany of Trinidad and Tobago and British Guiana.

Mention must be made of Kew's contribution to the general classification of flowering plants as exemplified in the "Genera Plantarum", the "Index Kewensis", the new arrangement in "Families of Flowering Plants", and the contribution of members of the staff to the modern International Rules of Plant Nomenclature. Exhibits connected with these were varied and instructive.

The Kew collection of drawings, paintings, and photographs of plants is the most comprehensive in the world. Fine series illustrative of the work of both Kew artists and of that of others from the fifteenth century to the present day formed a notable feature of the exhibition. Other special exhibits illustrated researches (including cytological) in connexion with the National Dianthus Collection, the methods of preserving plant materials, the organization of herbarium work, the use and preparation of Floras, plant teratology, researches on the genus *Utricularia* and on *Bromus carinatus*, the use of genetics in taxonomy, and the introduction of plants to horticulture.

The researches carried out by the Herbarium staff at Kew are mainly taxonomic in the widest sense of this term. Modern taxonomy includes more than describing and naming dried specimens. The close co-operation of the Herbarium staff with that of other departments of the Royal Botanic Gardens, Kew, was evident in the numerous well-chosen examples of living plants from all parts of the earth and all connected with researches carried out by past or present scientists at Kew. Again, the importance to taxonomists of anatomical and physiological characters was emphasized by a large exhibit of apparatus, slides, and accounts of experiments staged from and illustrative of the work of the Jodrell Laboratory. Though the work at Kew is primarily scientific research, problems of immediate economic importance are often closely linked with and sometimes lead to special investigations. Samples of such connected with timber, fibre-, perfume- and oil-producing plants, species yielding drugs, and crops of various kinds were on view with the published results.

In the Library, visitors were able to see many of the valuable books from the libraries of Bromfield, Bentham, and W. J. Hooker, as well as others more recently acquired. Old herbals, manuscripts, diaries, and original drawings were also on view. Books purchased by the Bentham–Moxon trustees add greatly to the usefulness of the Library. A special exhibit showed some of the books written by members of the Kew staff and of the periodicals prepared at and, in part, published by Kew: the *Kew Bulletin*, *Icones Plantarum*, "Index Kewensis", and (edited at Kew for the Royal Horticultural Society) the *Botanical Magazine* and the "Index Londinensis".

# SIZE AND SHAPE OF MACROMOLECULES*

By Prof. H. W. MELVILLE, F.R.S.

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POLYMER molecules of natural or synthetic origin can be generally classified as linear, branched or cross-linked. Sometimes these molecules are referred to as one-, two- or three-dimensional, respectively, the reason being that a linear molecule may be varied in length over a very considerable range, from a matter of a few angstroms up to as much as nearly a hundred thousand. Similarly, a two-dimensional molecule if placed on a plane surface may be extended in two directions up to the same kinds of limit. Correspondingly, a three-dimensional molecule may extend, without limit, in three dimensions. In this last-named case it is true to say that any isolated piece of polymer may represent one giant molecule, though in many actual cases there may be embedded in the three-dimensional array of atoms linear and branched-chain molecules, produced as a result of the synthetic process.

Progress in determining the size, shape and structure of these types has been very uneven, and this account is confined to a discussion of the problems that arise in dealing with molecules of synthetic origin only. Generally speaking, there are innumerable ways of building up linear molecules, the linearity of structure being assured by the chemistry of the synthetic process. It is equally easy to build up three-dimensional structures either by cross-linking linear molecules by suitable chemical methods, as in the vulcanization of rubber, or by choosing starting materials that would ensure the formation of three-dimensional molecules right from the beginning. The progress of synthesizing and characterizing the intermediate type of two-dimensional molecules proves to be very much more difficult, and little information is yet available about such substances. One-dimensional molecules are soluble in solvents, and hence it is possible to determine size, shape and often detailed structure comparatively easily. Three-dimensional molecules do not dissolve; at the most they only swell in suitable solvents, and hence the methods available for their study are very limited.

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* Substance of a Friday Evening Discourse given at the Royal Institution on March 20.

Linear molecules range in molecular weight from a few hundreds up to about ten million. In the low range, molecular weight can be measured by the classical methods of lowering of vapour pressure, though specially sensitive instruments are needed to measure the very small lowering of vapour pressure if, for example, the molecular weight rises to values of above twenty thousand. Small elevations of the boiling point can be measured by multiple-junction thermocouples to $10^{-4}$ deg. C., and even vapour-pressure thermometers under very closely controlled conditions can achieve a similar accuracy, so that molecular weights up to thirty thousand may be measured with an accuracy of about 5 per cent.

Beyond this the osmotic method is easily applicable. The problem here to be solved is that of obtaining suitable semi-permeable diaphragms. Cellulose prepared in a variety of ways in order to obtain a sufficiently porous structure is the most satisfactory method; but the procedures used for its preparation are empirical, and thus there is no means of controlling the production of such membranes except by trying in an actual osmometer. While considerable control of porosity can be achieved, the determination of molecular weights less than about twenty thousand is a very difficult and protracted matter. Recently, polyvinyl alcohol has been used with great advantage; its porosity to polymer can be made so low that molecular weights even down to a thousand may be measured. At the upper end of the scale of molecular weights, the problems are rather different. The osmotic pressure may only amount to a few millimetres of benzene when the polymer has a molecular weight of a million in a solution of less than 1 per cent by weight. The deviation of such solutions from ideal behaviour is so great that it is essential to extrapolate results to very low dilutions in order that molecular weights can be calculated. Since good cathetometers can read to about $10^{-2}$ mm., it is therefore practically impossible to measure molecular weights exceeding one million. In order to measure osmotic pressures of, say, $10^{-1}$ mm. a new kind of principle is used in which the weight of solvent that enters an osmotic cell is weighed directly in an instrument called an osmotic balance. By suitable arrangement of the geometry of the system and by using photoelectric means of detecting the movement of the beam of the balance, molecular weights of ten millions can be measured in a rather slow way because the ten million limit comes within the limits of practicability at the expense of slowness of operation.

Fortunately, there are other methods which operate satisfactorily in the higher ranges of molecular weights. The most direct method involves counting by the electron microscope the number of molecules in a given weight of polymer. With a resolving power of 50 A. it should be possible to 'see' molecules with a weight of a hundred thousand and more. The difficulties in doing such a direct experiment are quite formidable. To deposit on the sub-stage from a very dilute solution as little as, say, $10^{-16}$ gm. of material in the form of individual molecules free from dust is a problem easily stated but much less easily done. There is therefore much to be done along these lines before the method can become accurate. Similarly, the ultracentrifuge, while so useful with monodisperse biological macromolecules, is much more difficult to use with synthetic polydisperse material, especially when such polymers assume an elongated shape in solution.

Two less direct but more useful methods have more recently been developed. The first makes use of the optical turbidity exhibited by polymer solutions, which is the greater the larger the size of the dissolved molecule for a given weight concentration. The development of the photomultiplier photoelectric cell has made it possible to measure accurately such small turbidities; but since the turbidity of pure liquids is quite comparable with that of the solutions themselves, the method is not very suitable when the molecular weight falls below fifty thousand. At the upper end of the scale, that is, about a million, when the length of the molecules in solution is comparable to the wave-length of light, the marked dissymmetry of the scattered radiation makes it essential to measure the intensity of forward scattering as near the incident beam as possible. This makes for considerable experimental difficulties, though molecular weights up to about one million are readily measurable. Since scattering is proportional both to the number and weight of the polymer molecules, the molecular weights so obtained are a so-called weight average as contrasted with a number average found by osmometry. The ratio of weight to number average gives an indication of the polydispersity of a sample, the weight average always being the greater. If a sample were monodisperse, the ratio of weight to number average should be unity. However the lowest published values amount to about 1· even with the most carefully fractionated material and therefore it may be confidently stated that rea fractionation of polydisperse synthetic polymers ha not yet been achieved in spite of many statement which might lead one to suppose that such fractionation had been satisfactorily done. The other method now being explored, makes use of the accurat estimation of end-groups in which one or more of th atoms is made radioactive. Some knowledge of th mechanism of synthesis is required—for example whether there are one or two terminal groups of th required type in each molecule. By using initiato molecules of quite moderate radioactivity, such a azo compounds, molecular weights up to a millio may be determined with very considerable accurac and using as little as 10 mgm. of polymer.

Thus methods exist to cover the range of molecula weights required, and the only remaining difficult is that some linear polymers—for example, poly ethylene, polyvinylidene chloride—only dissolve in solvents at elevated temperatures such as 100° C., and some polymers, such as polytetrafluorethylene, not at all. The upper limit in the range is not likely to be extended, for there seems to be a practical limit to molecular weights up to about ten million. This applies only to polyvinyl polymers. The main reason for this among those vinyl polymers which grow by radical mechanism is due to the phenomenon of transfer. A polymer radical during its growth may react with its environment, abstracting from it an atom and thus terminating the growth of that particular radical. Such a reaction, even at low temperatures, will therefore put a very definite limit on molecular weight. If synthesis could be conducted at very much lower temperatures, some increase in molecular weight might be possible. Even if this could be done, solutions of such high molecular weight are very easily broken down by relatively low rates of shear if subjected to movement, and thus the handling of such polymer solutions is subject to very considerable difficulty.

The process of transfer referred to above has another important consequence. When polymer accumulates in the system, there is a possibility that a polymer radical will attack a polymer molecule. The result is that the polymer molecule is converted into a radical, and this radical grows in an environment of the monomer, producing a branched-chain molecule. The reaction is specially likely to occur if the polymer radical is reactive, and therefore branched-chain molecules are likely to appear towards the end of the polymerization process. While such a process has been suspected for a long time, definite proof has only recently been obtained. Measurement of the dissymmetry of scattering in the light-scattering method gives information about the average distance between the end of molecules. According to theory, the square of the distance *d* is proportional to molecular weight *M* (or, in other words, $M/d^2$ is a constant), and this relationship holds quite accurately for some molecules such as polystyrene. With other polymers such as polyvinyl acetate, $M/d^2$ is not constant; that is, for a given molecular weight *d* is subject to considerable variation. This can only be due to the formation of branched-chain molecules, and the higher the value of $M/d^2$ the greater the degree of branching. A further confirmation of this point of view comes from the observations that, if polymers of a given molecular weight are synthesized at a series of increasing temperatures, *d* gets smaller and smaller; that is, branching becomes more pronounced.

Unfortunately, light-scattering theory is not yet in a position to interpret these results quantitatively, and hence a method of synthesizing branched-chain molecules of known structure is necessary. This can be done in the following way. A truly linear polymer is made at a low temperature. It is then dissolved in the monomer from which it was originally derived except that one of the carbon atoms is made radioactive. Polymerization is then carried out at a much higher temperature, when transfer to polymer occurs, with the result that radioactive branches are grafted on to the linear polymer. Thus the radioactivity so acquired is then a quantitative measure of the amount of branching that occurs.

The study of three-dimensional molecules is in a much less advanced stage. The only problem that so far has been quantitatively solved in some cases is the determination of the length of the polymer chain between cross-links. This is done by measuring the extent to which the polymer swells in a given liquid. Using knowledge derived from a study of the interaction of linear polymers and the same solvent, it is possible to compute the amount of branching which has taken place.

# PRESSURE OF RADIATION[*]

By Prof. R. V. JONES, C.B., C.B.E.

Department of Natural Philosophy, University of Aberdeen

MECHANICS is the firmest branch of classical physics; and sooner or later each of the other branches was linked with mechanics by an experiment which usually proved vital to the new branch. In electrostatics, for example, Priestley's discovery in 1766 of the inverse square law governing the mechanical force between two electric charges made electrostatics into an exact science; there were similar events in magnetism (Michell, 1750) and in current electricity (Oersted, Biot and Savart, Ampère, 1820), and in heat the linking experiments were those of Joule (1840–50). One reason for the importance of all these great experiments is obvious: as soon as any connexion was established between mechanics and some new branch of physics, the magnificent system developed by Newton could be readily applied to the new branch.

The history of the study of light, however, was different. For, although Kepler[1] suggested in 1619 that light might exert a mechanical pressure, the experimental difficulties in the path of direct confirmation were insuperable for nearly three centuries. Without any such aid as a telescope or camera, Kepler had observed that the tail of a comet always streams out from the head in a direction which is primarily not along the comet's previous track like the trail of a celestial paper-chase, but which points almost exactly away from the sun. This can be seen from Fig. 1, where the telescope has been turned to follow the comet, thus drawing out the images of the fixed stars into streaks in the direction of the comet's motion. The tail is nearly perpendicular to this motion, as though blown sideways by a strong wind emanating from the sun. Kepler suggested that this wind might be due to light. While we are not sure that this 'light-wind' would be strong enough to cause the effect observed (material particles might contribute more to the wind than light does), Kepler's discerning observation and stimulating conjecture are the origin of the study of light-pressure.

Kepler's work was known to Newton, who accepted the observations; but Newton[2] pointed out that a comet's tail might equally well be likened to vapour rising from a body heated by the sun. However, the idea of light-corpuscles carrying momentum with them in a 'light-wind' was so appealing that a direct experiment was bound to be made. The first recorded attempt was that of Homberg[3] (1708), who believed that he had discovered the effect; but de Mairan and du Fay[4], who carried out a more serious experiment about 1750, failed to confirm Homberg's finding.

Michell, the inventor of the torsion balance, also attempted to detect the pressure of light in about 1750; his work was described by Priestley[5]. Michell did not actually use the torsion balance, although in the hands of later experimenters this proved to be a

[*] Substance of a Friday Evening Discourse given at the Royal Institution on March 6.

Fig. 1. Comet Morehouse (1908 III), September 29, 1908. Taken with the 30-in. reflector at Greenwich. Reproduced by permission of H.M. Astronomer Royal

vital device in observing the effect. Michell himself used a suspension resembling a compass needle with a thin vane mounted at one end. On to this vane he focused the rays of the sun and found that the vane moved. What he observed, almost certainly, was an effect due to convection currents in the air surrounding the heated vane; such currents have frequently been a serious cause of disturbance in delicate experiments.

The most obvious way of reducing convection currents was to place the vane in an evacuated chamber. This step was taken by Bennet[6] (1792), who found that he could then detect no repulsion distinguishable from the effects of direct heating. From his careful experiment with its negative result, he speculated against the corpuscular theory; and he was followed by Thomas Young[7] who, in his celebrated Bakerian Lecture of 1802, quoted with approval Bennet's conclusion that the absence of light pressure was evidence in favour of light being a wave and not a corpuscular motion.

Young's statement was slightly curious, since Euler[8] (1742) had already conjectured that waves would exert a force against an opposing surface. It is therefore worth looking at both the corpuscular and the wave model. A moving corpuscle will obviously give an impulse to an opposing surface, and a stream of corpuscles, such as the bullets from a machine gun, will exert the equivalent of a steady force. It is not so obvious that a succession of waves will do the same thing, although we have only too much practical experience of the mechanical effects of single shock waves in blowing down buildings. A succession of small shock waves, such as can be generated by a repeated electric spark, can be focused by a mirror to produce impulses strong enough to turn a small paddle wheel.

A succession of longitudinal sinusoidal waves (continuous sound waves of about 3,000 c./s. are suitable) can be shown experimentally to repel a suspended vane (Pohl's sound radiometer). At first sight it is not easy to see why such a wave should produce this effect, because it can be conceived as producing a series of alternate pushes and pulls as the compressions and rarefactions strike the surface, and in free space the compressions and rarefactions are usually regarded as equal in magnitude. Near a surface, however, in order to preserve equality of motion in the forwards and backwards displacement of individual particles, the pressure rise on compression exceeds the fall on rarefaction. There is, therefore, a small net push on the surface.

Finally, the simplest model of transverse wave can be shown to exert a force by the device of Fig. 2. Transverse waves generated at $H$ on a string and travelling towards the fixed end $S$ are damped out by a pair of pulleys $P$ and $P'$. In any general position of the string such as that illustrated, there is a resultant force $R$ on one of the pulleys due to the two tension forces $T$ acting on it, and $R$ is always a component acting away from $H$. The pulleys thus tend to move away from $H$ under 'radiation pressure', and the effect can be demonstrated if the pulleys are mounted on a lightly constructed boat floating in a trough of water.

From all these examples it appears that waves are just as capable of exerting a force as corpuscles are. The argument of Bennet and of Young was therefore incorrect; the reason why the pressure of light was still undiscovered was mainly that it was too small to be isolated from the various disturbing effects.

In 1873 it almost looked as though Crookes[9] had detected the pressure of light, when he made a blackened surface in an apparent vacuum move under the influence of light. This, however, turned out to be the 'radiometer effect' which is due, very roughly, to the molecules still left in the 'vacuum' hitting the heated surface and coming off at greater speed. Any doubt about the origin of the radiometer effect was quickly removed by an elegant experiment of Schuster[10] which showed that for any action on the vane there was an equal reaction on the gas.

1873 was also the year in which Maxwell's "Treatise on Electricity and Magnetism" was published. Maxwell showed that it was possible for electromagnetic waves to travel through the ether, and that these waves would be made up of transverse alternating electric and magnetic field vectors mutually perpendicular to one another. Maxwell[11] also showed that there was a pressure in the medium carrying the waves, and that this pressure was exerted normally to the wave fronts, and he assumed that this pressure would be transmitted to any surface on which the waves were incident. J. J. Thomson[12], in a footnote to the third edition of Maxwell's "Treatise", made the assumption more plausible by proposing a mechanism whereby the force would be communicated to a conducting surface. The alternating magnetic field of the wave would induce a current in the conductor, and the field of the induced current would react back on the inducing

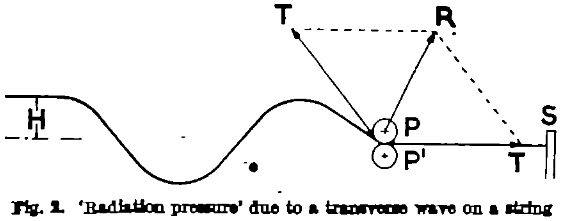


Fig. 2. 'Radiation pressure' due to a transverse wave on a string

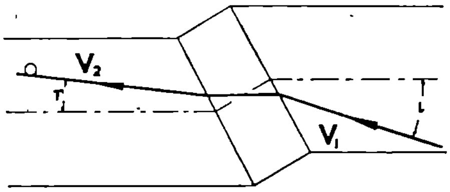


Fig. 3. Corpuscular model of refraction

field so as to cause a repulsion between the wave and the conductor. Maxwell's theory, with its impressively simple result, enabled him to calculate the repulsion due to light under any given conditions. Full sunlight falling on a black surface on the earth would, for example, exert a pressure of about $5 \times 10^{-5}$ dyne/cm.$^2$, which is about the same pressure as would be generated gravitationally by a single layer of atoms spread over the same surface.

Maxwell's calculation showed the experimenters how minute a force they would have to observe (Osborne Reynolds[13] calculated that it was about a thousand times as small as the Crookes radiometer effect), and it took another twenty-six years before Lebedew[14] in Russia and Nichols and Hull[15] in the United States were able to show that pressure of the predicted amount was in fact exerted by light. The difficulties that they had to overcome were threefold: to make suspensions so delicate that they would turn appreciably under the small forces involved; to defeat convection troubles; and to eliminate the 'radiometer' effect. The last two troubles were overcome simply by improving the vacuum. With the successful outcome of these experiments, the link between light and mechanical force was finally established.

There is an interesting consequence of the pressure of light: light must carry momentum, as was first seen from the electromagnetic point of view by J. J. Thomson[16]. A body emitting light is therefore giving momentum to it, and hence there must be a reaction on the emitting body. This reaction was detected by Poynting and Barlow[17], who described their experiment in the Bakerian Lecture for 1910.

Although under terrestrial conditions the pressure of light is very small, it is of great significance. The fact that light carries momentum enabled Einstein[18] to give a convincing illustration of the equivalence of mass and energy. Light pressure is thought to be a vital factor in the structure of stars, and to set an upper limit to their size. The radiation pressure outwards at the surface of a star tends to increase with stellar size at a greater rate than does the gravitational pull inwards at the surface. Above a critical diameter, therefore, an atom on the surface tends to be blown away by radiation rather than retained by gravity.

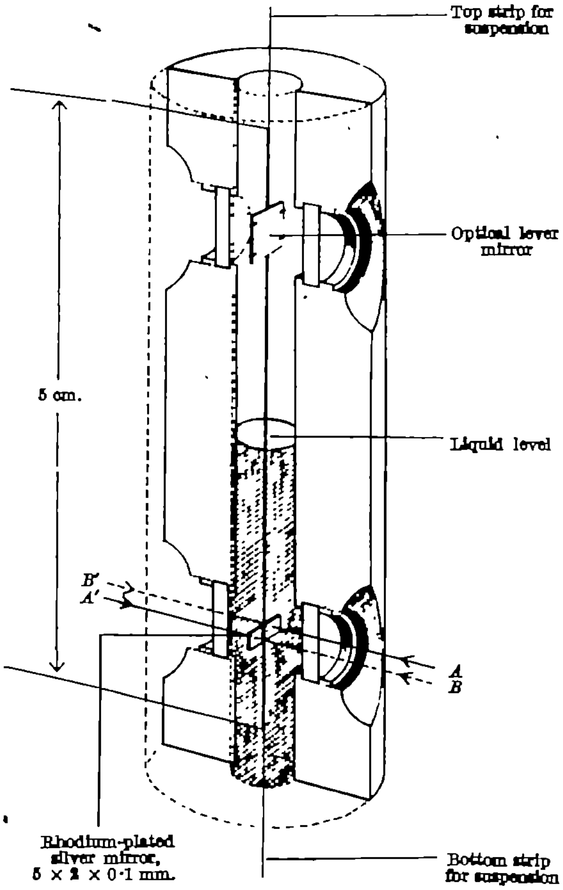
An interesting effect of a refracting surface on the momentum of radiation can be predicted and observed; this is easily seen from a model which demonstrates the corpuscular theory of refraction. The model (Fig. 3) consists of two level planes at different heights, separated by an incline; the lower plane corresponds to the optically denser medium, and the incline to the optical interface. If a ball is rolled over the upper plane towards the lower one with constant speed, $V_1$, it gains speed down the incline by an amount which is independent of the angle of approach, $i$. It therefore emerges across the lower plane with constant speed $V_2$ at an angle $r$ to the normal, and it is easy to see that

$$\sin i/\sin r = V_2/V_1 = \text{a constant.}$$

The model thus obeys Snell's law, and it can also be made to show the phenomena of critical angle and total internal reflexion. It is, in fact, the simplest example of the type of model used in the investigation of electric optics.

The model is, of course, imperfect, as can be seen from its implication that light travels faster in a denser medium; but since no model can be perfect, this one—which has been shown to be in several respects satisfactory—should not be completely rejected without further trial. In particular, it predicts that the momentum of the corpuscles is greater in the denser medium by a ratio equal to the refractive index. A stream of corpuscles will therefore impinge with a greater momentum on a surface immersed in the denser medium than the same stream would have done in the rarer medium. A corresponding prediction is made by the wave theory, since the radiation pressure is equal to the energy per unit volume, and this obviously increases as the waves slow down in the denser medium. Finally, since the momentum of an individual photon is $h/\lambda$, where $h$ is Planck's constant and $\lambda$ the wave-length, this momentum is greater in the denser medium since $\lambda$ is now smaller in the ratio of the refractive index.

All theories, therefore, make the same prediction: when light passes into a denser medium it gains momentum so that the ratio of the final momentum to the initial momentum is equal to the refractive index. Since momentum is conserved, there must be



Top strip for suspension
Optical lever mirror
5 cm.
Liquid level
B'
A'
A
B
Rhodium-plated silver mirror, 5 × 2 × 0·1 mm.
Bottom strip for suspension

Fig. 4

a reaction on the surface separating the two media, directed from the denser to the rarer medium. This can easily be seen from the corpuscular model. The reaction was observed experimentally by Barlow[19] (1912).

Recently the increase in momentum of the light itself has been directly observed at Aberdeen, the preliminary form of the experiment being already summarily reported[20]. The experiment has involved comparing the forces exerted by a beam of light on a small vane suspended by a torsion balance, first in air and then with the same beam and the same vane immersed in various liquids. Previous determinations of radiation pressure have almost all been made *in vacuo* because of the difficulties due to convection currents in air, but the present experiment requires that the pressure should be measured in liquids, where convection troubles and other thermal effects are likely to be much more acute than in any gas. Fortunately, it is possible to distinguish the effect of radiation pressure from the other effects by the fact that it is instantaneous, whereas the others, being thermal, take a few seconds to develop fully, depending on such factors as the heat capacity of the vane. A quickly responding suspension is therefore required, and one with a response time of about half a second was used. Convection troubles were minimized by making the suspension small (the reacting vane was of rhodium-plated silver, 5 × 2 × 0·1 mm.) and mounting it in a narrow (8-mm. diameter) tube, as shown in Fig. 4. A stretched suspension was used, for it would have been impossible to operate a vane suspended from above only, because surface tension would have dragged it to the side of the containing tube. A second mirror was added at the top of the suspension to enable the orientation to be observed. A minor problem was the technique of assembly of the suspension, since this had to be immersed in several liquids, and could therefore contain no cement soluble in any one of them. To minimize effects due to thermal causes, the experimental arrangement was made as symmetrical as possible. Two light beams were first thrown on to the vane (suspended symmetrically with its face vertical and its longest edge horizontal) in positions *AA′* so as to generate an anti-clockwise couple on the vane; the light beams were then rapidly moved to positions *BB′*, where they would generate an equal clockwise couple.

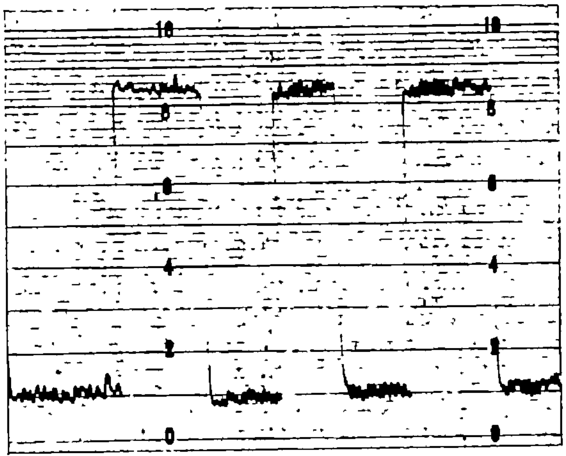


Fig. 5. Record of deflexion due to radiation pressure of light in air. Magnitude of deflexion, 5 × $10^{-5}$ radian. Disturbances probably Brownian

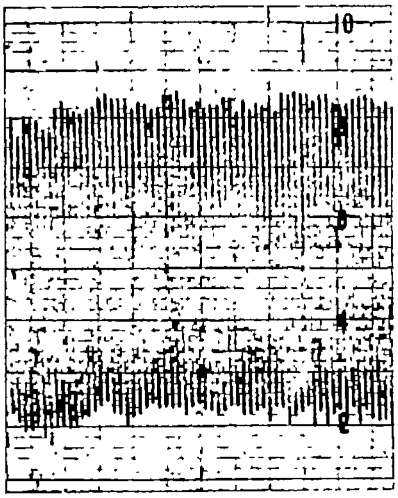


Fig. 6. Record of deflexion due to automatic switching of light in liquid (xylene)

Owing to the quick response required in the suspension, it was necessarily insensitive, and the typical change in orientation caused by moving the light beams was of the order of 5 × $10^{-5}$ radian, equivalent to the movement of a galvanometer spot of 0·1 mm. at a scale distance of 1 m. Incidentally, this is only about fifty times the root mean square of the Brownian fluctuations in the system. Both they and the change in orientation consequent upon moving the light beams can be seen in Fig. 5, which shows a record taken with air in the tube. To obtain satisfactory records of such small movements, it was necessary to use an optical lever amplifier; this had already been developed for other purposes[21], and it could, if necessary, be made so sensitive that with a mirror 5 mm. in diameter it would detect reliably a rotation so small that no part of the mirror moved by more than about 2 × $10^{-10}$ cm., or about one-hundredth of an atomic diameter.

The deflexions in liquids were not nearly so easy to interpret nor was the zero nearly so steady; but it was noticed that the first kick after moving the light beams was roughly of the correct magnitude, and it was thus possible to obtain preliminary observations of the increase in pressure in liquids. In order to isolate the immediate kick due to radiation pressure, it was decided to switch the light beams mechanically about once per second, so that an oscillating record (Fig. 6) was obtained. The air and liquid records could not then be compared directly, because of the increased damping of the oscillations of the vane in the liquid. This difficulty could be simply overcome by adding a very small magnet to the suspension, and arranging to deflect it by a magnetic field which reversed with the same frequency as that at which the light beam was switched. In principle it would have been possible to arrange the light and magnetic deflexion in anti-phase, so that the strength of current generating the magnetic field required to balance the light pressure could have been taken directly as a measurement of the latter pressure. Since the vane would then be at rest both in air and in liquid, no damping effects would have had to be allowed for. In practice, however, it was easier to find the alternating deflexion due to the light pressure, and then to find the current required to produce an equal alternating deflexion in the same

VARIATION OF RADIATION PRESSURE WITH REFRACTIVE INDEX

| Liquid | Water | Ethyl alcohol | Carbon tetrachloride | Xylene | Benzene | Carbon disulphide | Standard error (per cent) |
|---|---|---|---|---|---|---|---|
| Observed reflexion ratio | 1·274 | 1·305 | 1·413 | 1·424 | 1·432 | 1·539 | ± 1·5 |
| Corrected pressure ratio | 1·348 | 1·374 | 1·478 | 1·502 | 1·517 | 1·637 | ± 2 |
| Mean refractive index | 1·329 | 1·358 | 1·457 | 1·489 | 1·493 | 1·613 | ± 0·1 |
| Discrepancy (per cent) | +1·4 | +1·2 | +1·4 | +0·9 | +1·6 | +1·5 | |

medium. This method again eliminated the viscosity of the medium.

The foregoing experiment has been carried out by Mr. J. C. S. Richards (University of Aberdeen), aiming at an over-all accuracy of one per cent. For this accuracy, many observations (more than four hundred) were necessary on each liquid, to average out the effects of Brownian and other disturbances. It was also necessary to allow for effects such as the slight change of reflectivity of the vane on immersion in liquid, and the loss of light in the medium as it crosses the glass/air or glass/liquid interfaces on its way to the vane. Mr. Richards's results are shown in the table.

This table shows that the proportionate increase in momentum is within 1 to 1·5 per cent of the refractive index, the experimental results being consistently high by a small amount which is probably due to some unforeseen correction that we have not allowed for. The agreement is amply good enough, however, for us to conclude that the effect has been satisfactorily confirmed. Not only, therefore, does light press against a mirror but it also gains or loses momentum whenever it crosses a refracting boundary.

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# OBITUARY

## Dr. G. F. Herbert Smith, C.B.E.

GEORGE FREDERICK HERBERT SMITH was born on May 26, 1872, eighty-one years ago. Well known to mineralogists for his early work on geometrical rystallography and on the scientific study of gemtones, he was better known to a wider circle for his work as honorary secretary of the Society for the Promotion of Nature Reserves and numerous other ouncils and committees having to do with the preservation of wild life and the protection of Nature. Most of this work, however, was done in the fifteen years since his retirement from the Natural History Museum, where he had served successively as assistant in the Department of Mineralogy, assistant secretary and secretary of the Museum and keeper of minerals for a total of forty years.

Herbert Smith came to the Department of Mineralogy at twenty-five by way of Winchester and New College, Oxford, with firsts in the finals honours schools in mathematics and physics. He spent part of a year at Munich studying under Paul Groth, and at the Museum he produced some important papers on geometrical crystallography and devised a three-circle goniometer which he used for working out the intricate problems of the crystallography of the gold telluride, calaverite (1902), and the sulpharsenite of lead, sartorite, from the famous Binnenthal locality. Early in his career at the Museum he became interested in the study of gemstones and scientific methods of identifying faceted stones. To this end he designed a convenient form of refractometer and put in the hands of jewellers an instrument that all could use effectively with very little difficulty. From 1912 he was one of the examiners for the diploma in gemmology initiated by the National Association of Goldsmiths and so remained after its Education Committee became the Gemmological Committee in 1924 and finally formed the Gemmological Association in 1931. He was president of the Association in succession to Sir William Bragg from 1942 until his death. Among gemmologists his name is a household word, and his book "Gemstones", now in its twelfth edition, contains the record of his accumulated knowledge and experience in the scientific study of gemstones both as minerals and as gems.

After the death of Charles E. Fagan in 1921, Herbert Smith left the Department of Mineralogy to become assistant secretary of the Museum. Thenceforward he became involved in administrative work. During the early part of his period in this office an important event was the move in 1924 of the zoological collections preserved in spirit into the completed eastern half of the New Spirit Building. It was probably thanks to Herbert Smith's efforts that the Empire Marketing Board made a generous grant to enable a third quarter of this building to be completed in 1930 to provide accommodation for the overcrowded Department of Entomology pending the erection of its own building (which was in the event not completed until 1952 although the south half was occupied in 1936). Some of the work of preparing evidence for the Royal Commission on Museums and Galleries in 1927 fell to Herbert Smith, and he also had the congenial task of arranging for the celebration of the fiftieth anniversary of the opening of the Natural History Museum (1931). Several collecting expeditions in East Africa were organized during this period, culminating in the successful 'Ruwenzori' Expedition by the late F. W. Edwards and Dr. George Taylor in 1934. Accounts of these expeditions were published in the *Natural History Magazine*, a museum publication which Herbert Smith edited throughout its short life during 1927–36. The preparation and sale of postcards illustrating specimens in the collections was another of Herbert Smith's innovations and was completely successful.

He did many things to encourage a corporate spirit in the Museum staff, strongly supporting the formation of a sports club and rifle club, of which latter he was himself an active member. With three other senior members of the staff he organized the staff association for the scientific staff. This association was affiliated to the Society of Civil Servants, of which Herbert Smith was one of the honorary secretaries, 1918–25. He was also editor of its journal, 1923–30, and later a vice-president and president, 1929–32. It was typical of Herbert Smith that, in connexion with this work for the Society of Civil Servants, he arranged a special train to take its members and other Civil servants to Richmond, Yorkshire, to view the total eclipse of the sun in 1927. He wrote a guide to the eclipse and provided "pieces (5 by 2 ins.) of dark glass for viewing the Sun". It was no fault of his that cloud obscured the view.

The Civil Service Arts Council he served for fifteen years as honorary secretary and treasurer, and he also served on the Civil Service Sports Council and was chairman of its publicity committee from 1946. As another spare-time activity he represented the Trustees of the British Museum on the Council of the Royal Albert Hall from 1930 until his death, and was chairman of the Executive Committee, 1941–47, and a member of the Finance Committee, 1941–51.

In the last two years of his service in the Museum, he returned to the Department of Mineralogy as keeper and did some good work in arranging new exhibits of gemstones and semi-precious stones in specially illuminated cases. These unfortunately had to be dismantled only two years later on the outbreak of war so that the specimens could be put in a safer place.

Herbert Smith's work for the Society for the Promotion of Nature Reserves began in 1921 when, succeeding Charles E. Fagan in the Museum Office, he took over also the secretarial work of the Society. During his long term of office, the activities of the Society greatly increased. It was this Society that took the initiative in 1941 of getting together a conference to consider Nature protection in post-war reconstruction. This conference in its turn appointed, at the suggestion of the responsible Minister, the Nature Reserves Investigation Committee in 1942. Of both these bodies Herbert Smith was honorary secretary, and he was also chairman of the Geological Reserves Sub-Committee. These committees co-ordinated the work of no less than twenty-four regional committees in England and Wales. Two reports were issued in 1945, shortly after the end of the War, and their detailed recommendations were almost all incorporated in the report of the Wild Life Conservation Special Committee presented to Parliament in 1947[1,2]. The establishment of the office of Nature Conservancy was a direct outcome of the recommendations of this Committee.

Herbert Smith had been chairman of the Wild Plant Conservation Board since 1931 and was interested, too, in the Society for the Preservation of the Fauna of the Empire and the Convention for the Protection of the Fauna and Flora of Africa. In a wider field he was one of the British delegation to the International Conference for the Protection of Nature held at Brunnen in 1947[3] and of the later conference of Government representatives held at Fontainebleau under the auspices of Unesco in Paris during the following year. There he was chairman of the committee charged with the drafting of the constitution. His committee completed its task in two days and the finished draft was ready for the closing session. He attended the first General Assembly in Brussels in 1950 as head of the British delegation, and since that year he held the office of a vice-president of the Union.

Herbert Smith had outlived most of the friends who had known him as a young man. To many who served on his committees he may have seemed reserved, autocratic and obstinate. He was, in fact, determined to get things done and he usually succeeded. He understood what things were practicable, and by hard work and persistence he accomplished much. That was his reward for the devotion with which he worked for the protection of Nature, to which cause he gave, voluntarily and unpaid, almost all his time for the fifteen years that followed his retirement from the Natural History Museum.

He died after a short illness on April 20, 1953, and leaves a married daughter. His wife, a daughter of the late John Ellerton, of Leamington, died in 1936. He was a Fellow of the Royal Astronomical Society, a member and a past vice-president of the Mineralogical Society, and for many years a Fellow of the Geological Society and a member of the British Association. He was awarded the C.B.E. in 1949.

W. Campbell Smith.

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# NEWS and VIEWS

## Geography at Glasgow: Prof. A. Stevens

The retiring professor of geography in the University of Glasgow, Prof. A. Stevens, commenced his long association with the University as an arts student and graduated M.A. in 1907. After a short break, he continued his studies in the Faculty of Science and obtained his B.Sc. as a geologist. In 1914 he joined Shackleton's South Polar expedition, and was marooned for two years in the Antarctic. On returning home Stevens served with the Army until the end of hostilities. In 1919 he was invited to organize a Department of Geography at Glasgow; a lectureship had been established in 1909 but was in abeyance. It was not until as late as 1947 that a chair of geography was established with Stevens as the first professor. He has devoted his energies very largely to the development of the Department on what he believed to be a sound basis; the emphasis has been on regional geography. At the same time, he has contributed notably by papers and in discussion to theoretical aspects of his subject; his presidential address to Section E (Geography) at the British Association in 1939 is an example. Prof. Stevens has not been a prolific writer; but his papers have covered a wide field and each has been a stimulus to his fellow workers. There have been contributions of lasting value on physical geography in which his earlier interests undoubtedly lay, and latterly papers to the Institute of British Geographers have dealt with problems of population distribution in the British

Isles. He has also been directing research on a hypsometric survey of Scotland, and it is hoped that his retirement will not cut short this work.

### Dr. Ronald Miller

RONALD MILLER, who is to succeed Prof. Stevens at Glasgow, was the first member of the University of Edinburgh to graduate as M.A. with honours in geography, in 1931. As an Orcadian naturally interested in the sea, he then turned appropriately to oceanography and, after two years as a Carnegie Research Scholar, working in the Marine Laboratory of the Fishery Board in Aberdeen and on its research vessel, he earned the degree of Ph.D.(Edin.) for his contribution to the hydrography of the northern North Sea. As an assistant lecturer in geography under Prof. H. J. Fleure at Manchester (1933–36), he developed an interest in cartography, a subject on which he has since published several papers. He then entered the Colonial Service as geography specialist at Katsina Higher College, Nigeria, which was intended eventually to attain university college status. Working with African students in the field, he published studies of the Hausa and was engaged in further research on Nigeria when the Second World War supervened and he was embodied from the Supplementary Reserve into the Nigeria Regiment, where he served until 1944 and then reverted to civil employment at the request of the Colonial Office. He visited many parts of West Africa and acquired an intimate knowledge of the Hausa people and fluency in their language. He returned in 1946 to his Alma Mater as lecturer under Prof. A. G. Ogilvie, and has been primarily concerned with physical aspects of geography and with departmental work in the field. He has written on African topics and is continuing his work on Nigeria.

### Harrison Howe Lecture : Prof. H. C. Brown

THE Harrison Howe Lecture for 1953 of the Rochester Section of the American Chemical Society will be delivered on November 21 by Prof. Herbert C. Brown, professor of chemistry in Purdue University, Lafayette. The Lecture was founded in 1945 to commemorate the services to chemistry of Harrison E. Howe and his influence on American industry through his researches. Prof. Brown has been chosen this year for his contributions to stereochemistry and also for his work in the synthesis of hitherto unknown boron hydride derivatives. In the field of stereochemistry his studies have shed new light on the abnormal behaviour of strained molecules, and recently he has developed a method of measuring the magnitude of the strain factor in structurally related compounds. His work on the chemistry of boron hydride was conducted at the University of Chicago during the Second World War as part of a war-time project connected with atomic energy research and is noteworthy for the preparation of a new type of organoboron substance which is very useful as a reducing agent and source of hydrogen.

### Advisory Council on Scientific Research and Technical Development

THE Ministry of Supply announces the following appointments to the Minister's Advisory Council on Scientific Research and Technical Development: Prof. H. W. Melville, Mason professor of chemistry in the University of Birmingham; Prof. J. L. M. Morrison, professor of mechanical engineering in the University of Bristol; Prof. L. Rosenhead, professor of applied mathematics in the University of Liverpool; Prof. I. N. Sneddon, professor of mathematics in the University College of North Staffordshire; Prof. A. R. Todd, professor of organic chemistry in the University of Cambridge.

### Committee on Adult Education

MISS HORSBRUGH, Minister of Education, has appointed the following committee to inquire into the adult educational service of Great Britain: Dr. Eric Ashby, vice-chancellor, Queen's University, Belfast (chairman); Mr. A. L. C. Bullock, censor of St. Catherine's Society, Oxford; Prof. W. L. Burn, professor of modern history, University of Durham; Mr. T. Mervyn Jones, chairman, Wales Gas Board; Sir Wilfrid Martineau, formerly chairman of the Birmingham Education Committee; Mr. C. M. Skinner, a member of the Court of Governors, University of Manchester; and Mr. G. B. Thorneycroft, member of the General Council of the Trades Union Congress. The committee's terms of reference are: "To review the present system by which the extra-mural departments of universities, the Workers' Educational Association and the other responsible bodies provide local facilities for adult education, with special reference to the conditions under which these facilities are organized and are aided by grants from public funds; and to make recommendations".

### Technological Education in Britain

THE reply of Mr. Kenneth Pickthorn, Parliamentary Secretary to the Ministry of Education, to an adjournment debate on technological education, initiated by Mr. James Johnson on May 21, did not indicate that the Government has yet formulated any real policy. Mr. Pickthorn rightly pointed out that there had not yet been much time for technical colleges to obtain grants, or promises of grants, under Circular 255, but he could only express the hope that colleges with courses which attract the maximum—the advanced rate of grant of 75 per cent—would develop more and more into institutions for technological work only, and that the remaining colleges would concentrate on the needs of technicians. Mr. Johnson had particularly stressed, besides the desirability of developing the work of the major technical colleges (some thirty of about two hundred), the shortage of science teachers in secondary schools, pointing out that in 1951 not one of the 51 honours graduates in the honours school of chemistry at the University of Oxford went into teaching. Mr. Pickthorn said he thought that the quantitative shortage of science teachers is being exaggerated; indeed, the situation is slightly improving. He emphasized the impossibility of finding a rapid solution of this problem.

### City and Guilds of London Institute : Report for 1951

THE annual report of the council of the City and Guilds of London Institute for 1951 (pp. 64; 1952), in referring to the election of the Duke of Edinburgh as president, recalls that in 1881 the Prince of Wales became the first president and that the office has remained vacant since he became visitor and patron on accession to the throne in 1901. The report records a year of consolidation, but no long-term solution of the acute problem of accommodation is possible until the resources of the Institute are considerably increased. The council is desirous that the Institute's work in the field of art should be more widely known and appreciated. Honorary associate-ships were conferred on nine professors of not less than five years standing at the College, and the fellowship was conferred on Atholl Blair and H. Shoosmith. A Finsbury Medal has been instituted at the instance of the Finsbury Technical College Old Students' Association, and this body, in terminating the Streatfeild Memorial Lectures, has also offered the balance of the Fund to establish a major annual prize in a suitable branch of chemical technology, if possible where emphasis can be placed upon practical work. The first new Insignia awards (see *Nature*, 170, 828; 1952) were expected to be made during the winter of 1952, and the Institute believes that the introduction of the award will encourage students to take full advantage of the facilities provided in industry and technical colleges and lead to recognition of the value of practical training and experience. A deficit of £6,278 on the year and depreciation of the Institute's investments threaten curtailment of activities unless new income can be found.

## Jubilee of the School Nature Study Union

The latest issue of the School Nature Study Union journal (*School Nature Study*) represents a memorable event in the life of the organization—its fiftieth birthday. The Union was founded in 1903, largely owing to the enthusiasm of the Rev. Claude Hinscliff and Miss Kate Hall, and soon became the means of promoting considerable interest in the study of natural history in schools. The first president was Sir George Kekewich, and the vice-presidents included Lord Beauchamp, Sir John Cockburn, Sir Lauder Brunton, Mrs. Humphrey Ward and, later, Mr. H. G. Wells. During its life, many eminent biologists have served the Union as presidents or in other capacities, although probably no names are more pre-eminent than those of Miss C. Von Wyss and Mr. H. E. Turner, who were both members of the original committee formed in 1905 until their resignation in 1936. Besides the journal, which has been appearing for forty-eight years, the School Nature Study Union has performed a most useful service to teachers and others in the production of an extensive series of leaflets which give practical advice on how to teach natural history more effectively. Cordial greetings are extended to the School Nature Study Union in its jubilee year.

## Botanical Gallery at Bolton

Though the Museum and Art Gallery at Bolton was built just before the War it was only possible recently to install a botanical gallery. This is described in the *Museums Journal* for May by Mr. A. Hazelwood and indicates clearly some of the aspects of botany which can be so illustrated. Naturally recourse to modelling was considered essential, and the first exhibit is an enlarged model of a poppy which is used for demonstrating terms applied to the various parts of a flowering plant. Other exhibits deal with the morphology and some aspects of the physiology of the flowering plant, root forms, shoot forms, nutrition and adaptation to specialized environments, together with the fruit, dispersal and germination of a variety of plants. Another section is systematic and, after a series of colour transparencies of microscopic forms, follows with models of the larger thallophytes to the Angiosperms. Emphasis is given to the illustration of forest trees, and the series concludes with exhibits showing plants as food.

## Herbarium of Indian Plants

The discovery of an important herbarium in a recent acquisition by the Liverpool Public Museums is related by Mr. H. Stansfield, keeper of the Department of Botany, in the March number of the *Museums Journal*. This collection, which was given by the Liverpool Chemists' Association, consisted of several thousand specimens with no data, and by patient investigation Mr. Stansfield has been able to record its history. By noting various clues and following several lines of investigation, he was able to prove that the plants were those on which the text and illustrations of J. F. Royle's "Illustrations of the Botany of the Himalayan Mountains and the Flora of Cashmere" were founded. Some of the plants were collected in the plains of India of the north-west provinces, some are from the mountainous tract between the Sutlej and the Ganges and others from the valleys of Kashmir (Cashmere). The plants from the last-named locality were obtained during 1828–31 by native collectors. The herbarium with its important type-specimens has been placed in good order and will no doubt be consulted by many workers.

## Feeding Mechanisms in Deep-Sea Fish

Much of our knowledge of the habits and functioning of deep-sea fishes must, perforce, be derived from indirect evidence. From dissections of preserved material, the late Dr. V. V. Tchernavin has carefully reconstructed the probable sequence of movements involved in feeding in a bathypelagic stomiatoid teleost *Chauliodus*. His conclusions have now been published by the British Museum (Natural History) in a volume entitled "The Feeding Mechanisms of a Deep-Sea Fish *Chauliodus sloani* Schneider" (pp. viii+101+10 plates; 1953; 30*s*.). Jaw and head movements, basically similar to those of other teleosts, but on a much exaggerated scale, enable *Chauliodus* to capture and ingest prey larger than itself. For comparison with *Chauliodus*, the feeding mechanisms of certain other vertebrates are described briefly. Other valuable details described in the volume are the operation of breathing valves, the distribution and possible significance of light organs in *Chauliodus*, and the dissimilar feeding mechanism of another bathypelagic teleost, *Saccopharynx* (order Lyomeri). There is an extensive bibliography.

## Linen Research Association: Report for 1952

The report of the council of the Linen Research Association for the year ended September 30, 1952 (pp. 24; from the Association, Lambeg, Northern Ireland; 1952), records steady progress in almost every section of the Association's activities. Research on flax production has again been a matter of concern to the industry, and the council records its thanks to the Flax Development Committee for continued support of its research on flax scutch. The flax-production scheme in England is now to continue on a permanent basis, and also research work in Norfolk, but on a reduced scale. In the work on rayon staple, various causes of shading faults in plain dyed fabrics have been revealed and recommendations made for reducing the faults to a minimum. Arrangements have been made for the manufacture of the Linra photo-electric yarn irregularity gauge to assist in keeping yarn irregularity below a fixed level, and comparative tests of the Linra modified roller-breaker against other breakers are being arranged. Surveys in factories have been specially directed to the investigation of yarn-winding processes and of humidification. In sizing, promising results have been obtained in trials of a new brushing unit on a slashing machine, and fundamental work on the relationship between yarn and cloth has continued. Methods of bleaching linen goods have been evolved which indicate that still higher quality can be achieved.

## Fluorosis and Pollution

REPLYING to an adjournment debate in the House of Commons on May 14, initiated by Dr. Barnett Stross, of Stoke-on-Trent, who pressed for the instigation of a local inquiry into the incidence of fluorosis due to atmospheric pollution, the Parliamentary Secretary to the Ministry of Health, Miss Patricia Hornsby-Smith, said that, on the evidence available, neither the Ministry nor the Medical Research Council believes that an inquiry in that area is essential. The wider problem of fluorine would, however, have to be one of the items covered in the investigations now being undertaken by the Minister of Housing and Local Government into air pollution, as particularly applied to industrial areas. With regard to the question of fluorine in water supplies, Miss Hornsby-Smith said she did not wish to make any comment pending a full study of the report of the British mission to North America inquiring into this question.

## X-Rays accompanying μ-Meson Capture

INTERESTING observations on the X-rays accompanying μ-meson capture by nuclei are reported through the rather unusual channel of a 'press release' from Columbia University. Negative μ-mesons brought to rest in matter eventually disappear, either by spontaneous decay or by nuclear capture. In either case the process takes place in two fairly distinct steps. First the meson is attracted into quantum orbits around a nucleus, to which it is bound by the electrical forces. During this stage it emits X-rays or ejects atomic electrons as it jumps successively from one quantum state to another, until it reaches the state of lowest energy. Disintegration or capture then occurs. The orbits are like those of the interior atomic electrons, but about two hundred times smaller in linear dimensions (a consequence of the greater mass of the meson). The energy of the X-rays is similarly some two hundred times greater than the corresponding atomic X-rays. Rainwater and Fitch have observed these X-rays and made precise determinations of their energies. Since the deepest meson orbit and the nucleus are comparable in size for a heavy nucleus, the energy of the former is strongly influenced by the way in which electric charge is distributed in the nucleus. From their measurements Rainwater and Fitch conclude that the charge is considerably more concentrated towards the centre than had been previously believed. They deduce an *effective* radius 15 per cent smaller than is yielded by such methods as nuclear binding energies or neutron scattering.

## Industrial Application of Aerodynamic Techniques

A NUMBER of special applications of aerodynamic equipment and techniques which have been used in the course of investigations in the Aerodynamics Division of the National Physical Laboratory, Teddington, are described in a little handbook entitled "The Industrial Application of Aerodynamic Techniques" (National Physical Laboratory: Notes on Applied Science No. 2. Pp. 37. London: H.M.S.O., 1952. 3*s*. 6*d*. net). It is often impossible to use the wind tunnel for the solution of problems of fluid motion which arise outside the aircraft industry. Dr. R. A. Frazer's work on the aerodynamic stability of suspension bridges is an exception, and the model tests done for the Severn Bridge project are described. Civil and mechanical engineers will deduce without surprise that there are few industrial applications of text-book aerodynamics. This is, of course, true; but one feels that opportunity has been lost by conveying a too sober estimate of the possibilities of applying aerodynamic experience to industrial practice.

## Kodaikanal Observatory: Report for 1950

THE report for 1950 of the Kodaikanal Observatory (pp. 8; Delhi: Manager of Publications, 1951; 7 annas or 8*d*.) deals chiefly with the astronomical work there, though short references are given to geomagnetic observations and seismology; the meteorological data appear in the *Indian Weather Review*, and the administrative details in the annual report of the Indian Meteorological Department. A list of the forty-seven instruments in use is given and also a brief account of the constructional works relating to development projects, including the construction of a dome for housing a 20-in. Grubb reflector and of buildings for an ionosphere laboratory. There has been a considerable amount of co-operation with other observatories—the Solar Physics Observatory, Cambridge, the Royal Greenwich Observatory, the Meudon Observatory, and the Mt. Wilson Observatory—with which there has been exchange of spectroheliograms, photoheliograms, quarterly statements of solar flares, etc. During 1950 the Government of India granted two research scholarships in astronomy tenable for three years at the Kodaikanal Observatory.

## Beit Memorial Fellowships for Medical Research

BEIT Memorial Fellowships for medical research have been awarded as follows. *Fourth Year Fellowship* (£735 a year): Dr. Joan E. Keilin (University of Cambridge), to investigate, at the Department of Biochemistry, Cambridge, the catalytic activity of hæmatin compounds and the effect of oxidizing agents on hæmatins, the properties of purified helicorubin and its relationship to other natural hæmoproteins, and the reactions of hæmatins with proteins and their constituent amino-acids and peptides, with the aim of gaining more information on the structure of the hæmoglobin molecule, the link between the hæm and globin and the use of hæmatin as a reagent for the study of other biologically important proteins. *Junior Fellowships* (£630 a year): J. R. Cannon (University of Sydney), to continue at the University Chemical Laboratories, Cambridge, the study of the chemical structure of vitamin $B_{12}$; G. P. Lewis (University of Wales), to study, at the National Institute for Medical Research, Mill Hill, London, the relationship between structure and action of drugs, particularly of antagonists of histamine, acetylcholine, adrenaline and *nor*-adrenaline, in order to examine how far ionization of a drug or its receptor modifies drug action; W. L. Nicholas (University of Liverpool), to investigate, at the Department of Zoology, Liverpool, the determination of the growth requirements of free-living and parasitic nematodes in chemically defined media, with the view of its possible application to the chemotherapy of nematode infections; Dr. Evelyn E. B. Smith (University of Glasgow), to investigate, at the Department of Biochemistry, Glasgow, the enzymic mechanisms of transfer reactions involving uridine pyrophosphate compounds containing glucose, glucuronic acid and N-acetylglucosamine, and to study the biosynthesis of glucuronic acid, glucuronides and oligosaccharides containing glucuronic acid, using carbon and phosphorus isotopes.

### Lady Tata Memorial Trust: Awards

THE following awards have been made by the Lady Tata Memorial Trust for research on leukæmia and allied diseases, to be conducted in the places indicated during the academic year beginning October 1, 1953. *Grants for research expenses or for scientific assistance:* Dr. A. Fagraeus and Dr. B. Thorell (Stockholm), Dr. C. Merskey (Cape Town), Prof. C. Oberling (Villejuif, Seine) and Dr. C. C. Ungley (Newcastle upon Tyne), renewals; Dr. J. Nordmann (Paris), new award. *Part-time personal grant and grant for technical assistance:* Dr. J. B. G. Dausset (Paris), renewal with increase. *Senior Research Fellowships:* Dr. A. R. Gopal-Ayengar (London), extension for two months; Dr. J. Kieler (Copenhagen), new award. *Scholarships (whole-time or part-time):* Dr. R. Raak-Nielsen (Copenhagen) and Dr. R. Robineaux (Paris), renewals; Dr. F. Kissmeyer-Nielsen (Aarhús) and Dr. N. A. Stenderup (Aarhus), new awards. In addition, the period of tenure of a special scholarship awarded earlier this year to Dr. Gavino Negroni (Italy), for work at the Imperial Cancer Research Fund Laboratories, Mill Hill, London, will continue until April 30, 1954.

### University of Birmingham: Appointments

THE following have been appointed lecturers in the University of Birmingham: Dr. J. H. Cort (physiology), Miss Joyce B. Grace (bacteriology), Dr. T. O. Jeffries (physics), J. B. Woodward (mathematical physics) and Dr. K. White (physiology). The following have resigned from the University: F. R. N. Nabarro, lecturer in metallurgy, on appointment to the chair of physics in the University of the Witwatersrand, Johannesburg; and Dr. A. B. L. Beznak, lecturer in physiology, on appointment to the chair of physiology in the University of Ottawa.

### American Academy of Arts and Sciences: Foreign Honorary Members

THE following have been elected foreign honorary members of the American Academy of Arts and Sciences: Prof. Arne Tiselius, professor of biochemistry, University of Upsala; Prof. A. J. Kluyver, professor of microbiology, Technical University, Delft; and Prof. D. M. S. Watson, formerly Jodrell professor of zoology and comparative anatomy, University College, London.

### Meeting of Nobel Prize-winners in Lindau

MEETINGS of Nobel prize-winners were started some years ago at Lindau, Bavaria, on the shores of Lake Constance, for the purpose of creating and developing a general contact between leading scholars in an exact science and the professional and industrial workers whose daily work is based on the results of the investigations of these scientists. The method chosen for achieving this contact is for the Nobel Laureates to give lectures adapted in their content to the needs of practical men and giving a survey on the results of scientific research to the layman. The meeting this year, to be held during June 29–July 2 under the patronage of Count Lennart Bernadotte, is devoted to physics, and eight lectures will be given as follows: June 29, Prof. M. von Laue (Röntgen-ray interferences) and Prof. G. von Hevesy (biochemical effects of ionizing radiations); June 30, Prof. O. Hahn (modern alchemy) and Prof. C. F. Powell (high-altitude flights with free balloons); July 1, Prof. F. Soddy (discovery of the natural transmutation of the radio-elements) and Prof. P. A. M. Dirac (quantum mechanics and the æther); July 2, Prof. H. Yukawa (search for a unified theory of elementary particles) and Prof. W. Heisenberg (progress and difficulties in the quantum theory of elementary particles). The general arrangement is for lectures to be given during the morning so as to leave the rest of the day free for discussion groups and for excursions and other social activities. The fee for participation in the meeting is DM 30 or DM 10 a day. Further information can be obtained from the Sekretariat der Tagungen der Nobelpreisträger, Stadttheater, Lindau-Bodensee.

### Announcements

DR. L. C. BATEMAN, deputy director of research and formerly superintendent of chemical research of the British Rubber Producers' Research Association, has been appointed director of research of the Association in succession to Dr. Geoffrey Gee, now professor of physical chemistry in the University of Manchester.

DR. ERNST MAYR, curator of the Whitney–Rothschild Collection, American Museum of Natural History, has been appointed Alexander Agassiz professor of zoology in the Museum of Comparative Zoology, Harvard University. Two other appointments are those of Mr. James C. Greenway, jun., to be curator of birds in the Museum in succession to the late James L. Peters, and Mr. Raymond A. Paynter, jun., to be assistant curator of birds.

THE Philosophy of Science Group of the British Society for the History of Science is offering a prize of £50 for the best essay of not more than 4,000 words on: "What is the logical and scientific status of the concept of the temporal origin and age of the Universe?" (for example, as used in recent cosmological work). The essay should clarify the logical, theoretical, and observational aspects of the idea of assigning a quantitative age to the universe. Essays in English, French or German (in typescript) must reach the Honorary Secretary, Philosophy of Science Group, University College, Gower Street, London, W.C.1, not later than December 1, 1953, must bear a pseudonym, and be accompanied by a closed envelope containing the pseudonym and the author's name. Essays submitted will be treated as material offered to the *British Journal for the Philosophy of Science*.

ERRATA. In the article entitled "Food Products from Plants" in *Nature* of May 23, p. 917, paragraph 3, line 3, for "0·069*d*. per lb. of protein, compared with 0·8*d*. per lb. of protein from beef", read "0·069*d*. per gm." and "0·8*d*. per gm.", respectively.

# ENGINEERING IN THE UNIVERSITY OF NOTTINGHAM

## OPENING OF LABORATORY EXTENSIONS

THE original engineering laboratories of University College, Nottingham, as it then was, were completed in 1930, and until 1948, apart from a small extension of drawing-office accommodation, no further expansion was made. In 1930 the number of full-time students was 17, a number which by 1940 had increased to 44, and by 1946 (the date of the Barlow Report) to 128. In 1950 there were approximately two hundred students reading for degrees in engineering; this number was really far in excess of the facilities at the University's disposal, and adequate training was only given by running dual streams of undergraduates in each year. Such conditions could only be tolerated for a short time to meet a national emergency, and a further demand on accommodation was made when, on the University receiving its charter in 1948, it became possible to develop further the research schools in applied science.

The University was faced with the preparation of a long-term scheme for the development of technology, or of putting into operation a smaller scheme which would bring relief with the shortest possible delay. The first scheme would certainly have taken six years to plan and complete, and in this time the intake of applied science students would have had to be reduced. This seemed contrary to the national interest, and so it was decided to proceed with the smaller project which could be completed in a little more than two years, during which time the student numbers could be maintained and active research schools developed. The project has now been completed, the immediate extra accommodation provided by the extensions representing an increase of some 60 per cent; when rooms at present loaned to the Arts Faculty are available, the total increase of accommodation will be 80 per cent, making possible an intake of students at the rate of ninety a year.

The extensions to the laboratories were opened on April 14 by Lord Hives, chairman and joint managing director of Rolls Royce, Ltd. Lord Hives pointed out that, although society to-day is increasingly dependent on the achievements of applied science, too few of the present-day university students in Britain study this vital subject—only a sixth, in fact, of the 72·5 per cent at universities who are in some measure or other assisted financially by the State. That the percentage of technological students is so small is causing both educationists and industrialists much anxiety, and Lord Hives noted with satisfaction that Nottingham anticipated some time ago the increase in the facilities required for training.

In Lord Hives's opinion, the reason for the unsatisfactory state of recruitment is not to be found at the level of the university, but is something much deeper: it is to be found in the schools and in the attitude of mind of a great number of the parents in Britain. Since engineering, even in its fundamentals, is not taught in schools, too often when a boy comes to consider what he should study at the university, or what career to take up straight from school, he knows nothing at first hand of one of his country's greatest possible careers—engineering.

A distinguished careers master, Mr. Howard Ruby, of Dulwich College, put the position very neatly when he wrote recently that even when careers masters are well aware of the good prospects in an industrial career, their problem is to convince parents and boys, for there still survives in the minds of some parents the view that a career in industry is not so respectable as one in the Armed or Civil Services or other professions. Such a point of view is not only out of date but also harmful, and so long as it persists Britain will never have the skilled men that it requires. A unique place in the estimation of the world has been earned for Britain by its craftsmanship, the skill of its engineers and technicians and the ingenuity of its scientists, and it is necessary that young men should come forward in increasing quality and numbers for past triumphs to be maintained and even exceeded. The main lesson to be learnt from the United States is the high position in society given to industry in that country. As one of the recent Anglo-American productivity teams said in its report: "It is because of this social and intellectual prestige attaching to the highest position in industry that many of the best students choose industry for a career". Lord Hives emphasized the fact that in the engineering industry many of the key positions at the very top of the tree are held by trained engineers. In fact, there is no better training for an executive in the industry to-day than to have worked in his time as a skilled engineer. Yet to many people engineering is still something 'messy', something that polite young men ought not to get mixed up in. Technical engineering, on the other hand, can be the most exciting and fascinating way of earning a living, and the chief reason for this is that it can never remain static.

Prof. J. A. Pope, head of the Department of Civil and Mechanical Engineering in Nottingham, thanked the University Grants Committee and members of industry who through their generous support had made the developments possible, and paid tribute to the University surveyor, Mr. J. W. Popplewell, and his staff on achieving a useful and economical design of building; the capital expenditure per student place had been kept very low without any sacrifice of student amenities or teaching efficiency.

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# BRITISH GELATINE AND GLUE RESEARCH ASSOCIATION

## RESIDENTIAL CONFERENCE

THE first residential conference of the British Gelatine and Glue Research Association was held at Hulme Hall, University of Manchester, during April 8–11, and the progress made in the first two and a half years of research work was reported. The meeting was well attended, those present including representatives of gelatine and glue manufacturing firms, of firms using these products, and of government laboratories, research associations and university departments.

The Conference Lecture, by Dr. G. R. Tristram (University of St. Andrews), reviewed recent progress

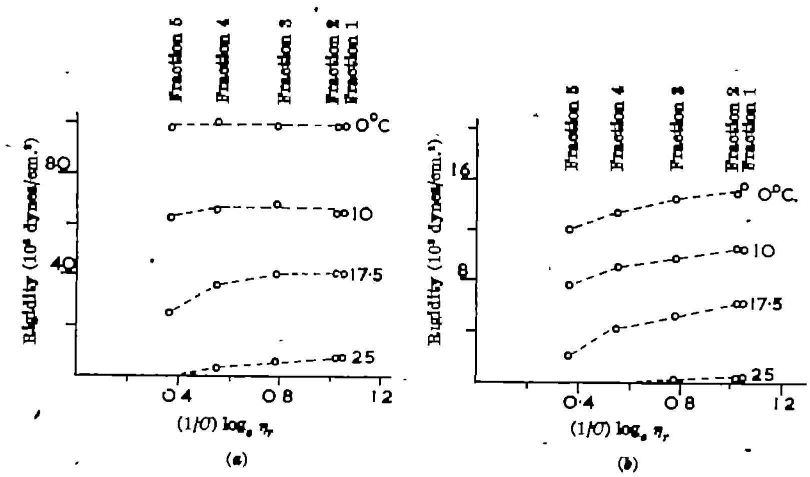

Fig. 1. Rigidity of gels from fractions of gelatin as a function of reduced viscosity ($C = 0·2$ per cent) at temperatures from 0°–25° C. in 1 $M$ sodium chloride at $p$H 7: (a) gel concentration 5·5 per cent; (b) gel concentration 2·2 per cent

in protein research. The techniques by which the amino-acid composition, N-terminal and C-terminal residues, and amino-acid sequence might be determined were given, and illustrated by F. Sanger's work on insulin. Although adequate to give the structure of insulin, which is a protein of comparatively low molecular weight, existing techniques appear inadequate for obtaining the sequence in proteins of higher molecular weight, and still more so for heterodisperse systems such as gelatin.

One of the principal raw materials of the industry was considered by Dr. J. E. Eastoe, in a paper on the composition of bone. The tissue selected for study was a powdered sample of compact bone from the central, tubular portion of the femur of the cow, since it could be obtained almost entirely free of other tissues. The organic components of the tissue were collagen (18·64 per cent), mucopolysaccharide (0·24 per cent), and a protein which resisted solution in boiling water (1·02 per cent). Free sugars were not detected, nor was fat present. Inorganic matter, with which citrate was included, made up 70·91 per cent, and with water (8·18 per cent) gave a total of 99·0 per cent. No significant chemical differences were observed between the bone collagen and hide or sinew collagens. The mucopolysaccharide contained some 70 per cent of a protein of amino-acid composition similar to blood albumin, while the carbohydrate portion did not correspond to published compositions[1] for chondroitin or mucoitin sulphate. Glucos-2-amine, galactos-2-amine, glucuronic acid, galactose and mannose were all detected in the carbohydrate, and they were estimated approximately. The resistant protein was shown to be neither collagen nor elastin.

Mr. D. Fysh gave a short paper describing the equipment being used for empirical studies of the extraction of bone glue. Preliminary results indicate the relative importance of the two stages—heating under steam pressure, and addition of hot water to give the glue liquor—in the extraction process.

The remaining papers were concerned with the properties of gelatin, which had been chosen as the main field of study. Dr. G. Stainsby described a new technique[2] for fractionating gelatin, using the solubility of the complex formed between gelatin and sodium dodecyl sulphate. The method makes extensive use of the work of Smith and Pankhurst[3,4] concerning the behaviour of the complexes. Successive raising of the salt concentration in a solution of gelatin and sodium dodecyl sulphate at 35° C. and $p$H 7 causes portions of the complex to separate as a coacervate. Material of high molecular weight is separated off at the lower salt concentrations. By acetone precipitation, the gelatin present in the coacervate may be separated from the sodium dodecyl sulphate and its properties measured. A very simple procedure involving the preparation of five fractions has proved adequate to show differences in the distribution of molecular weight between closely related gelatins.

P. R. Saunders reported on the properties of the gelatin fractions. Contrary to results obtained by J. D. Ferry for unfractionated materials of differing molecular weight[5], the molecular weight of a gelatin fraction has been shown to be of importance in determining the rigidity of a gelatin gel, only as the temperature approaches the melting point or the concentration is lowered to a point at which weak gels alone are formed. The method used for rigidity measurements[6], involving the deformation of a cylinder of gel, set in a precision-bore tube, under air pressure, was sufficiently simple to enable measurements to be made at two concentrations and four temperatures (0–25° C.) for fractions of six gelatins of widely differing types. The results for one gelatin are shown in Fig. 1. It can be clearly seen that at 0° C. and 10° C. the rigidity (5·5 per cent concentration) was independent of the reduced viscosity ($1/C \log_e \eta_{\text{rel.}}$, in 1 $M$ sodium chloride, $p$H 7) and hence of molecular weight. Confirming results by Pouradier[7], it has been shown that the melting point of gelatin does not depend solely on molecular weight. The viscosity of fairly concentrated solutions has been shown to be uniquely related, within the rather large experimental error, to the dilute solution viscosity.

Dr. A. Courts showed how the fluoro-dinitrobenzene technique of F. Sanger[8] can be used to determine the N-terminal amino-acid residues of gelatin and its degradation products. Typical figures for gelatin prepared from an alkali-treated calf-skin precursor and an acid-process pigskin gelatin are given in Table 1:

TABLE 1

| | N-terminal residues of gelatin (gm./100 kgm. gelatin) | |
|---|---|---|
| | Calfskin | Pigskin acid process |
| Glycine | 0·83 | 0·74 |
| Serine | 0·19 | 0·10 |
| Threonine | 0·11 | 0·08 |
| Alanine | 0·11 | 0·24 |
| Aspartic acid | 0·11 | 0·13 |
| Glutamic acid | 0·10 | 0·07 |
| Others | 0·12 | 0·19 |
| Total | 1·57 | 1·55 |
| Isoelectric point ($p$H) | 5·1 | 9·4 |

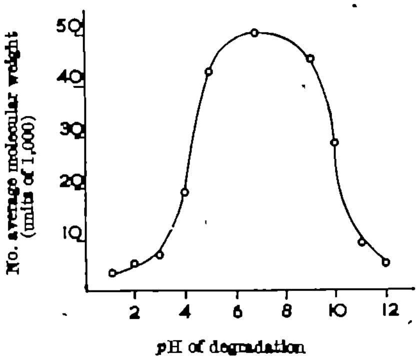

Fig. 2. $M_n$ of gelatin ($M_n$ initial = 58,000) after heating in solution for 24 hr. at 75° C.

The examples quoted in Table 1 were selected to give almost the same total of end-groups, to assist in comparison.

The number of N-terminal residues may be used to give the number-average molecular weight ($M_n$) for the gelatin sample, if it is assumed that the gelatin molecule is a single polypeptide chain with one N-terminal residue per molecule. The values of $M_n$ obtained for alkali-processed gelatins were 50,000–70,000, which is in fair agreement with osmotic determinations by Pouradier[7] for similar gelatins.

A number of samples of a gelatin, which gave $M_n$ = 58,000 by fluoro-dinitro benzene technique, were degraded at 75° C. for 24 hr. at 5 per cent concentration at different pH's. The effect on the values of $M_n$ is shown in Fig. 2. The curve is nearly symmetrical about pH 7. Further experiments at different temperatures suggest a figure of 19,000 cal. for the mean activation energy for breaking peptide bonds, as measured by the release of N-terminal residues. This figure is in quite good agreement with values deduced[9] from the viscosity and other properties.

A. W. Kenchington presented a paper on the methylation of gelatin, and on the means by which the degree of substitution can be estimated when gelatin is modified by organic reactions. The most important method, giving values for several groups, makes use of the titration curve. Provided the isoelectric point is also known, the titration curve can be used for giving values for carboxyl, imidazole, ε-amino and guanidino groups. The proportion of the dicarboxylic acids in the amide form can also be deduced. By analysis of the curves obtained for gelatin samples, the limits of titration suggested by Cannan[10] have been modified, so that at 40° C. they are:

TABLE 2

| | New values | Cannan's values |
|---|---|---|
| Carboxyl groups | pH 1·5–6·5 | pH 1·5–6·0 |
| α-Amino and imidazole | pH 6·5–8 | pH 6·0–8·5 |
| ε-Amino | pH 8–12 | pH 8·5–12·5 |
| Guanidino | not titrated | pK presumed > 12 |

The use of these limits secures agreement between figures for the grouping by analytical and titration-curve methods. The need for the changes results from the following: (i) the presence of a substantial proportion of hydroxylysine; (ii) the higher temperature of measurement reduces the pK of the ε-amino group; (iii) some proportion of the carboxyl groups have pK's in the region of pH 5, and their contribution will only become small above pH 6·5.

Methylation has been carried out by a slow reaction with methanol under acid conditions. Although almost complete methylation of carboxyl groups was achieved, a proportion of the esterified groups is very unstable, and readily loses methanol. Up to 33 per cent substitution, the derivative appears stable to most conditions, but not to alkalis. The degree of substitution was measured using a modified Zeisel method, and the values agreed well with the number of carboxyl groups no longer titratable in the titration-curve method. This suggests that no methylation of hydroxyl groups has taken place. There was also no evidence of methylation of the ε-amino groups. The methylated gelatin was not very different in general behaviour from its parent gelatin and gels were easily obtained. Some degradation had occurred, probably due to the low reaction pH.

E. Courtman outlined a method for determining total bacterial counts for gelatine. Wide variations of total count are known to occur for samples withdrawn from a single gelatine batch[11,12], which result, it would appear, from high local concentrations of bacteria in individual grains. The expression of results as a mean with limits of error will assist in preventing needless disputes over disagreeing values.

M. E. Adams reviewed the manifold uses of gelatine and glue. By classification according to relevant properties, she was able to show that problems of the interface represent the largest gap in knowledge of gelatine and glue.

A. G. Ward, director of research of the Association, in the concluding paper of the conference, outlined the present knowledge of gelatin and its preparation from collagen. The structural features of gelatin which determine the properties of its solutions and gels appear to be, in the main, charge distribution arising from the ionizable groups, molecular weight and molecular weight distribution, and some third factor which affects the rigidity of gels, particularly at low temperatures. This third factor also appears to influence the melting point and the point at which alcohol gives turbidity to a gelatin solution[7]. Little is known of the changes involved in converting collagen to gelatin, but the techniques now available will assist in studying this problem. In addition to these subjects, the Association will in the next five years use empirical methods both for problems of manufacture and for user problems, and also examine in a more fundamental way the behaviour of gelatin at the liquid–gas, liquid–liquid and liquid–solid interfaces. This behaviour is of importance in many uses of gelatine and glue.

A. G. WARD

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# CROP PROTECTION

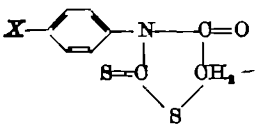
## SYMPOSIUM IN GHENT

THE annual symposia on crop protection, held at the College of Agriculture, Ghent, have attracted larger numbers each year since the present rector of the College, Prof. J. Van den Brande, organized the first meeting in 1948, and at the meeting this year, held on May 5, some two hundred and fifty persons participated. Although the majority were from Belgium and Holland, representatives from several other countries were present. The opening address by Prof. Van den Brande in the morning was followed by two simultaneous sessions for the reading of papers, and during the afternoon a further five papers were read.

Dr. J. G. ten Houten (Wageningen) gave an excellent general survey of the research now proceeding in the Netherlands on plant diseases and pests and their control. In the work on apple scab, the correlation between temperature and duration of wetting of apple leaves in relation to the primary infection and incubation periods for *Venturia inaequalis*, as established by Mills in the United States, has been confirmed under the climatic conditions prevailing in the Netherlands. By spraying eradicant fungicides (organo mercury compounds) up to five days after infection took place, it was possible to control apple scab by only three sprayings against the six required with protective fungicides like lime sulphur. Spraying with organo mercury compounds, however, can only be used on non-susceptible apple varieties, and such treatments should not be made after ascospore discharge has ceased. Research on the Rubus stunt virus of raspberries has shown that diseased shoots can be completely freed from the virus by immersion in water at 45° C. for 1–3 hours. Excellent control of the pea moth (*Enarmonia nigricana*) attacking canning and other peas which are harvested early has been consistently obtained by one application of parathion when the lower pods are about three-quarters grown. Toxicological trials indicate little consumer hazard if the recommended procedure is adopted. The potato root eelworm (*Heterodera rostochiensis*) is a serious pest in Holland, and to grow potatoes in infested soils or to take a potato crop more than once every three years from non-infested soil is prohibited by law. A team of research workers is concerned with the control of this pest. The investigations include soil treatment with chemicals, finding the substances in potato root extracts responsible for the hatching of the cysts, the possibility of using parasites (fungi and a newly found amoeba), and breeding resistant potato varieties. The control of cyst-forming eelworms with 'DD mixture' was the subject of a paper by Dr. J. Th. W. Montagne (Amsterdam), in which he said that soil treatment with the chemical combined with a short crop-rotation has been found to give the best results. Prof. Van den Brande, R. H. Kips and J. D'Herde (Ghent), also studying the eelworm problem, described how they had examined some of the newer systemic insecticides for nematocidal action. Again, Dr. M. Oostenbrink and Dr. A. F. H. Besemer (Wageningen) showed that a root rot disease in chrysanthemums, pyrethrums and other flowers grown for cutting is associated with parasitic eelworms. Large numbers of *Meloidogyne* sp. and *Pratylenchus* sp. were present in the sick fields, and it had been shown that attack by these pests was a primary cause of the disease, the fungus attack probably leading to the final collapse of the root. Soil fumigation with chloropicrin gave the most effective control.

Several papers were concerned with weed control. M. Slaats and J. Stryckers (Ghent) showed that under certain conditions ammonium dinitro-*o*-cresylate can be used for controlling weeds in hybrid maize; hormone-type weed killers damage the crop. Dr. F. H. Feekes (Baarn) discussed his work on the use of *iso*propyl-N-phenyl carbamate and sodium *iso*propylxanthate as selective weed killers. A striking control of chickweed (*Stellaria media*) was achieved with the former substance at 10 lb. an acre.

Dr. G. J. M. Van der Kerk (Utrecht) described a new group of organic fungicides which has arisen from his work on dithiocarbamic acid derivatives. These compounds are the N-phenylrhodanines with *para* substituents in the benzene ring (I). The most active compound so far obtained is *p*-phenylene-*bis*rhodanine (II), which, against the four fungi tested, is at least as fungicidal as the most active of the dithiocarbamic acid derivatives now used in crop protection.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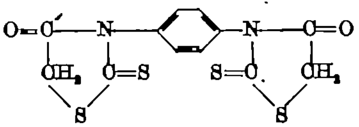
II

Another paper concerned with fungicides was presented by L. Bravenboer (Naaldwijk), who discussed his attempts to correlate the degree of control of *Cladosporium cucumerinum* obtained in practice with the results of laboratory experiments. Prof. R. L. Wain (London) reviewed the present position of systemic fungicides; he gave an account of the more recent British and American work in this field and described the investigations being carried out in his department with aryloxyalkylcarboxylic acids and other compounds. M. J. Zwijns (Maarssen), in discussing seed disinfectants, said that tetramethylthiuram disulphide has given excellent results as a seed dressing for beets, beans, peas, corn, flax and other crops; 2 : 3-dichloro-1 : 4-naphthoquinone and tetrachloro-1 : 4-benzoquinone have also proved satisfactory. R. Bovigne *et al.* (Gembloux) outlined the results of experiments using tetrachloronitrobenzene, methylnaphthyl ethyl ether, methyl α-naphthylacetate and *iso*propyl-N-phenyl carbamate for preventing the sprouting of potatoes. Dr. H. Franke-Grosmann (Reinbek-Hamburg) gave an interesting account of how the gall mite *Aceria gemmarum* (Nalepa) became a serious pest on willow following the use of DDT and BHC against leaf-eating beetles and weevils (*Phyllodecta vulgatissima* and *Pselaphorhynchites* spp.); much damage was caused in *Salix viminalis f. regalia*, whereas *S. americana* was attacked to a much less extent.

Other topics discussed were the value of the Fischer index as a means of estimating the keeping qualities of suspensions (P. H. Martens and J. Henriet, of Gembloux), the control of the cabbage seed-pod weevil with BHC and parathion (Prof. J. H. Schuurmans-Stekhoven, of Deventer), experience in the Netherlands with new types of acaricides

(A. F. H. Besemer and K. Hartsuyker, of Wageningen), a new method of applying pest control materials to plants (Prof. P. Froeschel, of Ghent) and a biological method for assessing residual parathion on cabbage leaves (Dr. J. J. Fransen, of Arnhem).

The organizers are to be congratulated on the satisfactory arrangement and smooth running of this successful symposium. R. L. WAIN

# RESEARCH IN RURAL ELECTRIFICATION

## WORK AT THE ELECTRICAL RESEARCH ASSOCIATION

AN open week, beginning on May 4, was held at the Field Station at Shinfield, near Reading, of the Electrical Research Association, and Mr. G. R. H. Nugent, parliamentary secretary of the Ministry of Agriculture and Fisheries, a Ministry which makes a substantial contribution to the work of the Association, officially inaugurated the proceedings.

The Electrical Research Association established its Rural Electrification Section in 1938 with the main object of developing equipment and operating techniques which are satisfactory to the farmer or grower and which, at the same time, present load characteristics favourable to the economic supply of electricity. The larger the energy taken by rural consumers, especially during off-peak periods, and the lower the power demand, the greater the possible economy. Mr. Nugent emphasized the benefit of electricity on the farm, especially in saving labour and thus increasing production with the present labour force, and also in providing amenities for farm workers to encourage them to stay on the land rather than to succumb to the attractions of the town. A large, and rapidly increasing, number of farms now have electricity, but too many of them fail to make full use of it. Although electric light and domestic power are certainly valuable, much fuller advantage should be taken of electrical methods in agriculture and horticulture. The Ministry, said Mr. Nugent, is fully in agreement with the aims of the research work at Shinfield; economic considerations are rightly kept to the fore in the development of new applications of electricity on the farm.

At the Field Station, basic research determines the form of equipment and the technique required for electrical operation. This is followed by full-scale tests and later by trials under practical conditions on farms and horticultural holdings in different parts of Britain. The co-operation of the agricultural research establishments and of farmers and growers is an essential feature of work of this kind, and the Association has been fortunate in obtaining such co-operation both from its neighbours—the University of Reading and the National Institute for Research in Dairying—and from others much farther afield.

The underlying principle in many of the investigations is simplicity of operation, with electrical methods involving low kilowatt loadings which can be used for a lengthy period. These are much more welcome to electricity supply than the high short-period loads which present difficult problems in rural electrification.

A number of researches already completed have formed the basis for equipment which is now commercially available. Among these are: barn hay-drying, a method of producing very high quality hay by blowing cold, or slightly warmed, air through grass stacked in the barn; a low-powered automatic hammer mill for farm grinding; a soil sterilizer of the immersion type for potting soil; and soil warming in frames and glass-houses by a simplified method in which a daily 'dose' of energy provides beneficial soil warmth but avoids the large consumption needed to maintain a suitable fixed temperature. Work now in progress on the horticultural plots aims at further improvement of the soil-warming technique and at finding the crops and varieties for which it is most likely to be economical in frames, under cloches and in open ground.

In the glass-houses, electric space-heating is used in combination with soil-warming, and different arrangements and forms of construction are being studied to reduce heat losses and so to minimize operating costs. Artificial illumination, using various kinds of lamps and of lighting fittings, is being applied to the raising of tomato seedlings. Laboratory work on soil sterilization by the electrode method, in which current is passed directly through the soil, is preliminary to *in situ* sterilization of glass-house soil. A model glass-house in the exhibition was fitted with many devices which may be developed in future for the complete control of all the factors involved in growing plants to perfection. Presuming that the plant physiologists achieve their goal, this is the ultimate object of the researches now in progress.

Laboratory work on the agricultural side is concerned with the requirements for drying many kinds of agricultural materials and with their equilibrium moisture content in different atmospheric conditions. Grain drying, grass drying and seed drying are studied experimentally, and a novel form of moisture-meter for grain has been developed. A 'farm of the future' in the display showed many new agricultural applications of electricity which, in combination with existing ones, could be used to provide an approximately constant load throughout the year. They would both save labour and give a high load-factor on the farm.

An electrically driven tractor which has been used for the cultivation work at the Field Station during the past three years has the advantages of simple and quiet operation, low running and maintenance costs, and ample tractive effort over a wide range of speeds.

In conjunction with the University of Reading poultry farm, investigations are being made on the possibilities of electrical methods in poultry husbandry. These include air-conditioning for laying hens, the effect of environment on the growth of chicks, and flash illumination in laying-houses as an energy-saving alternative to the usual artificially extended daylight. The destruction of pests by the use of high-frequency fields, the killing of weeds by an electrical discharge and fish-stunning by passing a current through the water in streams or in the sea, are other subjects studied. An experimental heat pump is used for heating one of the laboratory buildings, and its performance is being tested by comparison with that of a conventional plant in another building with similar thermal characteristics. The heat-pump principle is also being applied to dairy work with the object of using heat removed from milk in cooling it to heat water for washing.

Another display showed something of the researches of the Association on the possibilities of wind-power for electricity generation on different scales of use. A survey, for which several new measuring instruments have been developed, is in progress in western coastal areas of Great Britain and Ireland. Many specially favourable sites have been found, and pilot plants, of 100-kW. capacity, are being built in Orkney and for another site. The performance will be tested as a guide to the design of larger machines for which a basis has already been formed by comprehensive design and costing studies. At the same time, the study includes the design, development and use of smaller plants adapted to typical isolated communities in Britain and abroad where adequate alternative sources of power are difficult to come by. For topical interest, the actual record was displayed of the highest wind-speed yet recorded in the British Isles, namely, 125 m.p.h. on Costa Hill, Orkney, early this year.

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# LATTICE DEFECTS AND THE ELECTRICAL RESISTIVITY OF METALS

An informal conference arranged by the Department of Metallurgy, University of Birmingham, and concerned with recent work on the influences of deformation and irradiation on the electrical properties of metals, was held in Birmingham during April 24–25.

Following an introductory survey by T. Broom (Birmingham), which served to enumerate some present-day problems, J. A. Manintveld (Delft) presented new results for the recovery of resistivity of pure metals after heavy deformation at low temperatures. There is general agreement that a well-defined recovery process occurring at around 0° C. is due to the movement of single vacancies; but a satisfactory account of recovery at lower temperatures is lacking. Prof. M. J. Druyvesteyn (Delft) discussed possible processes for this and also gave results of an investigation into recovery of mechanical properties of polycrystalline wires after low-temperature deformation.

Various mechanisms for the generation of vacancies and interstitial ions during deformation were critically reviewed by Prof. N. F. Mott (Bristol), and one of these, the intersection of screw dislocations, was used by H. G. van Bueren (Eindhoven) as a basis for a theoretical treatment of resistivity-extension curves in which a three-halves power law is obeyed. P. Jongenburger (Eindhoven) completed the discussion of vacancy effects in pure metals by describing his calculations of scattering due to single vacancies in copper, silver and gold.

A new theoretical treatment by S. C. Hunter and Dr. F. R. N. Nabarro (Birmingham) of the resistance due to screw and edge dislocations in metals was presented and the need for a calculation of scattering from stacking faults was pointed out. Predictions of anisotropic scattering from single dislocations formed the basis of an account given by C. W. Berghout (Delft) of some experiments on the anisotropy of resistivity of plastically stretched foils. J. F. Nicholas (Melbourne) gave results of an investigation into the validity of Matthiessen's rule for cold-worked metals and alloys and put forward a qualitative interpretation of the small deviations found.

Resistance changes due to the irradiation of pure metals and the ordered alloy $Cu_3Au$ by electrons, neutrons, deuterons, etc., were discussed by R. A. Dugdale (Harwell). As in deformation studies, recovery experiments reveal effects almost certainly due to the diffusion of vacancies, and indeed recent work at Harwell on $Cu_3Au$ has shown very similar activation energies for recovery of resistivity measured after irradiation, after quenching and after cold-working.

Dr. K. Lücke (Göttingen) reviewed the influence of impurities in copper on the results of deformation and recovery experiments and also gave an account of work on resistance changes in iron due to strain-ageing. Two contributed papers dealt with resistance changes in alloys: Dr. W. H. Aarts and R. K. Jarvis (Johannesburg) reported increases of resistivity during room-temperature annealing of some silver–gold alloys following deformation at low temperatures; Dr. J. O. Linde (Stockholm) wrote giving the results of a study of the effect of deformation on the resistivity of certain binary, ternary and quaternary alloys of silver and gold with transition metals. Finally, J. F. Nicholas (Melbourne) pointed out the lack of any direct experimental or theoretical evidence for the supposition that large resistivity changes caused by the deformation of some alloys are due to the destruction of short-range order.

Many interesting points were raised in discussion and served to reveal the utility of resistivity studies as a means of investigating the structure of metals.

T. Broom

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# CROSSED AMORPHOUS AND CRYSTALLINE CHAIN ORIENTATION IN POLYTHENE FILM

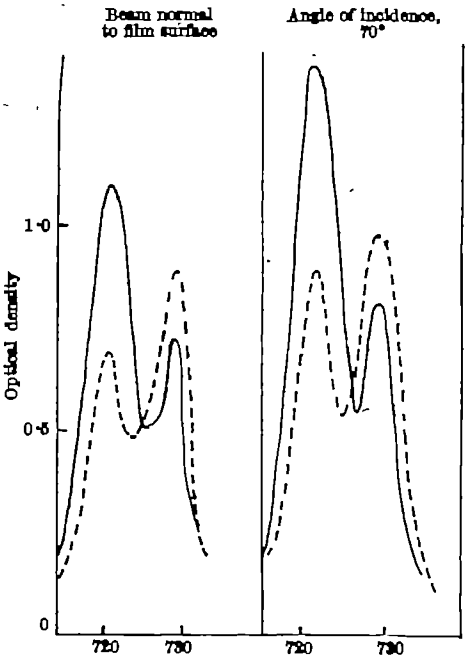
By D. R. HOLMES, R. G. MILLER, R. P. PALMER and C. W. BUNN

Plastics Division, Imperial Chemical Industries, Ltd., Welwyn Garden City, Herts

The structure of polythene film has been investigated by X-ray, optical and polarized infra-red methods. It was found that the polymer chains are oriented differently in the crystalline and the amorphous regions, the respective chain axes being perpendicular to each other. We are unaware of any previous investigations into the orientation in both crystalline and amorphous regions, and as a result this remarkable phenomenon has escaped notice.

Most polythene film is produced by extruding the viscous molten polymer through a slit, passing the resulting sheet downwards into a water quenching-bath, under an idler roller and finally on to a wind-up roller. The whole system is very nearly tensionless to prevent drawing of the film; nevertheless, the films produced do possess some orientation.

The samples available varied in thickness from 0·04 mm. to 0·11 mm. and proved to be of convenient thickness for all three experimental methods, and so no preparatory techniques which might have affected the molecular structure of the film were necessary.



——, Electric vector perpendicular; ----, electric vector parallel to the machine direction

The preferred orientation in the crystalline regions was deduced in the usual way from X-ray diffraction photographs of the film set up in various positions on the goniometer head. The indexing of the photographs and the subsequent interpretation of the results was carried out with the aid of the crystal structure proposed by Bunn[1]. It was found that the *a*-axes of the orthorhombic crystallites tend to lie parallel to the machine direction in the film (that is, the direction of travel of the film during production). The *b*- and *c*-axes are randomly oriented in a plane perpendicular to this direction.

Microscopic observation of the films in plane polarized light showed that all the films are optically biaxial and that the machine direction generally has the highest refractive index. Birefringence measurements on tilted specimens and on sections cut perpendicular to the machine direction and also observations of interference figures established the orientation of the optical indicatrix. With the usual nomenclature, $\gamma$ lies along the machine direction, $\beta$ is perpendicular to the machine direction in the plane of the film and $\alpha$ is perpendicular to both the machine direction and the plane of the film. $(\gamma - \beta)$ is about ten times as great as $(\beta - \alpha)$ and varies from $-11$ to $+41 \times 10^{-4}$ for the films examined.

Calculations of the principal refractive indices of the polythene molecule and crystal separately (from bond polarizabilities and the Lorenz–Lorentz equation)[2] showed that in both cases $\gamma_{AC}$ is parallel to the chain axis; the suffixes $A$ and $C$ refer to the amorphous molecule and the crystal respectively. For the molecule, $\beta_A$ is parallel to the plane of the carbon atoms but perpendicular to the chain axis, and $\alpha_A$ is perpendicular to both the plane of the carbon atoms and the chain axis. For the crystal, $\beta_C$ lies along the *b*-axis and $\alpha_C$ along the *a*-axis. The optical evidence, together with the X-ray evidence that the chain (*c*-) axes of the crystallites are perpendicular to the machine direction, indicated that there must be considerable orientation of the amorphous molecules with the direction of their chain axes parallel to the machine direction.

Confirmatory evidence was obtained by the use of infra-red absorption measurements on the doublet band which occurs in the polythene spectrum at 721 and 729 cm.$^{-1}$. This has been ascribed by Sheppard and Sutherland[3] to a rocking motion of the methylene groups, and Elliott *et al.*[4] and Rugg *et al.*[5] have shown that in fully drawn polythene both parts of the band exhibit perpendicular dichroism. Therefore, we deduce that the transition moment causing this absorption is perpendicular to the carbon chain and parallel to a line joining the hydrogen atoms of a methylene group. The direction of this transition moment lies in the *ab* plane of the polythene crystal and makes an angle of 41° with the *a*-axis[1]. The component parallel to the *a*-axis is greater than that parallel to the *b*-axis and there is no component along the *c*-axis.

When polythene is melted, the peak at 729 cm.$^{-1}$ disappears and is therefore ascribed to the crystalline regions of polythene. The second peak, at 721 cm.$^{-1}$, although probably due in part to the crystalline material, is mainly due to the rocking vibration of the methylene groups in the amorphous regions. Consequently it is possible to obtain some measure of the orientation in crystalline and amorphous regions separately.

Observations were made using polarized infra-red radiation with the electric vector parallel and perpendicular to the machine direction. With the beam normal to the film, the 'amorphous' band at 721 cm.$^{-1}$ showed perpendicular dichroism (that is, there was greater absorption of the light with the electric vector vibrating perpendicular to the machine

DETAILS OF RESULTS OF X-RAY, OPTICAL AND INFRA-RED EXAMINATION OF POLYTHENE FILMS

| Specimen No. | Thickness (mm.) | Birefringence $(\gamma - \beta)$ | Dichroic ratio | | Order of orientation | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Amorphous | Crystalline | X-ray (cryst.) | Infra-red (cryst.) | Infra-red (amorph.) | Optical (cryst. + amorph.) |
| 1 | 0·110 | 20·8 | 0·87 | 1·14 | 6 | 6 | 9 | 4 |
| 2 | 0·072 | 6·7 | 0·84 | 1·22 | 4 | 4 | 7 | 13 |
| 3 | 0·076 | 9·8 | 0·93 | 0·90 | 13 | 14 | 13 | 11 |
| 4 | 0·058 | 15·8 | 0·87 | 1·07 | 10 | 10 | 8 | 8 |
| 5 | 0·048 | 41·7 | 0·62 | 1·23 | 1 | 3 | 3 | 1 |
| 6 | 0·046 | 19·5 | 0·57 | 1·59 | 2 | 2 | 1 | 6 |
| 7 | 0·048 | 25·6 | 0·58 | 1·68 | 3 | 1 | 2 | 2 |
| 8 | 0·046 | 25·1 | 0·66 | 1·19 | 7 | 5 | 4 | 3 |
| 9 | 0·061 | 12·9 | 0·78 | 1·13 | 12 | 7 | 6 | 10 |
| 10 | 0·063 | 18·5 | 0·93 | 0·99 | 8 | 12 | 12 | 7 |
| 11 | 0·061 | 9·7 | 0·91 | 1·08 | 9 | 11 | 10 | 12 |
| 12 | 0·066 | 15·2 | 0·92 | 1·10 | 5 | 9 | 11 | 9 |
| 13 | 0·064 | 0 | 0·96 | 1·02 | 15 | 13 | 14 | 14 |
| 14 | 0·072 | −11·1 | 0·78 | 1·12 | 11 | 8 | 5 | 15 |
| 15 | 0·064 | 19·8 | 0·96 | 0·96 | 14 | 15 | 15 | 5 |

direction); but the 'crystalline' band at 729 cm.$^{-1}$ exhibited parallel dichroism. When the film was rotated about the machine direction as axis to angles of incidence of 30°, 45°, 60° and 70°, the dichroism remained the same for the crystalline band at 729 cm.$^{-1}$, but the perpendicular dichroism of the absorption band at 721 cm.$^{-1}$ decreased slightly as the angle of incidence increased (see graph). These results on the band at 729 cm.$^{-1}$ indicated that the crystals are oriented with their $c$-axes perpendicular to the machine direction and probably with their $a$-axes parallel to it.

The observations on the band at 721 cm.$^{-1}$ showed that in the amorphous regions the orientation was different from that in the crystalline regions, and that the plane of the carbon chain contained the machine direction. However, the optical evidence shows that the axis of the carbon chain is parallel to the machine direction, and with this established the infra-red dichroism indicates that there is a slight preference for the plane of the carbon atoms to be perpendicular to the plane of the film. In view of this preference, the optical result that β was parallel to the plane of the film indicated a slight preference for the $c$-axes of the crystallites to lie in the plane of the film. Details of the results on fifteen different samples of film are shown in the accompanying table. It should be noticed that samples showing good amorphous orientation generally possess good crystalline orientation in a perpendicular direction.

A consideration of the manufacturing process helps towards an understanding of the formation of such an unusual structure. The extrusion through the slit followed by the downward flow into the quenching-bath produces good alignment of the polymer chains parallel to the machine direction, ready for crystallization to occur as soon as the film reaches the quench-bath. The water quenching-bath is often nearly boiling and therefore relaxation takes place simultaneously with crystallization. Nancarrow and Horsley[6] and also Brown[7] have found that, when relaxation of stretched polythene monofilaments occurs, the crystallites tend to take up a position with their $a$-axes parallel to the original direction of stretch. Our observations show that a similar orientation occurs in the relaxation of polythene film. Many attempts[4,8] have been made to explain the orientations occurring during the stretching and relaxing of polymers in terms of preferred cleavage and slip planes and also from a thermodynamic point of view, but none has been completely satisfactory. It is probable that the preferred directions of crystal growth are equally important in the present case where crystallization and relaxation are occurring simultaneously.

The amorphous regions of the film are formed of those polymer molecules which have an unfavourable spatial configuration for crystallization and necessarily show good orientation with their long axes in the machine direction. No explanation can be advanced at present for the slight amount of amorphous double orientation observed.

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# CARBON DIOXIDE CONCENTRATION AND MAXIMUM QUANTUM YIELD IN PHOTOSYNTHESIS

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FOR fifteen years controversy has occurred about the maximum quantum yield in photosynthesis. Whereas one molecule of carbon dioxide is reduced by 3–4 quanta according to Otto Warburg and co-workers, at least 8 quanta are necessary according to Emerson and his school. Rabinowitch[1] has given a thorough review of the whole literature.

Warburg and co-workers[2,3] have, however, published the results of new experiments intended to explain why Emerson and his school have never been able to find a quantum yield higher than about 1/8. According to ref. 2, a carbon dioxide concentration of 5 per cent per volume is necessary both in an acid and in an alkaline medium in order to produce the maximum yield in *Chlorella pyrenoidosa*. Emerson's school used an alkaline medium (Warburg buffer No. 9), the carbon dioxide concentration of which is 0·2 per cent.

The optimum rate of photosynthesis at high light intensities in *Chlorella pyrenoidosa* is found both in an alkaline and in an acid medium already at very low concentrations of carbon dioxide (0·08 per cent according to Whittingham[4]). According to all reliable investigations[5], curves for different light intensities showing the dependence of the photosynthetic rate on carbon dioxide concentration at low concentrations merge into a single straight line. At low light intensities where the quantum yield is to be measured, saturation is achieved at lower concentrations rather than at high intensities.

The claim of Warburg that the optimum rate of photosynthesis at very low light intensities should need a concentration of carbon dioxide about two hundred times as high as the concentration necessary at high intensities thus seems erroneous. Experiments were therefore carried out with Warburg's strain of *Chlorella* in order to investigate the background of his statement. Both the rate of photosynthesis and the rate of respiration were measured by the Winkler method (oxygen metabolism). Fluorescent light was

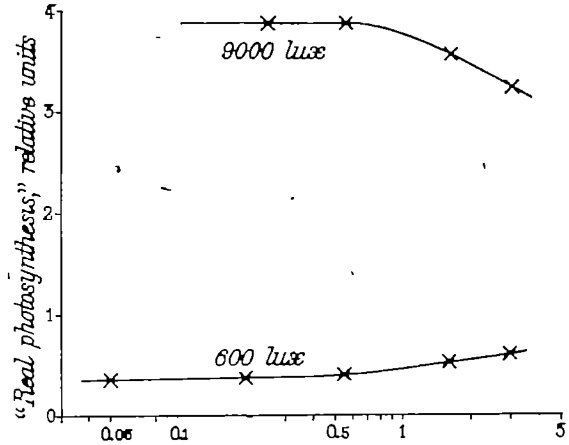

Fig. 1

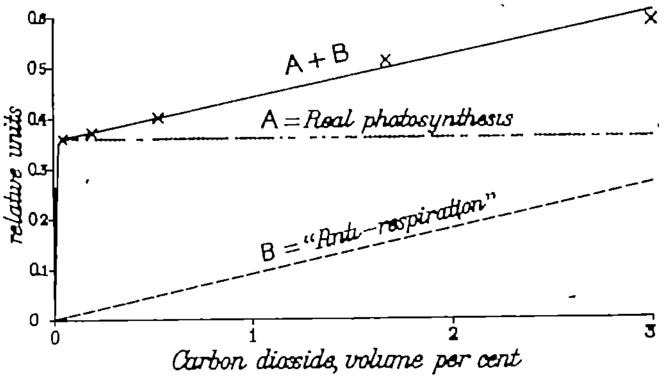

Fig. 2

employed. The maximum intensity was 9,000 lux. Lower intensities were obtained by using neutral filters. The experiments lasted 90–240 minutes.

The upper curve in Fig. 1 gives a typical example of a series of experiments at a high light intensity (pH 6·8, 21° C.). The different concentrations of carbon dioxide were made by mixing a solution of potassium bicarbonate with water saturated with carbon dioxide and water free of carbon dioxide. The concentration varied from 0·25 to 3·0 per cent. The lowest two concentrations were on the saturation plateau. Concentrations above 1 per cent, however, are too high for optimum photosynthesis. The rate at 3 per cent had decreased by 16 per cent.

In the lower curve in Fig. 2 the result of experiments made simultaneously at 600 lux is plotted. The shape of the curve differs definitely from the shape of the upper curve. From a concentration of about 0·3 per cent the curve unmistakably starts ascending. The rate of photosynthesis apparently increases by 50 per cent by increasing the carbon dioxide concentration from 0·5 to 3·0 per cent. This is nearly the same as shown by Warburg et al.[3].

The shape of the complete lower curve in Fig. 1, however, clearly indicates that this curve does not solely represent the dependence of photosynthesis on carbon dioxide concentration.

Kok[6] has shown that the light curve in photosynthesis undergoes a sudden change of slope somewhere near the compensation point. He presumes that dark respiration upon illumination is completely suppressed and substituted by another mechanism. A concentration of carbon dioxide of 5 per cent was employed. In later investigations[7] a concentration of only 0·2 per cent was employed. Although the temperature was increased to nearly 30° C. in order to bring about the break in the curve, only a slight break was found.

The only other investigator demonstrating the change of slope of the light curve in the neighbourhood of the compensation point is Van der Veen[8], who made his experiments with tobacco leaves in air with a carbon dioxide concentration of 3·6 per cent. In ordinary air (0·03 per cent carbon dioxide) a significant break has never been observed in leaves.

Variations of the carbon dioxide concentration have no influence on the rate of respiration of *Chlorella* in the dark. The rate was the same at 0·4, 1·2 and 5 per cent. The following survey is therefore presented concerning 'anti-respiration' in light, explaining at the same time the shape of the lower curve in Fig. 1.

(1) At low carbon dioxide concentrations light respiration corresponds to dark respiration.

(2) The part of the respiration located in the chloroplasts is apparently blocked up by high concentrations of carbon dioxide when at the same time a sufficient rate of photosynthesis is going on.

(3) Phosphates rich in energy produced during photosynthesis either reduce the respiratory intermediates back to the carbohydrate level or respiration is simply stopped due to the blocking up of the respiratory system. In Fig. 2 the lower curve shown in Fig. 1 is analysed according to this classification.

A third—possibly as likely—explanation is that normal photosynthesis is replaced by a photochemical reduction of intermediate respiration products (cf. Franck[9]).

Warburg et al.[10] have published experiments according to which the oxygen uptake by a *Chlorella* suspension in light was exactly the same as in the dark. They therefore rejected all hypotheses which postulate an interrelation between photosynthesis and respiration. As they, however, worked under conditions of complete absence of carbon dioxide, their argument does not concern the present theory.

Instead of computing the quantum yield from the slope of the light curves, Warburg and co-workers have confined themselves to measurements at a single light intensity. They first compensated for respiration by using white light, and then, by adding a definite amount of light energy, they measured the increase in rate of oxygen production or carbon dioxide uptake. Warburg et al.[3] mention that the absorbed light intensity must be small if a maximum yield is to be obtained. In fact, they used extraordinarily small light intensities. The intensity used for measuring quantum yield is normally at most about a third of the intensity necessary for reaching the compensation point. Linearity of light curves of *Chlorella*—apart from the break in Kok's curves—is found up to light intensities at least 3–4 times the intensity necessary for compensation of respiration.

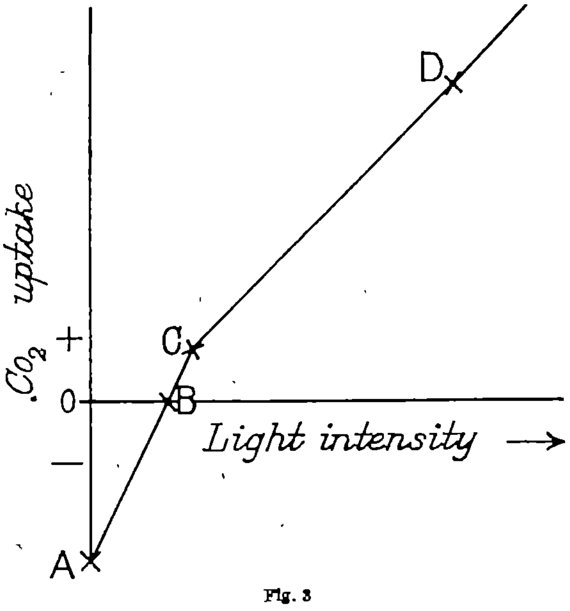

Fig. 3

In dense cell suspensions where light intensity varies considerably from cell to cell, 'anti-respiration' must be supposed to increase far above the compensation point. In Warburg's experiments a light absorption in the red part of the spectrum of about 2/3 was found. Fig. 3 gives a schematic light curve of *Chlorella* at a high concentration of carbon dioxide. *A C* is that part of the curve where 'anti-respiration' increases with increasing light intensity, *C D* is that part where 'anti-respiration' is constant and where the quantum yield is to be measured, *B C* that part where Warburg measured the quantum yield. It is not, therefore, surprising that this 'yield' is about double the size of the real one.

Efforts were made to measure 'anti-respiration' by using carbon-14. There are, however, too many complications if rate of photosynthesis and rate of respiration are to be measured separately by means of tracer carbon. The final report will appear in *Physiologia Plantarum*. [Jan. 7.

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# SYNOPTIC ROCKET OBSERVATIONS OF THE UPPER ATMOSPHERE

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ONE of the main limitations of present-day rocket research in the upper atmosphere is the fact that it is possible to make only a few launchings each year, generally from only one location (at White Sands, New Mexico)[1]. For many important investigations it would be desirable to conduct rocket observations more frequently, even though the payloads and the peak altitudes may not be particularly high. What is needed, then, is a method which combines the following features: (i) a cheap rocket (less than £300); (ii) an inexpensive and easy method of launching; (iii) the possibility of making launchings in any geographical location, for example, over the open sea and over the inaccessible polar regions or desert regions; (iv) the possibility of making a number of launchings within a short time interval, perhaps as short as a few minutes; (v) the possibility of controlling the time of firing to an accuracy of a few seconds in order to correlate it with occurrences observed from the ground; (vi) the possibility of making time-correlated measurements at two or more geographical locations.

An approach to these points, which might offer the first real possibility for synoptic rocket observations, would be provided by launching a small rocket from a high-flying (piloted or pilotless) aircraft. This suggestion arises from the pioneer experiments of Van Allen and collaborators[2], who have devised an inexpensive scheme for transporting some 20 kgm. (40 lb.) of apparatus to altitudes of about 80 km. (270,000 ft.). The essence of their scheme is to mount the apparatus on a small rocket, lift this entire assembly to an altitude of 15 km. (50,000 ft.; that is, above 90 per cent of the atmosphere) with a large polyethylene balloon, then fire the rocket in a near-vertical direction. The same rocket launched from sea-level reaches only about 20 km.; thus by eliminating the aerodynamic resistance of the lower atmosphere, a great increase in the peak altitude of the rocket can be realized. During the summer of 1952, several such launchings were successfully carried out near the geomagnetic pole under the leadership of Lieut. M. S. Jones, of the U.S. Office of Naval Research. The rockets employed were the very small, rapid-burning 'Deacon' rockets using a solid propellant of high specific impulse. The cost per rocket was about £300.

An important advantage of the aircraft-launching method suggested here lies in the elimination of inevitable and uncertain delays, which are inherent in balloon launchings and depend on surface wind conditions, plus the time it takes the balloon to reach altitude. In addition, the aircraft firing does away with the logistic difficulties and expense of transporting helium, balloon launching crew and equipment to the desired launching location. A further consideration is the fact that the actual location of firing, and therefore the probable impact area, can be controlled to much narrower limits than with balloons which are subject to wind conditions; this greatly simplifies the range-safety problem.

The uses to which such an inexpensive research rocket can be put are very wide and likely to be of importance in many investigations on the upper atmosphere. The region from 40 km. up to 80 km. (the position of the temperature minimum and generally taken to be the lower boundary of the ionospheric region) is an interesting one from the point of view of the structure of the atmosphere. Since the small rocket is not stabilized, and since it might not be worth while to install aspect-recording devices such as have been used for larger rockets, a different and perhaps simpler approach will have to be taken in some of the measurements. On the other hand, it would not be difficult to obtain a certain amount of gyroscopic stability by imparting a high angular velocity to a small flywheel with its axis mounted along the rocket axis; this might even be done from the launching plane by means of compressed air or electrically just before the actual firing. Measurements of ambient air pressures in the interesting region will be facilitated by the use of rockets of lower velocities. The technique of exploding grenades at high altitudes to obtain sound velocities, and thereby the temperature distribution[3], could, of course, be adapted easily for studying the latitude, diurnal and seasonal variations of upper air temperatures and winds. Studying the composition of the upper stratosphere would seem especially worth while in view of the recent discovery by Prof. F. A. Paneth's group that gravitational separation of light and heavy gases becomes appreciable at altitudes as low as 70 km.[4]. Air sampling bottles should be very appropriate for this investigation since the time spent between 70 km. and 80 km. is more than 90 sec., as compared with less than 15 sec. for the standard Aerobee rocket in current use. The accuracy to which the time of firing can be controlled, plus the easy accessibility of the rocket until just a few seconds before firing, make very feasible the scheme suggested by Prof. F. E. Simon for collecting a much larger air sample by means of a liquid hydrogen condensation pump[5].

Prof. L. F. Bates has suggested the intriguing possibility of releasing material from a rocket so as to change the concentration of certain rare atmospheric constituents, such as sodium[6]. Even a small increase in the interval 70–80 km. might produce spectacular results in the light emission from the night sky. Again, the long time which the rocket spends in the interesting region may at last make this experiment possible.

Of particular meteorological importance would be regular synoptic measurements of the ozone content in the upper stratosphere using omnidirectional ozone detectors, such as photocells sensitive to the ultra-violet with suitable filters. Actual measurements of the vertical distribution of ozone would provide valuable calibrations of the zenith angle method used in sea-level observations[7]. Thus it would be possible not only to conduct simultaneous measurements at widely different locations of the ozone content and its distribution with altitude, but also to measure rapid changes in a particular location. The relation of such data to tropospheric weather[8] and to upper air temperatures would be of the greatest importance. Measurements in the highest layers of the ozonosphere in relation to solar phenomena would provide a valuable check of photochemical theory[9].

Essential to the understanding of photochemical and ionization reactions in the upper atmosphere[10] are periodical measurements of the solar ultra-violet radiation. They could be carried out without the necessity of sun-pointing and following devices, by using such wide-angle detectors as thermoluminescent crystals[11] or photon counters[12].

Another attractive opportunity for meteorological research arises from the possibility of synoptic high-altitude photography for the study of the distribution of clouds over a large area.

Several ionosphere investigations suggest themselves: for example, the measurement of high-altitude electric current systems in the auroral zone during different geomagnetic and auroral conditions by means of rocket-borne magnetometers[13], and radio propagation experiments to measure ion and electron densities. The low rocket velocity would simplify more direct methods for determining ion densities to check theoretical predictions[14] for this important quantity.

The altitudes reached by this rocket are of special usefulness for certain types of cosmic-ray experiments. For studying the position and extent of the low energy cut-off in the primary radiation[15], it would be desirable to make time-correlated measurements of the total intensity at various geomagnetic latitudes. Another important investigation concerns fluctuations, correlated with solar phenomena, of the extremely soft component of the primary radiation which may enter at very high latitudes, but which is unable to penetrate more than about 1 gm./cm.$^2$ thickness of matter. This soft radiation is thought to be the most sensitive indicator of solar effects of cosmic rays. The short time which the rocket spends above the appreciable atmosphere (above 50 km. for cosmic-ray purposes) constitutes no particular handicap, for omnidirectional detectors giving high counting-rates can be used; a statistical accuracy of one per cent is easily obtainable.

It is clear that the list of possible investigations given above is incomplete. Once this technique of upper air exploration has been put in operation, many other, and possibly more important, investigations will undoubtedly suggest themselves to specialists in various fields.

Compared to ground-launched large rockets, the method suggested here would not only be within the scope of a much more modest research budget, but also would actually make possible studies of physical problems of the atmosphere and studies of extra-terrestrial radiation which are outside the range of, but complementary to, present-day high-altitude rocket experiments. It would, in fact, put rocket research on much the same basis as weather balloon soundings or ionosphere radio soundings.

The opinions or assertions in this article are the private ones of the writer, and are not to be construed as official, or reflecting the views of the United States Navy.

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# GREGARIOUSNESS IN BARNACLES IN RELATION TO THE FOULING OF SHIPS AND TO ANTI-FOULING RESEARCH

By DR. E. W. KNIGHT-JONES and DR. D. J. CRISP

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BECAUSE of their relevance to applied work, we feel it is desirable to direct attention to the results of investigations at this station on the setting behaviour of three species of barnacles, *Balanus balanoides*, *Balanus crenatus* and *Elminius modestus*, as observed in the laboratory. The last two species are important fouling organisms, and it seems likely that the phenomena described below will also be found in other species not yet investigated. Gregarious settlement in *Elminius modestus* has previously been reported as a result of field experiments[1].

Setting is encouraged by gentle water movement which stimulates attachment. After alighting on a suitable surface, the cyprids walk about, pulling themselves forward by each antennule alternately, and changing direction only infrequently. They swim off again much more readily than has hitherto been assumed, and on an unsuitable surface such as glass, or one with loose particles, or at a sharp edge, they may swim off almost at once. If, however, they encounter a barnacle of their own species or even the persistent basis of such an individual, they then rarely swim off, but instead embark on a characteristic setting-action pattern. During this stage, which has been observed by Doochin[2], a cyprid walks more slowly with random changes in direction of increasing frequency, pivoting on one antennule and testing the substratum with the other. After spending about half an hour in the reconnaissance of a small area, stopping and turning in one small depression after another, it normally comes to rest in one of them. Here it moves to and fro, rotates and flicks the posterior cirri vigorously to sweep out any silt or loose particles. It then pulls itself down on its antennules in a direction facing the incident light, or as nearly as is compatible with its fitting snugly into the depression. Contrary to previous belief[3], this final orientation is achieved by a distinct reaction at the time of setting. Slight rolling movements, due to alternate pulling on the antennules, then ensue, and the attachment cement is ejected and spread around the antennulary suckers. Finally, all movements cease until metamorphosis is heralded by renewed activity about twenty hours later in *Balanus balanoides* and *B. crenatus*, and about four hours later in *Elminius modestus*. It is interesting to note that the setting behaviour pattern of barnacles, with a wide initial exploration and a detailed final search after encountering its own species, is remarkably similar to that of oysters[4] and *Spirorbis*[5], providing a good example of convergent evolution.

We have also noted that if cyprids make contact with attached individuals on a surface intrinsically unfavourable for setting (for example, glass, or one crowded with recently settled barnacles) they may swim off again but are then more ready to begin colonizing bare surfaces. This explains the especially rapid fouling of surfaces in the vicinity of shores where adults are abundant[1] and the rather slow initial colonization of new sea-walls[6] and ships newly painted with non-toxic paint. Such craft moored alongside quays heavily barnacled by the appropriate species will tend to be fouled more readily than they would be if moored away from such places, even though cyprids be equally abundant. Moreover, once a ship has been fouled, cleaning by mere scrubbing down will leave behind the bases, and these will stimulate rapid re-colonization.

The property of the cemented bases which stimulates setting is removed only by such powerful reagents as attack quinone-tanned proteins; sodium hypochlorite, for example, dissolves the bases away. Tests carried out on cyprids show that the surface gives a strong argentaffine reaction, local chromaffine staining and a positive response to the diazo and indophenol tests, indicating the presence of a phenolic substrate. These observations afford evidence that the epicuticle of barnacles, like that of other arthropods[7], contains a quinone-tanned protein. The thin epicuticle and the attachment cement have been shown by Thomas[8] to be of the same material and secreted by similar tegumental glands. It is probably this substance which is detected in some way by the crawling cyprid. To remove the bases by chemical means from the bottom of a ship is scarcely practicable, nor is it necessary, for if the bases are covered with new paint, or even by a continuous film of nitrocellulose, they will no longer induce setting.

When testing anti-fouling paints, differences between toxic panels and non-toxic controls are sometimes masked by abnormal variations in numbers of barnacles setting on replicates. This may render any valid comparison difficult, and in any event reduces the precision of the experiment. Such differences now appear to be due, not so much to variation in the numbers of larvæ available for attachment, but rather to the hitherto unsuspected fact that the presence of settled individuals induces others to settle. Hence the rate of settlement will not be uniform, even when the number of cyprids arriving from the plankton is constant. If, for example, each cyprid explores an area $A$, and settles only if it meets a previously settled individual, the rate of increase, $dn/dt$, in the number per unit area, $n$, assumed randomly distributed over the surface, will be $dn/dt = N(1 - \exp - An)$, where $N$ is the number arriving on unit area in unit time. Thus colonization of a bare panel will show an initial time-lag prior to the setting of a pioneer individual, then a logarithmically increasing rate of settlement (while $An \ll 1$), then a steady rate (when $An \gg 1$) equal to $N$, and finally a decreased rate since a crowded surface is repellent. Small time-differences in gaining an initial settlement, since they are followed by a logarithmic increase, will result in wide divergences in numbers on replicate panels, until crowding, by reducing settlement on the more densely populated surfaces, leads to greater uniformity. Results conforming to this sequence have been repeatedly obtained in practice.

It also follows from these observations that a test panel which has gradually lost its toxicity might remain clean for some time if settlement is light, but when the first pioneers become attached, further settlement might take place so rapidly as to suggest sudden loss of toxicity. On the other hand, cyprids persistently attempt to settle on test panels adjoining dense populations of adults. If the paint is not quite lethal, metamorphosis may take place, but the spat readily fall off, presumably because the paint is still able to upset the cementing mechanism. Those that first succeed in cementing themselves permanently may afterwards show deficient basal growth or distorted bases, as previously noted by Weiss[9].

On the basis of these findings, we suggest the following refinements in the testing of anti-fouling paints for effectiveness against barnacles.

(*a*) The test raft should be kept well covered with barnacles.

(*b*) The test surface should, if possible, be contiguous with a heavily barnacled surface.

(*c*) Control panels of two kinds should be employed: (i) quite bare, with a surface similar to the paint surface but non-toxic, to indicate the 'pioneer' attack; (ii) covered with bases of locally abundant species to give the maximum settlement.

(*d*) In comparing the number setting on test panels and non-toxic controls, due allowance should be made for the influence of previously settled individuals on the rate of settlement.

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## LETTERS TO THE EDITORS

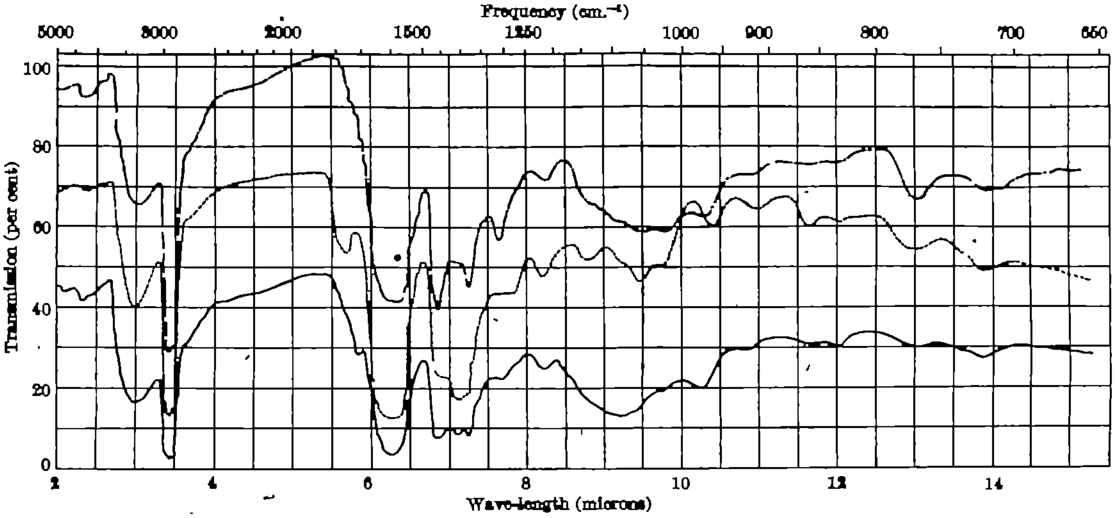
*The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications*

### Fluoroacetate Poisoning: Comparison of Synthetic Fluorocitric Acid with the enzymically synthesized Fluorotricarboxylic Acid

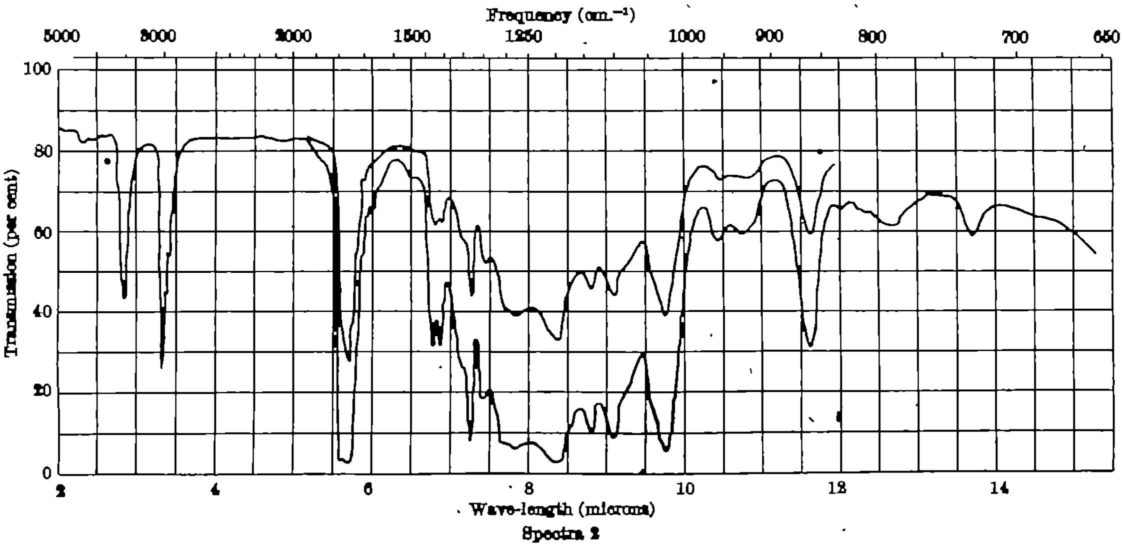
THE hypothesis advanced earlier to account for the toxicity of fluoroacetate ($FCH_2.COONa$) has been proved recently by the isolation of an enzymically synthesized mono-fluorotricarboxylic acid in crystalline form[1], prepared from the products of interaction of kidney tissue with fumarate and fluoroacetate. Though there was much to suggest that it was mono-fluoro*citric* acid, this had not been rigorously proved by a comparison of the infra-red spectrum with a synthetic specimen. The recent synthesis by one of us (D. E. A. R., in the press) of fluorocitric acid has made it possible to compare the infra-red spectra of the barium salts of this with the barium salt from 1·5 mgm. of the enzymically synthesized (natural) crystalline compound isolated in Oxford (by R. A. P. and R. W. W.).

*Infra-red spectra.* The curves obtained from the barium salts are shown in the accompanying spectra; this salt was used as it proved to be the most convenient compound for infra-red study. Though the spectrum of the product of biochemical synthesis differs slightly from the spectrum of barium fluorocitrate, the differences are such as would be caused by the presence of small amounts of barium citrate and barium sulphate as impurities; in the purest specimen (–·–), the citrate present is thought not to be greater than 5 per cent, which explains why it was not detected by the colorimeter tests[1].

These spectra were obtained from 'Nujol' mulls of the barium salts, using a micro technique. The spectrometer used was a double-beam Perkin–Elmer, Model 21.



Spectra 1



Spectra 2

Spectra 1. Comparison of infra-red spectra of barium salt of synthetic fluorocitrate (dotted curve) with the spectra of barium salts of fluorotricarboxylic acid enzymically synthesized from fluoroacetate; ———, first sample showing the band at 9·75 microns; –·–·–·–, highly purified crystalline specimen

Spectra 2. Ethyl fluorocitrate

The spectrum of the sample of ethyl fluorocitrate, from which the barium fluorocitrate was prepared, is also reproduced for reference.

*Activity as inhibitor of citric acid metabolism.* Using the usual test, Peters *et al.*[1] found that 0·61 μgm. of the 'natural' fluorocitrate inhibited the disappearance of 1 μmole citric acid under the conditions of the test made with particle preparations from kidney.

During the course of the work at Porton (by D. E. A. R.), several specimens of synthetic fluorocitric acid have been examined in Oxford, which have not shown more than half the biochemical activity of the 'natural'. The barium salt from the purest synthesized specimen was dissolved in hydrochloric acid and the barium precipitated with sodium sulphate. After removal of barium sulphate, an activity test showed the following for μmoles inhibited: 10 μgm. barium salt inhibited 4·86 μmol. citric acid, from which it can be calculated that 1 unit of inhibitor is equivalent to 1·04 μgm. synthetic fluorocitric acid. Another test gave 1·07 μgm.

Allowing for experimental error, an average of 1·05 μgm. (synthetic) has approximately one-half the biochemical activity of the 'natural', determined as 0·61 μgm. on average (0·58–0·64, ref. 1). As there should be two optically active centres in fluorocitric acid, there should be four stereoisomers; if these are present in equal proportions in the synthetic mixture, then only one optically active centre seems to be important for the activity. Elsewhere, we have reported[2] that the synthetic fluorocitrate has similar convulsive effects in the pigeon brain to those obtained with the enzymic preparation.

*Conclusion.* As the spectra of the enzymically synthesized compound show no bands which cannot be accounted for by the bands seen with the synthetic fluorocitric acid together with bands expected from traces of barium salts, the compound made enzymically must be actually monofluorocitric acid; it has approximately twice the activity of the synthetic specimen.

We are grateful to the Chief Scientist, Ministry of Supply, for permission to publish some of these results.

R. A. Peters
R. W. Wakelin

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D. E. A. Rivett
L. C. Thomas

Ministry of Supply, Porton.
March 25.

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# A New Application of EDSAC to Crystal Structure Analysis

It is well known that the structure of a centrosymmetric crystal could be solved by selecting a number $N$ of structure factors ($F(\mathbf{h})$'s), and evaluating the electron density

$$\rho(\mathbf{r}) = \frac{1}{V} \sum_{\mathbf{h}} \pm |F(\mathbf{h})| \cos 2\pi \mathbf{h}.\mathbf{r}$$

for each of the $2^N$ possible sign combinations on the $F(\mathbf{h})$'s. The correct choice of signs would give a recognizably correct structure when $N$ was sufficiently large. For crystals of moderate complexity, experience has shown that the structure can be determined after the correct signs of about twenty of the largest structure factors have been found. Even when a very rapid means of evaluating a multi-dimensional Fourier series, such as Pepinsky's X.R.A.C.[1], is available, it is not feasible to evaluate and inspect about $2^{20}$ (more than a million) electron-density maps. Our application of the EDSAC consists effectively in making the machine survey this large number of alternative answers, and select from them a few which fulfil certain criteria. The following is a brief outline of the method.

Not all sign combinations are *a priori* equally probable; but inequality relations between structure factors, for example, generally rule out only a small proportion of them—in the example which we give later, they impose no immediate limitations. On the basis of results obtained by Sayre[2], it may be shown that the extent to which $\chi \equiv \sum\sum_{\mathbf{h}\,\mathbf{h}'} U(\mathbf{h})U(\mathbf{h}')U(\mathbf{h}+\mathbf{h}')$ is positive may be taken as a measure of the 'plausibility' of a particular set of signs, as a positive value of $\chi$ corresponds to positive peaks in the electron-density map. ($U(\mathbf{h}) = \dfrac{F(\mathbf{h})}{F(0)f}$, see Harker and Kasper[3].) The $U$'s involved in this summation are in practice only those of greatest magnitude. We have used salicylic acid[4] as an example. As an approximation, the differences in magnitudes of the largest eighteen $U$'s were ignored, and then $\chi$, apart from a scale factor, is given by making all the $|U|$'s unity. $\chi$ was evaluated for each of $2^{16} = 65{,}536$ independent possibilities. This calculation was completed in less than three hours using the EDSAC. On the scale that we used, possible values of $\chi$ ranged from + 29 to − 29. The number of sign combinations corresponding to each value of $\chi$ is shown in the accompanying table.

| Value of $\chi$ | No. of sign combinations |
|---|---|
| 29 | 0 |
| 27 | 0 |
| 25 | 0 |
| 23 | 0 |
| 21 | 6 |
| 19 | 27 |
| 17 | 79 |
| 15 | 250 |
| 13 | 632 |
| 11 | 1,320 |
| 9 | 2,404 |
| 7 | 3,975 |
| 5 | 6,043 |
| 3 | 8,076 |
| 1 | 9,386 |
| − 1 | 9,644 |
| − 3 | 8,588 |
| − 5 | 6,536 |
| − 7 | 4,356 |
| − 9 | 2,472 |
| − 11 | 1,111 |
| − 13 | 426 |
| − 15 | 159 |
| − 17 | 42 |
| − 19 | 4 |
| − 21 | 0 |
| − 23 | 0 |
| − 25 | 0 |
| − 27 | 0 |
| − 29 | 0 |
| Total | 65,536 |

The correct sign combination (known in this case since the structure is already known) is not one of the six giving the largest value of $\chi$, but is one of twenty-seven giving the next largest value. It would be quite feasible to investigate the $\rho$-distribution corresponding to each of about thirty sign combinations, but in fact in this case other criteria could be used for limiting the search still further.

We have also developed a method, which again makes use of the EDSAC, by which those sign combinations which give acceptably large values of $\chi$ can be singled out in a few minutes of machine time. We believe that in this way it will be possible to determine rapidly the structures of crystals of about the same complexity as the example we have mentioned. The method we have outlined would be particularly valuable when used in conjunction with X.R.A.C., which would provide a rapid means of testing the most plausible sign combinations.

A full account of this work will be published elsewhere.

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May 14.

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## Cytoplasmic Particles in Bean Root Cells

In a recent report, E. Robinson and R. Brown[1] have described particles obtained by aqueous extraction from bean root cells which are similar to the isolated microsomes described by Claude[2], Brachet and Jeener[3] and Chantrenne[4]. The particles observed by the latter workers in extracts from many different animal tissues and from yeasts were found to contain ribose nucleic acid, whereas the results of Robinson and Brown suggest that the particles obtained by them may not contain ribose nucleic acid. Preliminary observations made by us on particles isolated from bean root cells by differential centrifugation indicate that particles containing ribose nucleic acid are obtainable from this material, and that the content of this substance varies with the size of the particle in the same way as with the particles isolated by Chantrenne[4] from mouse liver. The presence of the particles in the root-tip cells has also been demonstrated by an electron microscope study of thin sections of the root tips and of the isolated particles.

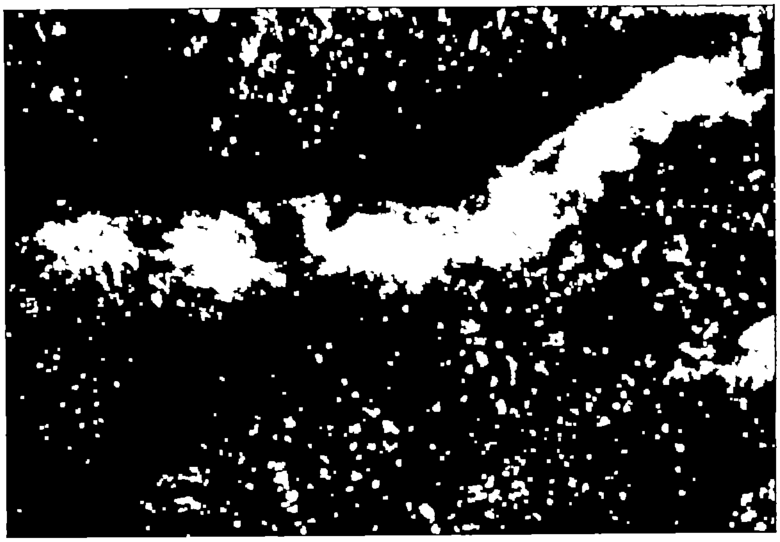
Roots were obtained by germinating seeds of broad bean on filter paper saturated with water at 20° C. The lateral root tips were harvested after seven days, care being taken not to include that part of the root distal from the tip where secondary thickening occurs, and the particles were isolated as follows:

The root tips were suspended in 15 volumes of $M/150$ phosphate buffer, $p$H 7·2, at + 4° C., broken up by a brief treatment with a blendor at low speed, and homogenized in a Potter homogenizer. Debris was then removed by two centrifugations at 1,400 $g$ for 10 min. at 0° C. The centrifugate, which contained a negligible amount of intact cellular material, was discarded. The opalescent supernatant was then centrifuged for one hour at 1,400 $g$, at 0° C., giving a centrifugate, $A$, which was resuspended in the buffer and washed by centrifugation at the same speed. Centrifugate $B$ was obtained by centrifuging the supernatant from $A$ at 25,000 $g$ for 1 hr. at 0° C., and was washed in the same way. Fraction $C$ was isolated from the supernatant of $B$ by centrifuging for 2 hr. at 130,000 $g$ in a Phywe ultracentrifuge at a mean temperature of 23·5° C.

| Fraction | Centrifuging conditions | mgm. RNA/mgm. N |
|---|---|---|
| $A$ | 1,400 $g$ for 1 hr. | 0·5 |
| $B$ | 25,000 $g$ for 1 hr. | 0·81 |
| $C$ | 130,000 $g$ for 2 hr. | 1·01 |

The centrifugates $A$, $B$ and $C$ were dispersed in small quantities of distilled water, and determinations of the nitrogen content per millilitre were made by a micro-Kjeldahl method. The ribose nucleic acid content of the suspended granules was estimated by the method of Ogur and Rosen[5]. Measured samples of the suspension were shaken with an equal volume of 5 per cent perchloric acid for 8 hr. at room temperature. The extracted ribonucleotides were estimated in a Hilger spectrophotometer by their absorption at 260 mμ, using a highly purified yeast ribose nucleic acid as a standard. The variation of the ribose nucleic acid content of the fractions with the condition of centrifugation is shown in the accompanying table. From this table it can be seen that the ribose nucleic acid content of the granules increases as the size of the granules decreases, as found in the case of animal material[4]. The magnitude of the ribose nucleic acid content and its variation with centrifuging conditions is of the same order as that observed previously[4] for liver microsomes.

The occurrence of the small particles inside the cells was also studied. The apical 4–5 mm. of roots of the same variety of beans were fixed in a bichromate and osmium fixative (Newcomer–Zirkle procedure[6]) and embedded in ester wax. The roots were cut longitudinally into sections of about 0·1 μ thickness



Thin section of a bean root. Magnification × 20,500. The cytoplasm is filled with small granules. Two larger cytoplasmic organelles ($A$ and $B$) which would be resolved by ordinary light microscopy can also be seen. The structure of particle $B$ appears slightly analogous with that of animal mitochondria (ref. 7) on a microtome, the design of which was begun in this laboratory by S. G. Tomlin and developed and completed by S. Fitton Jackson and W. E. Seeds (unpublished). The sections were examined in a Metropolitan-Vickers *EM*3 electron microscope at 75 kV. and a magnification of × 8,200. The cell walls showed middle lamellæ and did not appear to be distorted; they also contained dense bodies which were round in section. No precipitation effects were observed in the cytoplasm, which contained many particles of various sizes and types. The smallest particles observed were small dense bodies, the size of which was estimated very roughly as about 400 A. in diameter (see photograph). The particles which were sedimented at 130,000 *g* were also examined in the electron microscope, and were apparently identical with the minute cytoplasmic particles observed in thin sections.

The choice of the fixative was decided by the fact that it had yielded good structural preservation of the cytoplasmic organization of these cells, so far as could be ascertained with the light microscope. Improved methods of fixation are being developed, however, since this fixative gives variable results.

In our opinion, therefore, bean root tip cells contain cytoplasmic particles which, as regards their ribose nucleic acid content, are completely analogous to the particles studied by previous workers in animal tissues and in yeast. The particles described by Robinson and Brown very probably contain ribose nucleic acid also; a possibility which they took care not to exclude in their communication. We have recently learned from Dr. Robinson (private communication) that she too has now fractionated these particles in an ultracentrifuge and has obtained from them an absorption curve resembling that of nucleic acid.

We wish to thank Prof. J. T. Randall and Dr. M. H. F. Wilkins for encouragement in this work, and Dr. E. Robinson for helpful discussion. We also wish to thank Miss F. Ticehurst for help with the photography. One of us (J. C.) acknowledges a grant from the British Empire Cancer Campaign which enabled him to participate in this study. We are also grateful to the Rockefeller Foundation for the purchase of equipment used in this investigation.

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---

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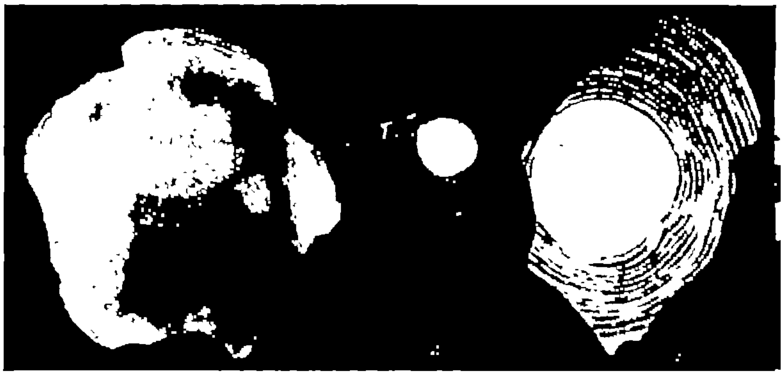
## Nuclei of *Cyclodypeus carpenteri* Brady

This beautiful large nummulite is collected now and then in the living state in the East Indian seas; but the major interest of the collectors always seems to be in the shell. We have, so far as I am aware, no description of the living animal, nor even of its pseudopodia; and nothing since the time of Lister[1] about its protoplasmic structures.

Lister gives a succinct account of what was then known of *Cycloclypeus*, with illustrations (ref. 2, pp. 130–132), and discusses the morphology of the shell with regard to its probable course of development. The initial chambers of both the megalospheric and the rare microspheric forms are described; and, in the case of the former, "a single large nucleus was found in one of the large central chambers" as figured in Lister (ref. 1).

Quite recently, by the good offices of Mr. Cameron D. Ovey of the British Museum (Natural History), London, there came into my possession two specimens preserved in neutral formalin, and sent by Miss Ruth Todd of the U.S. National Museum, New York. They are from a collection labelled U.S. 6184, "Outer slope, Bikini Atoll, Marshall Is.". The smaller specimen measured 11 mm. in its greatest diameter, and the larger one 25 mm. They are illustrated herewith.



*Cycloclypeus carpenteri*. (1) Microspheric, and (2) megalospheric, whole specimens; on the same scale. (3) The megalospheric form enlarged to show the whorls of chamberlets, partly decalcified, in the very thin peripheral parts of the empty shell

During careful decalcification in 70 per cent alcohol acidified with nitric acid, it became apparent that the smaller specimen was megalospheric, displaying the typical central shell structure shown by Lister (ref. 2, p. 131). Traces of the septal canals were seen in the organic shell matrix between the chamberlets, but no protoplasm remained in the shell. The canals contain, here and there, collections of the brown xanthosomes (? excretory granules), which are also present in patches elsewhere on the animal. The larger specimen, on the other hand, showed no indication of the robust central structure of this phase, and although its centre was not clear, it was certainly microspheric. The shell contained protoplasm, and pieces of the large fragile disk-like animal were stained in borax carmine and mounted in balsam on slides. In about a dozen of the middle whorls of chamberlets there appeared a large number (several hundreds in all) of rounded nuclei, some 15–20 $\mu$ in diameter, one to three in a chamberlet. No intranuclear structure could be made out. The 'heterostegine' type of protoplasmic intercommunication between the chamberlets is clearly seen, that is, connexions with adjacent chamberlets on either side in preceding and succeeding whorls, but none with neighbours of the same whorl; and the canal system full of protoplasm is also visible in the thick septa of the shell.

This note is published only partly in order to record the expected multinuclear nature of a microspheric *Cycloclypeus*. Our too fragmentary knowledge of this surviving protozoan prehistoric monster will no doubt some day be amplified, and a great part of the object in writing this letter lies in the hope that it may help to speed that day.

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Dec. 18.

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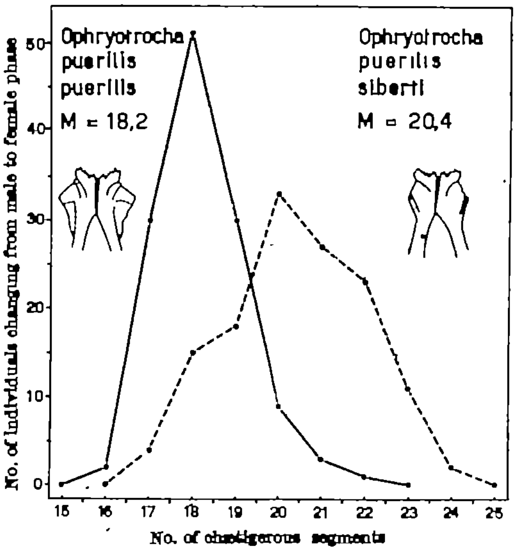
## Genetic and Morphological Evidence for Subspecific Differences between Naples and Plymouth Populations of *Ophryotrocha puerilis*

INDIVIDUALS of *Ophryotrocha* until now classified as *O. puerilis* and collected in the Bay of Naples and at Plymouth breed normally, if kept in Naples water, under conditions described elsewhere[1]. The Naples and the Plymouth populations are unquestionably closely related and have the same chromosome number ($2n = 8$). However, cross-breeding between a Naples individual and a Plymouth individual has constantly resulted in embryos which degenerated at an early stage and were eaten by their parents.

*O. puerilis* is known as a protandrous hermaphrodite[2]. Comparative studies of the first appearance and development of eggs in numerous individuals kept under identical conditions at a temperature between 17° and 18° C. gave the following results: (*a*) Small oocytes first appear in isolated Naples individuals at a mean size of eighteen chætigerous segments, whereas in isolated Plymouth individuals they appear at a mean size of twenty chætigerous segments (see graph). (*b*) The complete maturation of oocytes takes place in all the isolated Naples individuals, while the maturation of oocytes is seldom reached in isolated Plymouth individuals. (*c*) The Plymouth individuals in the female phase appear to reverse into the male phase more rapidly than the Naples individuals under the action of environmental factors[3]. This result may be partially explained by observations (*a*) and (*b*).

A careful morphological examination of the Naples and Plymouth specimens—both alive and preserved—revealed to one of us no substantial differences other than in the two parts of the mandibles (nomenclature from McIntosh[4]). The crenate apical portion of each of these pieces is supported by a plate which is comparatively large in the Plymouth individuals, but is much reduced or even absent in the Naples individuals. The wing-like border occurring close behind the anterior region is also rather elongated in the Plymouth strains, more triangular and broader in the Naples strains (see graph).



*Ophryotrocha puerilis puerilis* (continuous line) and *O. puerilis siberti* (broken line). Left: mandibles of *O. puerilis puerilis*; right: mandibles of *O. puerilis siberti*

In a survey of the available literature on the Mediterranean and Atlantic *Ophryotrocha*, no detailed observations have been found on the structure of the mandibles; but some information has been collected by the examination of some carefully drawn outlines of the armature[4] of the proboscis. It appears, for example, that the *Ophryotrocha* from Whitstable oyster beds described by McIntosh[5] under the name *Staurocephalus siberti* almost certainly corresponds to the Plymouth *Ophryotrocha* now being cultivated in the Naples Zoological Station.

From a strictly genetic point of view, the *Ophryotrocha* from Plymouth now studied should be named as a separate species from the Naples *Ophryotrocha* which is the true *puerilis*, since Claparède and Mecznikow[6] collected their specimens in the Bay of Naples. However, a number of considerations, which will be discussed elsewhere, induce us to adopt the trinomial nomenclature (*Ophryotrocha puerilis puerilis* Clap. and Meczn. from the Bay of Naples, and *O. puerilis siberti* McInt. from Whitstable and Plymouth) in order to stress the close relationship between the two populations.

A more detailed paper on this subject will be submitted elsewhere.

Our thanks are due to Mr. F. S. Russell, and to the staff of the Marine Biological Laboratory, Plymouth, for the many courtesies extended to us.

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Feb. 15.

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## Cytology of the *Dryopteris spinulosa* Complex in Eastern North America

THE *D. spinulosa* complex in Europe (cf. Manton[1]) consists of three tetraploid species (*D. cristata*, *D. spinulosa* and *D. dilatata*) and the hybrids between them, together with at least one diploid previously included in *D. dilatata* but probably deserving taxonomic separation.

(1) *D. spinulosa* (O. F. Muell.) Watt. (typical)
 Massachusetts—tetraploid ($n = 82$)
 Michigan—tetraploid ($n = 82$)
(2) "*D. spinulosa* (O. F. Muell.) Watt. (typical)"
 Massachusetts—triploid (pairs and singles)
 Michigan—triploid (pairs and singles)
(3) *D. spinulosa* var. *intermedia* (Muhl.) Underw.
 Massachusetts—diploid ($n = 41$)
 Vermont—diploid ($n = 41$)
(4) *D. spinulosa* var. *fructuosa* (Gilbert) Trudell
 Michigan—triploid (pairs and singles)
 (Considered to be *D. spinulosa* (typical) × var. *intermedia*)
(5) *D. cristata* (L.) Gray
 Massachusetts—tetraploid ($n = 82$)
 Vermont—tetraploid ($n = 82$)
(6) × *D. boottii* (Tuckerm.) Underw.
 Massachusetts—triploid (unpaired)
 Vermont—triploid (unpaired)
 Michigan—triploid (unpaired)
 (Considered to be *D. cristata* × *D. spinulosa* var. *intermedia*)
(7) *D. cristata* var. *clintoniana* (D. C. Eat.) Underw.
 Massachusetts—hexaploid ($n = 123$)
(8) *D. hybrid* (*D. cristata* × *D. spinulosa*, "typical")
 Massachusetts—triploid (unpaired)
(9) *D. goldiana* (Hook.) Gray
 Vermont—diploid ($n = 41$)
(10) *D. marginalis* (L.) Gray
 Vermont—diploid ($n = 41$)
(11) *D. hybrid* (*D. marginalis* × *D. spinulosa* var. *intermedia*)
 Massachusetts—diploid (unpaired)

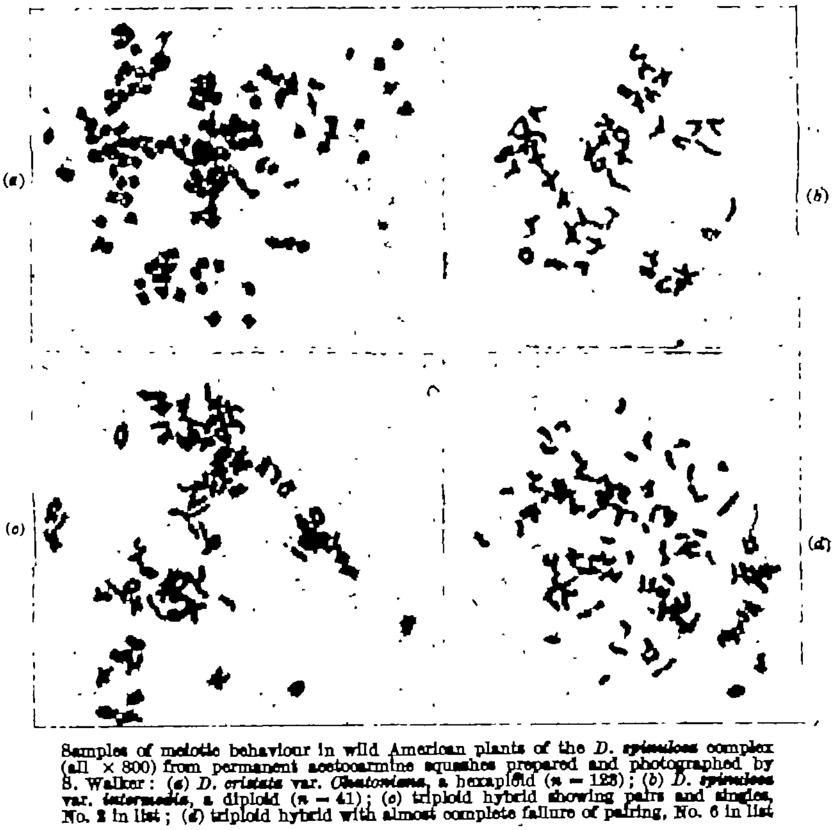
In America the situation seems to be more complicated. There are a greater number of named types, including both species and hybrids, and we have reason to think that these do not exhaust the number of cytologically distinguishable entities which exist. The above list gives some preliminary cytological observations made on wild American specimens sent to us by the kindness of Prof. R. H. Wetmore of Harvard and of Dr. W. H. Wagner, jun., formerly of Harvard and now of Michigan. The nomenclature used is that of Gray's "Manual"[2] and the identifications have been authenticated before dispatch from America by Dr. Wagner and confirmed, after completion of the cytology in Leeds, by Mr. A. H. G. Alston of the British Museum, to all of whom we are most grateful.

Commenting on this list, it should be noted that the two diploid species *D. goldiana* and *D. marginalis* placed at the end as Nos. 9 and 10 are not in themselves included in the *spinulosa* complex, but information about them is needed since they are involved in certain hybrids, notably No. 11 and perhaps No. 7.

Within the complex itself, *D. cristata* (No. 5) is the same as in Europe, namely, tetraploid. *D. cristata* var. *clintoniana* (No. 7), however, being hexaploid, is perhaps the amphidiploid hybrid between normal *D. cristata* and *D. goldiana*. We have not so far found any evidence that the European tetraploid *D. dilatata* is present in America unless it be the *D. spinulosa* var. *americana* which we have not yet examined. On the other hand, tetraploid *D. spinulosa* (No. 1) is certainly present, though the fact that some of the plants sent to us from each of two localities under this name were triploids (No. 2) suggests that there is something else breeding with *D. spinulosa* (typical) and possibly resembling it morphologically, but diploid.

We do not think that the undoubtedly diploid *D. spinulosa* var. *intermedia* (No. 3) is the form in question, since the putative hybrid between this variety and *D. spinulosa* (typical) has a different morphology which is well known under the name of *D. spinulosa* var. *fructosa* (No. 4). There is also the evidence of the putative hybrids with *D. cristata*. These are of two kinds. The wild hybrid thought to be *D. cristata* × *D. spinulosa* var. *intermedia* (No. 6) is known as *D. boottii* and, as expected, it proves to be triploid with almost complete failure of chromosome pairing. Another wild hybrid (No. 8) of different morphology was sent to us as probably *D. cristata* × *D. spinulosa* (typical). In morphology, this resembles closely the European hybrid (*D. uliginosa*) of this constitution, which is tetraploid[1]. The American hybrid is, however, yet another triploid with complete failure of chromosome pairing, suggesting that its parentage cannot involve typical *D. spinulosa* itself but could involve the unknown diploid.

We would be grateful for further supplies of American material bearing on this problem, and in the meantime the mutual relationships of American



Samples of meiotic behaviour in wild American plants of the *D. spinulosa* complex (all × 800) from permanent acetocarmine squashes prepared and photographed by S. Walker: (*a*) *D. cristata* var. *Clintoniana*, a hexaploid ($n = 123$); (*b*) *D. spinulosa* var. *intermedia*, a diploid ($n = 41$); (*c*) triploid hybrid showing pairs and singles, No. 2 in list; (*d*) triploid hybrid with almost complete failure of pairing, No. 6 in list and European forms are being investigated by a programme of controlled breeding.

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May 18.

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## Effect of Nitrogen Mustard on an Inherited Character in the Rat

IN 1949, the late P. Ellinger[1] described some experiments which suggested that treatment of rats with nitrogen mustard had produced a mutation in the gene or genes controlling the output of nicotinamide methochloride. He followed up this work with some extensive experiments, and recently asked me to analyse the results. Prof. Ellinger died before I had the opportunity of discussing with him the results of the analysis, and this communication is therefore published without the benefit of his advice.

Ellinger mated a given pair of parents twice, first without treatment, and again one day after treatment of one or both parents with nitrogen mustard (0·2 mgm./kgm. injected intraperitoneally). The daily nicotinamide methochloride output of each member of the two litters was measured. Ellinger reported four such experiments, in two of which the mean output of the offspring born after treatment of the parent was significantly lower than that of the offspring born before. Such an effect can be attributed to a gene mutation or a chromosome rearrangement only if there is, in the absence of the treatment, no litter-to-litter variation of a similar magnitude. In a genetic study of the nicotinamide methylating mechanism, Ellinger and Armitage[2] found the output to be controlled by a number of genes, but also subject to considerable environmental fluctuations. It therefore seemed possible that the changes observed in the nitrogen mustard experiments were environmental rather than genetic, and unconnected with the treatment.

The results are now available of thirty-nine non-sterile matings, in which litters were produced before and after treatment of one or both parents with nitrogen mustard. Usually, $F_1$ litters were produced by mating rats within the post-treatment litter, and often subsequent generations were obtained. In sixteen of the thirty-nine primary matings, the mean logarithm of output was higher in the litter produced after treatment than in that produced before, and in twenty-three the mean was lower. There is evidently no strong evidence of a systematic rise or fall in mean logarithm of output after treatment. In four matings the change in the mean logarithm of output was particularly marked (at least 0·40 logarithmic unit). Further examination of the results of these four matings suggests very strongly, however, that the changes were not genetic. In the first place, each of these changes affected the whole litter rather than (as would have been expected had a mutation occurred) an individual rat. Secondly, the output of $F_1$ rats, one of whose parents had an abnormally high or low output, always reverted to about the level of the treated animals and of their pre-treatment offspring. Finally, a comparison is possible with some data on untreated animals[2]. Five pairs of untreated rats each produced two litters. For four of these pairs the two litter means were very similar. In the fifth case the difference in mean logarithm of output was 0·34, a difference greater than most of those found in the nitrogen mustard experiments.

It must be concluded that the observed changes in output are probably due to environmental causes unrelated to the nitrogen mustard treatment.

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Jan. 9.

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## Function of the Foot in the Lucinacea (Eulamellibranchia)

THE Lucinacea, comprising the families Ungulinidæ, Thyasiridæ and Lucinidæ, all have a characteristically slender vermiform foot. Its anatomy has been described by Barrois[1] and Menégeaux[2] and its locomotory movements by Stoll[3]. In some species, for example, *Diplodonta rotundata*, the slightly bulbous tip is distinct from the rest of the foot. The foot can extend four or five times the length of the animal and the tip can swell out even when the foot is extended. When the foot is contracted, it lies with the tip close to the posterior edge of the anterior adductor muscle. This muscle (Fig. 1) is characteristically elongate.

These animals live in a variety of soft substrata from sand to mud, both intertidally and sublittorally, to great depths. They burrow to a depth that is equal to the length of the extended foot. All Lucinacea have anterior and posterior inhalant currents.

It has been found that, in addition to its normal movements for burrowing and locomotion, the foot forms an anterior inhalant tube lined with mucus. This has been demonstrated in *Loripes lucinalis*, *Thyasira flexuosa* and *Phacoides borealis*. This habit

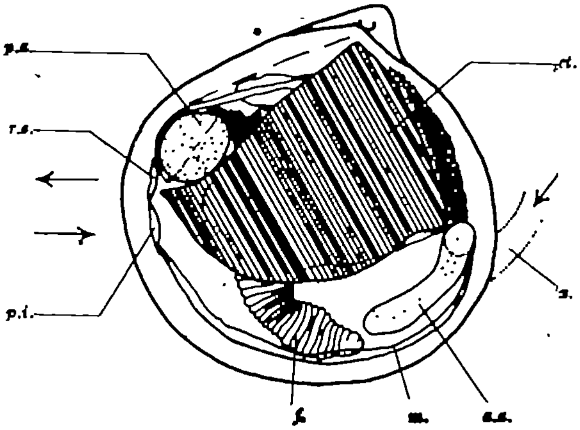

Fig. 1. *Loripes lucinalis*, with right valve removed. *a.a*, anterior adductor; *ct.*, ctenidium; *f.*, foot; *m.*, mantle edge; *p.a.*, posterior adductor; *p.i.*, inhalant aperture; *r.s.*, retracted exhalant siphon; *s.*, position of the anterior inhalant tube

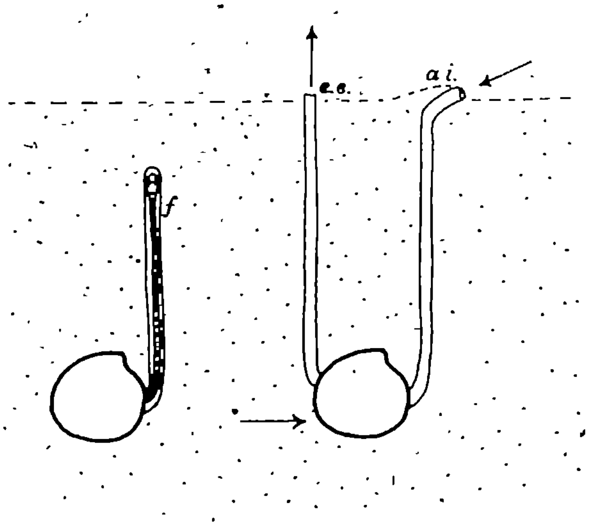

Fig. 2. Form and position of anterior inhalant tube of *Loripes lucinalis*. *f.*, foot; *a.i.*, anterior inhalant tube; *e.s.*, extended exhalant siphon

was discovered when observations were made on the burrowing mechanism of *Loripes*. The animals were allowed to burrow in specimen tubes containing sand taken from the place they were collected. Some animals came to lie by the side of the tube so that the movements of the foot could be observed. When they had buried themselves to a depth of approximately 4 cm., the foot was observed to issue from between the valves at the anterior end of the anterior adductor and gradually force its way to the surface. In these observations the foot alternately extended and contracted, each extension being longer than the last until the surface was reached. The foot secretes the mucus lining the tube. Microscopic examination of the epithelium of the foot shows numerous mucus-secreting cells which are most dense near the tip.

The tube does not open vertically to the surface but turns for two or three millimetres along the surface of the substratum (Fig. 2). After twenty-four hours, it was found that the sand could be washed from the specimen tube leaving the anterior inhalant tube intact and fastened to the glass. The tube extends from the anterior end of the anterior adductor, while the mantle between the adductor and the shell edge (Fig. 1) forms a continuation of the tube into the mantle cavity. This inhalant channel is additional to the posterior inhalant aperture. The relative importance of the two inhalant currents and the effect of the anterior one on the ciliary currents within the mantle cavity will be discussed elsewhere.

The foot is periodically protruded after the tube has been formed, and its main function is to keep the tube, and particularly the aperture at the surface, free from debris. If the entrance is deliberately blocked, the foot is almost immediately protruded and clears the obstructing particles, often laying down an additional short length of tube. Once the tube has been formed the animal remains in this position for a considerable period.

*Loripes lucinalis*, which was obtained from the sandy beaches at Roscoff, was carefully examined in the field. The position of the anterior inhalant tube was clearly marked in the sand by a rust-coloured deposit which also discoloured the part of the shell where the tube enters. This colour is due to fine surface sediment that has been drawn into the tube. Carmine particles were accepted, and although it was not possible to keep the specimens long enough for the tube to become discoloured, the shell in this region did become coloured with carmine.

A mucous tube is not laid down by the posterior exhalant siphon when this is present. Yonge[4] showed that in *Thracia pubescens* separate mucous tubes are formed by the siphons. In some gastropods essentially the same type of tube is formed by the proboscis. This has been demonstrated by Yonge[5] in *Aporrhais* and by Morton[6] in the Struthiolariidæ. Thus the Lucinacea show a third method of forming a mucus-lined tube.

I acknowledge the help and kindness of Prof. P. Drach and the staff of the Marine Station, Roscoff, and also of Prof. C. M. Yonge. Thanks are due to the John Murray Committee of the Royal Society for financial assistance.

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## Some Relationships between Morphology and Antigenic Structure in Bacteria

THE problem of correlating morphological with antigenic concepts in bacteria has made surprisingly little progress since the flagellar, capsular and somatic antigens were first recognized. Antigenic analysis has indeed required that certain somatic antigens should be regarded as occupying locations nearer or farther from the surface of the cell, but this is almost the entire extent of the concept.

Information does, however, appear to be available, which enables certain antigenic phenomena to be explained in morphological terms. The observation of Pijper[1] that somatic agglutination of typhoid bacteria occurs by the adherence of the poles of the cells, whereas in *Vi* agglutination the entire surface is affected, has a logical explanation when it is realized that the basophilic material associated with the growing-point of the cell is concentrated at the poles, where it is covered by an exceptionally thin cell wall or by none at all[2]. In Rough variants the arrangement of the growing points is entirely different, as they have a characteristic septate structure[3]. Thus we may logically assume that the secretory nucleo-proteins of the growing point represent an important somatic antigen, whereas the *Vi* antigen is a surface material.

The well-recognized fact that the Gram-positive genera constitute, as a rule, much less satisfactory antigens than the Gram-negative, can be explained in part by the fact that the former commonly have a similar septate structure to that of the Rough variants of Bacteriaceae[4]. In this type of structure the metabolically active growing-points, and the cytoplasmic septa, which precede and secrete the cross-walls, and which appear to be similar in both function and constitution to the growing-points, are mainly internal instead of being exposed at the surface. At the same time, the cell envelopes of the Gram-negative genera have been shown to have a higher lipid content and a much fuller range of amino-acids in the protein fraction than have those of the Gram-positives[4]. Their cytochemical behaviour more closely resembles that of intact wool proteins, whereas the Gram-positive cell envelopes resemble degraded wool proteins in this respect[5].

From these observations the following conclusions can be drawn; they are not completely proved, but must be regarded as intrinsically much more probable than the contemporary hypothesis (which most bacteriologists probably do not take very seriously) of antigenic variation by progressive loss of surface layers like the leaves of an onion. The well-known $S \rightarrow R$ variation in the pneumococcus is, of course, concerned with the loss of the capsule and is not referred to.

(*a*) The nucleoprotein material of the growing points is an important somatic antigen.

(*b*) The 'loss' of certain somatic antigens in Rough variants of Bacteriaceæ is due rather to the alteration in position of this material from a surface to an internal site than to its actual disappearance.

(*c*) The loss of further somatic antigens in Rough variants, and the low antigenicity of Gram-positive genera, are due to the chemically simpler structure of the cell envelopes in bacteria of septate morphology.

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## Sporulating Anaerobes on English Flax

ALLEN[1] reported that the majority of spore-bearing anaerobes isolated in pure culture from anaerobic and aerobic flax-rets in England, and which appeared usually to be the active agents in retting, possessed the characteristics of *Clostridium ertium*. Dowson[2] found that *Bacillus polymyxa*, a facultative sporulating organism, was capable of causing a soft rot of potato. This organism is capable of attacking pectin and therefore has potential retting abilities. *B. amylobacter* Bredemann, which is a synonym of *Cl. butyricum* and wrongly includes more han one true specific group[3], is mentioned in the literature as a retting organism[4]. So far as I am aware, no other strict anaerobe, facultative anaerobe or micro-aerophilic organism has been reported in England as a possible retting agent.

In other leading flax-retting countries, however, *Cl. pectinovorum*, a plectridial anaerobe, and *Cl. felsineum*, an orange-pigmented anaerobe, are conidered to be the major retting agents, the latter being superior to the former. *Cl. tertium* has not been cited, except by Lanigan[5], who observed that a micro-aerophilic species related to *Cl. tertium* but differing from the latter in that it liquefied gelatin was most commonly found on Australian flax. *B. polymyxa*, if found, is considered of minor importance. Hellinger[3] found *Cl. aurantibutyricum*, an orange-pigmented butyric acid-producing organism, and *Cl. pectinovorum* var. *pseudoplectriforme*, to be commonly distributed in Israel flax rets. *Cl. aurantibutyricum* proved to be a highly efficient retting organism comparable to *Cl. felsineum*.

I have recently been investigating the microbial flora, more especially the sporulating anaerobes, on samples of English flax from Norfolk, Suffolk and Wiltshire. Straw samples were placed under simulated retting conditions, that is, immersed in water at 32° C., and sporulating anaerobes were isolated in pure culture using maize mashes, yeast–glucose–chalk media and potato/yeast–glucose agar slants in test-tubes under anaerobic conditions. A micro-aerophilic plectridial organism classified as *Cl. pectinovorum* (cf. Weizmann and Hellinger[6]), and *Cl. butyricum* were invariably present and numerous in all samples. An orange-pigmented anaerobe was found; but it formed a small part only of the flora of some of the flax. It was identified as *Cl. aurantibutyricum*, and not *Cl. felsineum*. *B. polymyxa* was obtained, but it was present in extremely small numbers.

The English isolates of *Cl. pectinovorum* were compared with a typical strain of the organism obtained from Prof. Kluyver of Delft, and a strain of *Cl. tertium* (541) obtained from the National Collection of Type Cultures. Studies carried out with these organisms tend to show that *Cl. tertium* is identical with *Cl. pectinovorum*. The strains examined were micro-aerophilic and also liquefied gelatin, the former a feature characteristic for *Cl. tertium*, the latter a distinguishing feature of *Cl. pectinovorum*.

The flax-retting abilities of the organisms isolated were tested on sterilized flax straws according to the method of Hellinger[3]. The new isolates of *Cl. aurantibutyricum* were remarkably active. Retting progressed moderately well after 48–54 hr. and the fibre bundles were completely liberated from the stem matrix after 66 hr. None of the strains of *Cl. pectinovorum*, including also the Dutch strain and *Cl. tertium* (strain 541), showed any sign of retting in 6–11 days at 32° C. Continuous aeration was tried, but also gave negative results. The *Cl. butyricum* isolates were also ineffective, whereas *B. polymyxa* caused a certain amount of loosening of the fibre bundles.

It is perhaps possible that *Cl. tertium* (strain 541) and the Dutch strain of *Cl. pectinovorum* had lost their original retting ability on long-continued artificial cultivation.

Full details of this work will be given elsewhere. It was done while on leave from the Weizmann Institute of Science, Rehovoth, Israel. Grateful acknowledgments are due to Mr. Gillham, Directorate of English Flax Production of the Ministry of Materials, and Major Searle, director of H.M. Norfolk Flax Establishment, King's Lynn, for their ready co-operation in giving me laboratory facilities and assistance.

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## Rooting of Cut Shoots of Cotton in Culture Filtrate of *Fusarium vasinfectum*

A study was made of the toxicity of culture filtrates of the cotton-wilt pathogen, ***Fusarium vasinfectum*** Atk., grown in synthetic Czapek's medium, to cut shoots of cotton. This indicated that, under laboratory conditions, the culture filtrate (fourteen days old) when dialysed against distilled water at 4–5° C. for four days to rid the crude filtrate of metabolites—earlier observed to be toxic to the plant—brought about typical wilt symptoms, which have been described in detail elsewhere[1]. Higher dilutions of this dialysed neat filtrate did not produce any symptoms of toxæmia, but induced rooting. However, the dialysed filtrate autoclaved at 15 lb. pressure for 15 min. (with the view of inactivating the toxin) induced profuse rooting in the cut shoots of cotton at all concentrations, and in no case were there any typical wilt symptoms.

These observations indicate that the dialysed culture filtrate of ***F. vasinfectum*** probably contains two or more factors: (i) a thermolabile factor producing wilt symptoms at higher concentrations; and (ii) a thermostable factor stimulating vigorous rooting in the cut shoots even at dilutions. It is likely that the latter factor is ineffective in the presence of higher concentrations of the former, since at these concentrations of the neat dialysed filtrate only typical wilt symptoms are produced, but not rooting.

So far as we are aware, stimulation of rooting of cut shoots of cotton plants by dialysed fungal filtrates has not been previously reported, and it is therefore considered worth while to record this interesting phenomenon. Detailed work on the nature of the factor or factors contained in the dialysed filtrate and their interaction with each other and also their effects on cut shoots of different host plants are now under way, and the results of these investigations will be reported in detail elsewhere.

We thank Prof. T. S. Sadasivan and Dr. C. V. Subramanian for their suggestions and guidance.

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## High Molybdenum Levels in Herbage on Acid Soils

It is generally considered that there is a marked correlation between molybdenum uptake by plants and soil reaction. Evans *et al.*[1] and others have shown that a change in reaction from strongly acid to alkaline results in increased uptake, especially in the alkaline region. So far as we are aware, all cases of molybdenum deficiency hitherto reported have been in acid soils, while excess levels of molybdenum in herbage, responsible, in part at least, for complicated copper-deficiency effects in livestock, have been reported only from slightly acid to strongly alkaline soils. This in general has also been our experience[3]. However, in an extension of our work, a case has been found where the conditioned copper-deficiency syndrome occurs in cattle confined to pasture growing on strongly acid soils. It was thought at first that this might possibly be a case of simple copper-deficiency. The animals were severely affected. Blood samples showed copper values varying from 0·03 to 0·07 mgm. per cent. Herbage samples taken from the pastures concerned showed copper values in the region of 13 parts per million and molybdenum values of 7·0–13·0 p.p.m. The herbage consisted of bent grasses, crested dogstail, Yorkshire fog, *Juncus* spp., sedges and other species typical of poor pasture on acid soils.

The soil in the area concerned, while situated on the slope of a drumlin, is moderately impeded. The surface soil (0–8 in.) is a grey-black silt loam and overlies a grey, slightly mottled brown, plastic clay loam sub-soil. Representative soil samples showed a *p*H varying from 4·9 to 5·2 with a calcium exchange-level of 5 m. equiv. and hydrogen exchange-level of 14 m. equiv. per 100 gm. Organic carbon averaged 12 per cent. These samples also showed very low levels of available potash and phosphate. The total molybdenum content varied from 2·1 to 3·00 parts per million, with a readily available level of 0·80–0·90 p.p.m., as determined by Grigg's oxalate method. These are the highest readily available molybdenum levels so far recorded by us, a threshold value for excess levels in slightly acid to alkaline soils being 0·30 p.p.m.[3].

The fact that there has been a relatively high uptake of molybdenum by herbage plants in these strongly acid, low calcium soils is consistent with the finding of Stout *et al.*[2], who, using culture solutions, showed that absorption of molybdenum by plants is far greater from acid soils than from soils of neutral reaction. It is possible that in the soils investigated by us the agents responsible for the fixation of molybdenum may be absent, and it is thought likely that this may be associated with the reduced condition of the soil and its organic matter content. This aspect of the problem is being investigated. The experience obtained indicates that it is desirable to extend considerably the range of soil conditions, especially where reaction is concerned, under which excess molybdenum uptake by herbage may be expected.

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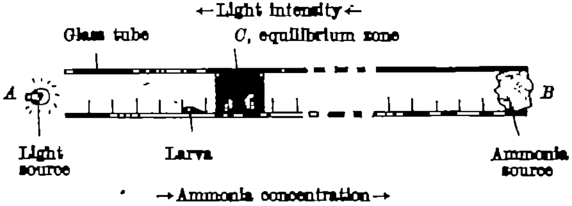
## A Simple 'Response Balance' for studying Insect Behaviour

The responses shown by insects to insecticides are usually measured in terms of paralysis or death. Since the insects lose their power of co-ordinated movement during the primary stages of poisoning they cannot respond to stimuli which modify their normal behaviour. When the concentration or dosage of insecticide is very low, however, insects may be irritated or repelled by the insecticide without loss of muscular co-ordination. Under such conditions the responses shown to other stimuli, for example, a light stimulus, become of interest, especially where the



Apparatus for measuring responses shown by insects to light and chemical stimuli

kinetic effects of the chemical and light stimuli are opposed. In the present communication, a description is given of an apparatus, or 'response balance', used for studying systems of this kind (see diagram).

The apparatus consisted essentially of a glass tube 24 in. long and 1 in. internal diameter. A 60-watt lamp connected to a variable resistance was placed near end *A*, and a plug of cotton wool soaked in the repellent was inserted in *B*. The apparatus was used in a dark room at 20° C.

In a typical experiment, mature *Calliphora* larvæ, which are negatively phototropic, were used as test insects; the source of repellent vapour was a strong ('880') solution of ammonia. Five larvæ were placed in the tube at *A* and the light intensity gradually increased until the larvæ started crawling towards the ammonia source. With increasing concentration of ammonia vapour the repellent stimulus became stronger, and the larvæ frequently turned round towards the light, then back towards the ammonia source. At this stage the light source was kept constant; the larvæ crawled about at random within restricted equilibrium zones (*C*), 2–3 in. in length, where the kinetic effect of the light stimulus balanced that of the chemical stimulus. When the light source was dimmed, the chemical repellent stimulus became the dominant factor, and the larvæ crawled towards the light, the equilibrium zones being displaced in this direction; the effect was reversible, the larvæ moving towards the ammonia source when the light was made brighter.

*Sensitizing effect of kerosene on chemoreceptors.* The sense organs of insects are bounded by a thin cuticular sheath[1]. Since it was known that oils, such as kerosene, greatly increase the permeability of the cuticle of *Calliphora* larvæ to a variety of chemical substances and insecticides[2], experiments were tried to see whether kerosene might sensitize the chemoreceptors in this insect to ammonia vapour. The above experiment was repeated using (*a*) five mature larvæ as controls, and (*b*) five mature larvæ which had been lightly painted with kerosene. Values obtained to the nearest inch for the distance *B*–*C* between the ammonia source and the mid-point of each equilibrium zone were:

*controls*, 8, 7, 7, 5, 4 in.;
*oiled larvæ*, 17, 14, 13, 12, 10 in.

A similar experiment was carried out in which test larvæ were painted with medicinal paraffin instead of kerosene. Values obtained for *B*–*C* were:

*controls*, 9, 7, 6, 6, 4 in.;
*oiled larvæ*, 11, 8, 6, 5, 5 in.

The observations that kerosene, but not medicinal paraffin, sensitizes *Calliphora* larvæ to the repellent action of ammonia vapour suggest that chemoreceptors stimulated by ammonia are made more sensitive by an increase in cuticle permeability. A similar difference between the effects of these oils on the uptake of contact insecticides had already been correlated with their relative dispersive actions on the lipids of the outer fatty epicuticle bounding the bulk cuticle framework[3].

*Lethal effect of ammonia vapour.* When the light source was made very intense, control and kerosene-treated larvæ crawled nearer to the ammonia source until they began to roll about at random, showing a loss of neuro-muscular co-ordination. There were no sharply defined equilibrium zones, and when the light was dimmed the larvæ did not crawl away from the ammonia source as observed for larvæ in contact with lower concentrations of ammonia vapour. Within a few minutes the larvæ became paralysed; they were removed from the tube and kept in open Petri dishes, where they died within 10–15 hr. The initial kinetic effect of the light stimulus was thus greater than that of the opposing chemical stimulus, even though the larvæ moved into a lethal concentration of ammonia.

Although irritant vapours, such as ammonia, may stimulate a variety of sensory endings in insect cuticle[4], the sensitizing effect of kerosene on these receptors suggests that fatty components similar to those in the bulk epicuticle may act as a protective barrier in the cuticular sheaths of sensilla, including those which act as more specific organs of smell and taste. This view may have some bearing on the findings of Dethier and Chadwick[5] that the lipid solubility of different chemical substances is related to their stimulating activity on the tarsal organs of taste in *Phormia*.

This report is based on work begun at the Department of Zoology, Imperial College of Science and Technology, and continued at the Department of Colloid Science, Cambridge. A full account will be given elsewhere.

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## Significance of Nannoplankton

ATKINS[1], in 1945, reported on the productivity of the English Channel as estimated by two independent methods. The silicate turnover indicated a far lower productivity than did the phosphate turnover, and from this he deduced that only a relatively small fraction of the phytoplankton could consist of forms with siliceous skeletons. Knight-Jones and Walne[2] later showed that the very small nannoplanktonic form, *Chromulina pusilla*, was present in English Channel waters in numbers averaging about 1,000 per ml. They quoted other work showing that as much as 90 per cent of the phytoplankton may be small enough to pass through a fine silk tow net, and 40 per cent through a No. 2 Whatman filter paper.

The Florida current off Miami was sampled for a period of one year, and the phytoplankton content, as indicated by metered Clarke–Bumpus No. 20 net hauls, was compared with the results from samples filtered through a No. 54 Whatman filter paper. The results are shown in the accompanying table.

PHYTOPLANKTON CONTENT OF FLORIDA CURRENT WATER IN HARVEY UNITS PER CUBIC METRE

In this area, one H.U. is approximately equivalent to 0·017 mgm. of organic carbon

| Net haul | Paper-filtered | Filtered / Net |
|---|---|---|
| 0·42 | 401 | 955 |
| 0·61 | 448 | 734 |
| 0·87 | 1,380 | 1,586 |
| 4·68 | 6,750 | 1,442 |
| 5·60 | 1,660 | 296 |
| 6·10 | 657 | 108 |
| 6·37 | 7,950 | 1,248 |
| 6·70 | 1,540 | 230 |
| 7·65 | 9,220 | 1,205 |
| 17·8 | 20,000 | 1,124 |
| 18·7 | 23,350 | 1,249 |
| 19·7 | 20,950 | 1,063 |
| 59·1 | 57,600 | 975 |
|  |  | Mean 937 |

In this area, then, the nannoplankton is rather consistently about a thousand times as rich as the fraction of the phytoplankton which can be captured with a net. While the ratio appears very high, it may be pointed out that Hart[3] demonstrated a great increase in the proportion of armoured dinoflagellates in lower latitudes as compared with antarctic seas. Between 60° and 40° S., they averaged only 7 per cent of the phytoplankton, whereas between 40° and 20° S. they averaged 63 per cent. If the nannoplanktonic forms are considered to be largely unarmoured dinoflagellates, then it is not unexpected that they should constitute a high proportion of the phytoplankton in warmer waters. In any event, it is clear that net hauls provide a quite inadequate picture of the standing crop of phytoplankton.

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# Hormonal Nature of Extracts of Parathyroid Gland stimulating Phosphate Excretion

Stewart and Bowen[1] have recently reported that preparations of parathyroid hormone after treatment with formaldehyde lose their power to raise the serum calcium-level of dogs, while still remaining able to increase the excretion of urinary phosphate. In view of these results, we wish to report on the properties of certain extracts obtained from ox parathyroid glands by a different method.

In our work acetone powders, made from frozen glands by the method of Tepperman, L'Heureux and Wilhelmi[2], have been extracted at 75° with 15 parts of 80 per cent acetic acid. After 5 min. at this temperature, heating was stopped and extraction was continued for 1½ hr. Mechanical stirring was maintained throughout. After centrifugation and removal of most of the acetic acid *in vacuo*, such extracts were dialysed for one week at 0° against a large volume of dilute acetic acid. Both the material which remained inside and that which passed through the membrane were tested by subcutaneous injection into parathyroidectomized rats. After appropriate times, the resulting changes in serum calcium[3], serum phosphate or urine phosphate[4] were measured.

The results of such tests summarized in the accompanying table show that, like Stewart and Bowen, we have succeeded in obtaining material from the parathyroid gland which is able to increase the excretion of phosphate in the urine without having any direct effect on the serum calcium-level. Because at least some of the phosphate-stimulating material in our 80 per cent acetic acid extracts consists of molecules small enough to pass through a 'Cellophane' membrane, we have not had to resort to the use of a protein denaturing agent such as formaldehyde to achieve dissociation of the two activities. Whether the parathyroid gland normally secretes a single molecular species active in relation to the blood-level, and the excretion, of both calcium and phosphate remains one of the most interesting questions for the future. Alternatively, it may possibly be that the hydrochloric acid – acetone procedure of Tepperman *et al.* leads to an association of originally separate molecules.

TESTING OF PARATHYROID EXTRACTS

| Extract | Increase in serum calcium | Increase in urine phosphate | Decrease in serum phosphate | Increase in serum calcium | Increase in urine phosphate |
|---|---|---|---|---|---|
|  | Material which had passed through 'Cellophane' membrane |  |  | Material unable to pass through membrane |  |
| *A* |  | + (0·04) |  |  | + (0·4) |
| *B* |  | + (0·4) |  |  |  |
| *C* | No change (40) |  | + (1·2) | + (81) |  |
| *D** | No change (57) |  |  | + (10) |  |

Amount of material injected per rat (mgm.) is shown in brackets. Average number of animals used per test: urine phosphate 56, serum phosphate 32, and serum calcium 14. Since there were large differences between the responses of individual rats in the serum and urine phosphate experiments, rather large numbers of animals had to be used. In these tests all the results were significant, $P < 0{\cdot}02$. The serum calcium of the rats used to test the diffusible material showed an average fall of 5 per cent (due to taking blood samples) whereas the non-diffusible material caused an average rise of 16 per cent.

* Extract *D* was made by extracting under similar conditions but for 50 min. instead of 5 min.

In view of the above separation of the phosphate activity from that concerning calcium metabolism, it is of interest to consider whether the effect of the parathyroid gland on phosphate metabolism is due to a hormone or to a non-specific factor. That such a hormone exists, either as part of the calcium-active hormone or as a separate molecular species, is suggested by the observation of Engfeldt[5] that after parathyroidectomy the serum inorganic phosphate of rats rises for a few days and then remains steady at a level some 2 mgm. per cent higher than that before operation. Even more important is the finding of Tweedy, Chilcote and Patras[6] that the urinary phosphate excretion of rats becomes very sensitive to parathyroid hormone immediately after parathyroidectomy. We have recently confirmed that result and have observed that the increased sensitivity does not diminish for several weeks after operation. Corresponding falls in serum inorganic phosphate have also been noted after amounts of hormone so small as to cause only very slight decreases in the normal rat.

Despite these points, Stewart and Bowen do not suggest that the phosphate-eliminating effect is due to a hormone, their reason being that they extracted phosphate-eliminating material from both thymus and spleen by the same method as that used by Tepperman *et al.* for preparation of the parathyroid hormone. They consider rather that extracts of all three glands are able to stimulate the excretion of phosphate by virtue of their content of "pharmacologically active tissue degradation products".

Although there is not as yet sufficient evidence for the secretion by the thymus or spleen of a hormone effecting phosphate metabolism, the facts summarized above on the results of extirpation of the parathyroid would seem to show that this gland at least secretes a factor necessary for the maintenance of normal phosphate excretion. Although the method of extraction of thymus and spleen used by Stewart and Bowen no doubt yielded a preparation consisting largely of protein, it is of interest that Nitschke[7] prepared extracts of thymus and spleen having fatty properties which were found markedly to depress the serum inorganic phosphate of dogs. While such material if present as lipoprotein could presumably explain Stewart and Bowen's results, it would appear to have different physico-chemical properties from the phosphate-eliminating extract prepared by us from parathyroid glands. The most important conclusion seems to be that the excretion of inorganic phosphate by the kidney is under the control of a hormone secreted by the parathyroid. Whether the extracts of other glands which have been shown to have activity in this respect contain the same or similar hormones or only non-specific factors remains to be determined. However, it seems certain that whatever the role of the factors derived from other tissues, the secretion of the parathyroid must be quantitatively of considerable importance since extirpation of this gland causes marked effects.

Finally, it should be noted that although, so far as the phosphate effect is concerned, the products of parathyroid and thymus seem to act in the same sense, this is probably not true in relation to their effects on serum calcium. Thus Nitschke[7] has reported extracts of thymus and spleen insoluble in fatty solvent, which he claimed led to a lowering of serum calcium. It would clearly be of interest to know what effect, if any, Stewart and Bowen's thymus extracts have on serum calcium.

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Dec. 18.

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## Asparagine in Blood Plasma

FREE asparagine has twice before been reported in animal tissues, namely, in the liver, kidney and spleen of sheep[1], and, recently, in human urine[2]. The evidence given below shows that it is also present in the blood plasma of both man and the goat: the concentrations are, in fact, comparable to those of many other free amino-acids in blood plasma.

If an amino-acid mixture is analysed by chromatography on 'Dowex-50' resin exactly as described by Moore and Stein[3], but at 20° C. instead of 37·5° C., glutamine and asparagine emerge as a single peak. When a blood plasma dialysate is heated to 100° C. at *p*H 6·5 for two hours so as to remove glutamine and then subjected to chromatography by this procedure, a ninhydrin-reacting peak still appears in the glutamine–asparagine range. If this fraction is heated to 100° C. with $2N$ hydrochloric acid for three hours, or incubated at *p*H 7·0 and 30° C. for three hours with 1 ml. of guinea pig serum, which, unlike other mammalian sera contains an asparaginase enzyme[1], then, after chromatography, an equivalent amount of ninhydrin-reacting material appears in the aspartic acid range. When the material in the asparagine range is run through a column of 'Dowex-50' with $0·5N$ hydrochloric acid as eluent it emerges as a peak in the same position as known samples of asparagine; if, on the other hand, the material is first hydrolysed with hydrochloric acid, then peaks emerge in the positions of aspartic acid and ammonia. When the fraction in the asparagine range is deionized and subjected to paper chromatography with aqueous phenol, a single spot is obtained in the position of asparagine; if the material is first hydrolysed with hydrochloric acid a spot is obtained in the position of aspartic acid. The material in the asparagine range when reacting with ninhydrin either in solution or after paper chromatography always gives the delayed colour production which is typical of asparagine.

The concentrations of asparagine in blood plasma samples from four men were 1·4, 1·3, 1·3 and 1·0 mgm./100 ml. The average of the concentrations in five plasma samples from a single goat was 0·95 mgm./100 ml. The concentration of asparagine is thus of the same order as the concentration of many other free amino-acids in plasma.

I am grateful to Dr. D. G. Jamison for his co-operation in obtaining the samples of human blood.

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## Some Histochemical Observations on Periodic Acid – Amino-Acid Mechanisms

THE periodic acid Schiff technique has been used histochemically primarily as a means of localizing the 1,2 glycol linkage in tissue sections[1]. It is known, however, that periodic acid is also capable of cleaving the 1,2 hydroxylamino linkage with the production of some aldehyde radicals, and although the exact reaction mechanism is not understood, it is believed by some to react in a somewhat similar manner with a number of amino-acids possessing structurally neither of these linkages. The amino-acids serine and threonine, as well as the "hydroxylysine" of Van Slyke, fall into the first category, whereas cystine, methionine, tryptophane, glycine, alanine, tyrosine, histadine, aspartic and glutamic acids fall into the latter group[2]. This investigation was initiated to study specifically this phase of the periodic acid Schiff mechanism, and although the results were not conclusive, it was felt that a brief description of the experiments might be of interest to others working in this particular field.

Two series of experiments were prepared, one utilizing paraffin-prepared tissue sections from formalin, alcohol and Bouin-fixed blocks of rat, rabbit and human spleen, liver, intestine, cardiac and skeletal muscle, the other using amino-acid impregnated agar and gelatin blocks. These sections and blocks were oxidized in aqueous periodic acid under varying conditions of concentration, time and temperature. The sections were then processed by the McManus periodic acid Schiff technique[3], and the blocks were similarly tested for the presence of aldehyde radicals[4]. The sections, after staining, were compared with routinely stained periodic acid Schiff control sections and with sections stained by the alloxan, ninhydrin, Millon, Axenfeld and xanthoproteic protein localization techniques[5]. It was hoped that in this way correlation could be obtained between the normal protein localization picture and any protein (amino-acid) localizations obtained with intensified periodic acid oxidation. The impregnated blocks were similarly oxidized, and colour development with leucofuchsin was checked against impregnated – unoxidized, unimpregnated – oxidized and unoxidized – unimpregnated control blocks. The sections and blocks were oxidized at 27° C. for periods up to six weeks in 0·5 per cent periodic acid, up to 24 hr. in varying acid concentrations at temperatures up to 60° C., and for periods up to one week at 27° C. in periodic acid concentrations up to 6 per cent.

As previously noted, these experiments were essentially empirical. After 10 min. oxidation in 6 per cent periodic acid at 27° C. or at 60° C. in a 0·5 per cent solution, leucofuchsin coloration was apparent in non-polysaccharide tissue components. A sequence of reaction seemed evident with prolonged oxidation. Initially, the tissue glycol components stained, the intensity increasing with additional oxidation. Non-polysaccharide components became leucofuchsin-positive more slowly, reaching a maximum coloration after several hours oxidation. If oxidation was prolonged, there developed a gradual decrease in coloration in the glycol components, followed more slowly in the non-polysaccharides. After very prolonged oxidation (four days in 0·5 per cent acid at 27° C.) a diffuse non-specific stain was obtained, giving some indication of a gradual destruction of the aldehyde radicals initially produced by the oxidation, such as has been suspected in histochemical chromic acid oxidations. At the peak of their intensity, these non-glycol colorations stained strongly the same tissue components demonstrated by the protein-localization technique, superimposed, of course, on an intense glycol-localization picture. The correlative value of the impregnated blocks was minimal, due to erratic behaviour, although many cases of definite aldehyde production were present after oxidation. Although serine and threonine gave positive coloration after 5 min. in 0·5 per cent acid at 27° C., the results of this phase of the experiment were too non-specific for positive confirmation of periodic acid demonstration of amino-acids in general.

Even though no specific conclusions can be drawn from these experiments, one point is apparent. When tissue carbohydrates are localized by the periodic acid Schiff method, it should be remembered that although a carefully controlled reaction probably reacts only with 1,2 glycols to form aldehyde radicals, this specificity may well be destroyed by excessive oxidation with involvement of amino-acids, especially those containing hydroxylamino linkages. This possibility should be kept in mind when utilizing the periodic acid Schiff procedure.

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## Kinetics of Reaction in Ethanol Solution from −80° C. to +20° C.

RATES of reaction in solution have not usually been measured over a range of temperature greater than about 50° C. Measurements over a bigger range would give more accurate values of the energy and entropy of activation, and interesting deviations from the linear Arrhenius relation between log $k$ and $1/T$ might be expected, especially in proton-transfer reactions[1]. We have measured the rate between − 80° C. and + 20° C. of the reaction between ethoxide ion and trinitrotoluene in ethanol, which appears to proceed by a proton transfer:

$$C_6H_2(NO_2)_3CH_3 + EtO^- \rightarrow EtOH + [C_6H_2(NO_2)_3CH_2]^-.$$

The ion produced is coloured and the reaction can be followed photometrically. At room temperature, rates were measured on a rapid-reaction apparatus of the Hartridge–Roughton type using the 'stopped-flow' method[2]; the fastest reaction observed had a half-period of 0·2 sec. At the lower temperatures a thermostat using solid carbon dioxide as refrigerant was employed. The observed velocity constants covered a range of more than 5 powers of 10.

The relation between $\log_{10}k$ and $1/T$ is linear within experimental error over the whole temperature range, as the accompanying table shows. In this table we compare the observed values of the velocity constant $k$, expressed as $k = 10^n k'$, with the values calculated from the equation $k = 1 \cdot 026 \times 10^{12} \exp(-13{,}600/RT)$ mole litre$^{-1}$ sec.$^{-1}$. It will be seen that the deviations are random in direction and not too large compared with the estimated experimental errors.

| $T$ (°C.) | +19·1 | −30·0 | −40·0 | −50·0 | −60·0 | −70·0 | −78·5 |
|---|---|---|---|---|---|---|---|
| $n$ | + 1 | − 1 | − 1 | − 2 | − 2 | − 3 | − 4 |
| $k'$ (calc.) | 6·34 | 5·52 | 1·64 | 4·40 | 1·03 | 2·12 | 4·34 |
| $k'$ (obs.) | 6·30 | 5·61 | 1·64 | 4·42 | 1·00 | 2·18 | 4·58 |
| % diff. | + 0·6 | − 1·6 | + 0·0 | − 0·5 | + 3·0 | − 2·8 | + 5·7 |
| Est. exp. error | ± 3 | ± 1·5 | ± 1 | ± 1 | ± 3 | ± 3 | ± 5 % |

This implies that the energy of activation $E$ is constant within the limits of experimental error, and certainly within 100 cal./mole, at 13,600 cal./mole. A change in the value assumed for $E$ of so little as 40 cal./mole leads to a definite trend in the difference between observed and calculated results. The $A$-factor can be given with corresponding accuracy: $\log_{10} A = 12 \cdot 0 \pm 0 \cdot 1$, with $A$ in sec.$^{-1}$.

The constancy of $E$ implies that the value of $\Delta C_p$ in the expression $E_{(T°C.)} = E_{(-80°C.)} + \Delta C_p(T+80)$ is too low to be detected. A low value of $\Delta C_p$ would be expected for this reaction, since the difference between the specific heats of the transition complex and the reactants will be mainly due to any changes of solvation that occur on forming the transition complex, and these depend largely on the change of charge, which is here zero. Moreover, these changes of solvation would also be reflected in the entropy of activation, and so in an abnormal $A$-factor; and for this reaction $A$ is nearly normal.

This work will be reported in full elsewhere.

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Jan. 13.

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[1] Bell, R. P., "Acid-Base Catalysis", chapter 8 (Oxford, 1941).

[2] cf. Chance, *J. Franklin Inst.*, 229, 455, 613, 737 (1940).

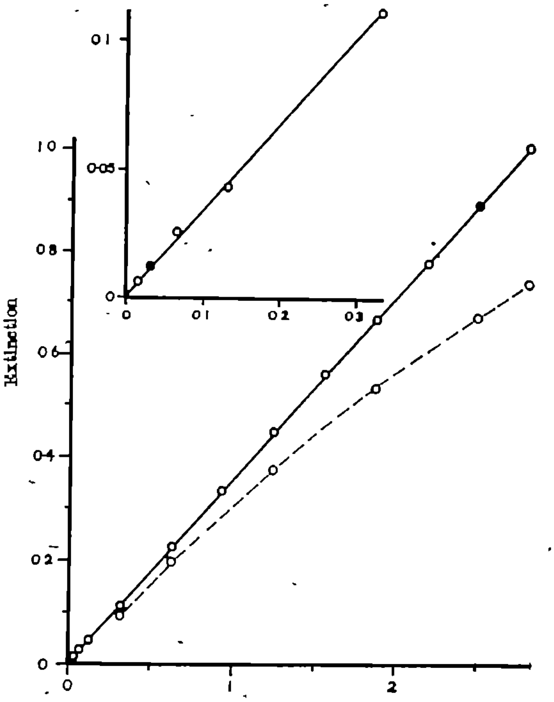
## Determination of Creatinine by the Jaffé Reaction

It has often been stated that the colour-producing reaction between creatinine and alkaline picrate does not obey Beer's law[1–3]. This implies that a calibration graph relating creatinine concentration to light extinction is not a straight line. Curves have been obtained with photoelectric absorptiometers using filters which pass an appreciable band of wave-lengths, for example, 495–550 mμ [4].

Beer's law, however, is only strictly true for monochromatic light[5]. It does not appear to be generally known that an instrument measuring on a very narrow band of wave-lengths gives a linear calibration graph for creatinine, although Borsook and Dubnoff[6] mentioned this fact in describing their method for estimating creatine. The accompanying graph was plotted from readings obtained with a Beckman spectrophotometer for a series of dilutions of a standard solution of creatinine zinc chloride. The modification of the Jaffé reaction published by Bonsnes and Taussky[1] was employed, but the linearity is not peculiar to this particular method. Within the limits of probable volumetric and reading errors, the points fall on a straight line over the range of concentrations which can be read satisfactorily.

The wave-length 520 mμ seems to be the most convenient to use. At longer wave-lengths the sensitivity decreases. At shorter wave-lengths the sensitivity is greater; but this is not an advantage, because at 520 mμ it is already sufficient for the accuracy of the method as a whole. Although the anomalies in light absorption at low concentrations of creatinine reported by Garner[3] suggest that below 515 mμ the relationship would not be linear, similar graphs were in fact obtained at 490 mμ and at 480 mμ, the range of concentrations which could be read being about half as great as at 520 mμ. There was no evidence of any systematic departure from linearity, but apparently fortuitous deviations at low concentrations (see inset graph) became relatively greater, or appeared for the first time, as the wave-length was reduced. The slit-width had to be increased to work at the shorter wave-lengths.

The calibration graph is reproducible if the conditions are kept constant, but this may be difficult to achieve. It has been found that the time for which the colour is allowed to develop before reading is not critical within the limits given by Bonsnes and Taussky, but the temperature of the solutions at the time of reading does have an appreciable effect.



———— Calibration graph for standard solutions of creatinine zinc chloride read with the Beckman spectrophotometer. λ = 520 mμ; slit-width, 0·04 mm. Inset: lower part of the graph drawn on expanded scales. Concentrations refer to creatinine base in the solutions, after diluting but before adding alkaline picrate. The lowest point corresponds to a creatinine concentration about a tenth of that found in a normal serum filtrate. — — —, Calibration curve for the same solutions read with a 'Spekker' absorptiometer, with Ilford 604 filters (nominal band-width 500–540 mμ)

Rather than standardize these and other variables, it is probably simpler to read one or more known solutions with each batch of unknowns, the linearity of the graph then enabling it to be drawn for the conditions prevailing at the time. If the temperature of the solutions alters through heating up while in the instrument, it is advisable either to adopt a standard reading procedure or to warm all the solutions to a suitable temperature beforehand.

Three other practical points may be worth mentioning. Acetone is one of the many substances which give the Jaffé reaction, and it should not be used for drying glassware[7]. Standard creatinine zinc chloride solutions in $N/10$ hydrochloric acid will not keep for more than a few weeks at room temperature[8]: they can be kept under toluene in the refrigerator. Finally, the reagent proportions suggested by Bonsnes and Taussky have the advantage that the alkaline picrate solution does not form a precipitate, and will keep for longer in the mixed form.

G. R. Hervey

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Dec. 18.

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[1] Bonsnes, R. W., and Taussky, H. H., *J. Biol. Chem.*, 158, 581 (1945).

[2] Hawk, P. B., Oser, B. L., and Summerson, W. H., "Practical Physiological Chemistry", 472 (Philadelphia: Blakiston, 1947).

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[4] Peters, J. H., *J. Biol. Chem.*, 146, 179 (1942).

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# FORTHCOMING EVENTS

(*Meetings marked with an asterisk * are open to the public*)

## Sunday, June 21

International Hæmophilia Society (at the Seymour Hall, Seymour Place, London, W.1), at 2 p.m.—General Meeting.*

## Monday, June 22

Royal Geographical Society (at 1 Kensington Gore, London, S.W.7), at 3 p.m.—Annual General Meeting.

British Society for the History of Science (in the Lecture Theatre, Science Museum, Exhibition Road, London, S.W.7), at 5.30 p.m.—Dr. Philip George: "The Scientific Movement and the Development of Chemistry in England from 1664–5 until 1750, as seen in the papers published in the *Philosophical Transactions* of the Royal Society".

University of London (at King's College, Strand, London, W.C.2), at 5.30 p.m.—Dr. Karl K. Darrow: "Solid-State Electronics".* (Further Lectures on June 23, 25 and 26.)

## Tuesday, June 23

Society for Endocrinology (at the Royal Society of Medicine, 1 Wimpole Street, London, W.1), at 5.30 p.m.—Dr. Charles Huggins (Chicago): "The Prostatic Glands as Targets for Steroids".*

## Thursday, June 25

Royal Scottish Forestry Society (in the Meeting Pavilion, Room B, Royal Highland Show, Alloa), at 2 p.m.—Mr. Frank Oliver: "The Gale of 31st January 1953—an Appreciation of the Situation".

University of London (in the Physiology Theatre, University College, Gower Street, London, W.C.1), at 4.45 p.m.—Prof. J. H. Quastel, F.R.S.: "The Action of Drugs on Enzyme Systems".*

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# APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Biochemist (honours science graduate) primarily for research duties in the Geriatric Department of the Sunderland Hospital Group, carried out mainly at the Sunderland General Hospital—The Senior Administrative Medical Officer, Newcastle Regional Hospital Board, Blythswood South, Osborne Road, Newcastle-upon-Tyne 2 (June 27).

Demonstrators (2) in Inorganic Chemistry—The Registrar, King's College, Newcastle-upon-Tyne (June 27).

Principal of Croydon Polytechnic—The Chief Education Officer, Education Office, Katharine Street, Croydon, Surrey (June 27)

Senior Lecturer to teach Metallurgy, a Lecturer to teach Inorganic and Physical Chemistry, and a Lecturer to teach all branches of Physics, at the College of Commerce and Technology—The Director of Education, Leopold Street, Sheffield 1 (June 27).

Assistant (Experimental Officer grade) in the Pathology Department, for routine work on selection and indexing of fruit stocks for virus infection and assistance with experimental work on plant virus diseases—The Secretary, Scottish Horticultural Research Institute, Mylnefield, Invergowrie, Dundee (June 30).

Assistant Principals (2) at the Nigerian Colleges of Arts, Science and Technology—The Secretary, Advisory Committee on Colonial Colleges, 15 Victoria Street, London, S.W.1 (June 30).

Lecturer in Applied Chemistry (with honours degree or equivalent, with teaching and industrial or research experience)—The Principal, Royal Aircraft Establishment Technical College, Farnborough, Hants (June 30).

Lecturer in Physics, and a Lecturer in Genetics, at the University College of the Gold Coast—The Secretary, Inter-University Council for Higher Education in the Colonies, 1 Gordon Square, London, W.C.1 (June 30).

Assistant Lecturer to teach Chemistry to H.N.C. and A.R.I.C. standard, at the Technical College of Monmouthshire, Crumlin—The Director of Education, County Hall, Newport, Mon. (July 1).

Speech Therapist in charge of the Speech Therapy Clinics—The Clerk of the County Council, County Hall, Newport, I. of W. (July 1).

Assistant Lecturer (Grade III) in Physiology (veterinary)—The Registrar and Secretary, The University, Bristol (July 4).

Director—The Secretary, Hill Farming Research Organization, Moredun Institute, Gilmerton, Edinburgh 9 (July 4)

I.C.I. Research Fellowships in Physics, Chemistry, Metallurgy, Engineering or Geology, or in a subject allied to these—The Registrar, University of Wales, University Registry, Cathays Park, Cardiff (July 4).

Lecturer in Philosophy—The Registrar, King's College, Newcastle-upon-Tyne (July 4).

Metallurgist at the Ministry of Supply, London headquarters, to assist in research and development work on metallic materials for aircraft construction and to progress research contracts with Universities, Research Associations, Materials Manufacturers and Aircraft Constructors—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting F.245/53A (July 4).

Physical Chemist at a Ministry of Supply Research Establishment near Sevenoaks—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting F.246/53A (July 4).

Lecturer in Bacteriology at the Royal Infirmary, Glasgow—The Secretary of University Court, The University, Glasgow (July 8).

Assistant Agricultural Economists in the Ministry of Agriculture and Fisheries—The Civil Service Commission, Burlington Gardens, London, W.1, quoting 4219/53 (July 9).

Electrical Engineers in Ministry of Supply Experimental Establishments mainly at Malvern, Farnborough, Christchurch and Sevenoaks, for research, development or design in telecommunications, radar, electronics, instrumentation or light electrical measurements—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting D.232/53A (July 10).

Junior Lecturer in Applied Pharmacology and Therapeutics—The Dean, St. Thomas's Hospital Medical School, London, S.E.1 (July 10).

Director (with university degree in agriculture or horticulture) of the States' Experimental Station—The Secretary, Department of Agriculture, 6 Bond Street, St. Helier, Jersey, C.I. (July 11).

Senior Lecturer in Physics at the University of Hong Kong—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (July 15).

Organic Chemist as Research Assistant to the Professor of Medical Chemistry in the John Curtin School of Medical Research, Canberra, for research on the synthesis of new heterocyclic compounds, in particular, pteridines, pyrimidines and pyrazines—The Secretary, London Office of the Australian National University, 27 Russell Square, London, W.C.1 (July 17).

Research Officer (Protein Chemist) (with university honours degree in science with physical—organic—or biochemistry as major subjects and, preferably, research experience in some aspect of protein chemistry) in the Biochemistry Unit of the Wool Textile Research Laboratory, Parkville, Melbourne, to study the chemical composition and reactivity of collagen by application of physical organic or biochemical procedures used in this laboratory for research on wool keratin—The Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting No. 462/56 (July 18)

Lecturer in Mining (with a university degree in mining and a first-class Colliery Manager's Certificate), and a Demonstrator in Chemical Pathology—The Registrar, The University, Leeds 2 (July 20)

Physicist (honours graduate) to assist in problems related to the treatment of cancer by X-rays, radium and telecobalt—The Secretary and House Governor, Mount Vernon Hospital and Radium Institutes, Northwood, Middx (July 25).

Physicist or Metallurgist (Ph.D., with additional research experience, or equivalent qualifications, are essential) in the Division of Tribophysics of the Commonwealth Scientific and Industrial Research Organization, located at the University of Melbourne, to work with its metal physics group—The Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting No. 370/81 (July 25).

Director (with the status of Professor) of the newly established Dental Research Unit located in the University of the Witwatersrand Oral and Dental Hospital at Johannesburg—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (July 31).

Senior Lecturer in Geology (specialized either in stratigraphy and palæontology, or in economic or mining geology), at the University of the Witwatersrand, Johannesburg—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (July 31).

Lecturers in the Department of Chemistry at University College of Fort Hare, South Africa—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (August 1).

Lecturer in Prehistory at Auckland University College, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (August 31).

Assistant Professor of Micro-Anatomy (histology and embryology), and an Assistant Professor of Gross Anatomy, in Dalhousie University, Halifax, Nova Scotia—Prof. R. L. DeC. Saunders, c/o Mrs. MacDougall, Upper Slaughter, Cheltenham (September 7).

Demonstrator in Electrical Engineering—Prof. G. F. Tracy, Electrical Building, University of Toronto, Toronto 5, Ont., Canada.

Head of the Department of Mathematics, Cardiff College of Technology and Commerce—The Director of Education, City Hall, Cardiff.

Lecturer (Grade B) in Chemistry (with postgraduate experience in organic or inorganic chemistry)—The Clerk to the Governing Body, Battersea Polytechnic, Battersea, London, S.W.11.

Lecturer in the Department of Civil Engineering (with a good honours degree; and practical or research experience in Civil Engineering Hydraulics would be an advantage)—The Secretary and Registrar, The University, Southampton.

Lecturer in Mathematics—The Clerk to the Governors, Mid-Essex Technical College, Market Road, Chelmsford.

Medical Research Officer and a Research Entomologist for the Virus Research Unit in Nigeria, for research on arthropods of medical importance, with particular reference to viral and rickettsial diseases—The Director of Recruitment (Colonial Service), Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting CDE.117/14/02.

Physiologist (Scientific Officer or Senior Scientific Officer grade) (with a good honours degree in physiology, or an equivalent qualification, and research experience, preferably involving the perfusion of isolated organs) for research on the physiology of lactation—The Secretary, National Institute for Research in Dairying, Shinfield, Reading, quoting Ref. 53/8.

Professor of Physical Metallurgy—The Head of the Department of Metallurgical Engineering, University of Toronto, Toronto 5, Ont., Canada.

Research Assistant (graduate preferred) in the Department of Inorganic and Physical Chemistry, for the preparation of crystallographic data and the coding of problems for calculations on an electronic computer, and also the actual running of problems through the computer—Prof. E. G. Cox, Chemistry Department, The University, Leeds 2.

Wool Textile Research Council Scholarships (*a*) for work on infra-red spectrometry and (*b*) for work in wool textile technology—The Principal, Technical College, Bradford.

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# EDUCATION IN AFRICA

THE recent report of the Parliamentary and Scientific Committee referred to a memorandum from the Colonial Sub-Committee dealing with questions relating to education, agriculture and fisheries, health, forestry and the future of the Colonial Development and Welfare Fund, in which the dependence of Colonial development on the application of modern scientific knowledge in the utilization of natural resources was emphasized. This in turn depends very largely on the technical competence of the indigenous populations and their ability to participate in the process, and it is from this point of view, quite as much as from that of political development, that the study of educational policy and practice in British Tropical Africa recently issued by the Nuffield Foundation and the Colonial Office is of outstanding interest*. It includes the reports of two missions, one, led by Mr. A. L. Binns, to East and Central Africa, and the other, led by Dr. G. B. Jeffery, to West Africa (both of which were financed by the Nuffield Foundation), and the record of the proceedings at the subsequent conference at Cambridge in September 1952, of which Sir Philip Morris was chairman. An analysis of the reports is printed elsewhere in this issue (p. 1134).

The Cambridge conference, at which the Colonial Office and the United Kingdom were represented, consisted mainly of representatives of Colonial territories, chiefly in territorial teams forming an almost complete cross-section of the educational world of British Africa. It was the first occasion for a review of the whole groundwork of education in Colonial territories by those concerting it since 1925, when a general policy for British education in Africa, based upon the work of the Phelps–Stokes Commissions of 1920–21 and 1923–24, was outlined in a "Memorandum on Educational Policy in British Tropical Africa"; it was thus also the culminating event in a long process. Soon after the War, it was realized that, in view of political changes, the extent to which education was becoming rooted in African soil, and the urgency of some problems in educational policy and affairs in Africa, needed careful review and, in many respects, to be thought out afresh.

The approach favoured was more intimate and less formal than that of a Royal Commission. The small groups of experts who, under Mr. Binns's and Dr. Jeffery's leadership, visited Africa were able to initiate in each territory they visited discussions fundamental to the problems of each particular territory. The two reports they prepared formed the basis for the conference discussions, and for that purpose the conference was divided into five groups in which education was discussed from the different vantage points of responsibility and control; the expansion of the educational system; the teaching profession; organization and curriculum; and education and the adult.

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* African Education: a Study of Educational Policy and Practice in British Tropical Africa. (Produced on behalf of the Nuffield Foundation and the Colonial Office.) Pp. xii+187. (London: Crown Agents for the Colonies, 1953.) 8s. 6d.

The purpose of the conference was not to make policy which should thereafter be imposed upon the territories which were participating, or to fix a common pattern of education on a considerable proportion of a vast continent. It did not seek to pass general resolutions. Its object was to place on record the best views which could be formulated and expressed, so that hereafter those responsible for shaping policy or carrying out educational work should find in the record of the conference opinions and conclusions which had been refined by discussion but which had not been pressed into uniformity. As Mr. Oliver Lyttelton writes in his foreword, the volume poses the problem of education as a challenge and a stimulus to education, and it may well point the way to fresh advances. Moreover, unlike the reports of the Phelps-Stokes Commissions, the conclusions of which were limited to specific territories, the Binns and Jeffery reports present conclusions of general validity even where they were not specifically adopted by the conference.

Throughout the work of the two groups which visited Africa and of the subsequent conference, the method adopted was devised to ensure that the wisdom and experience of those in the field were freely drawn upon in any conclusions which might be reached, and that the processes in which they had participated might have the maximum chance of being relevant and fertile. Certain limitations were, however, placed upon the study. It was limited in the first place to the education of Africans; and higher education, apart from a brief section on university education, so far as affecting the work of the schools and the training of teachers at Makerere College, was omitted, because the ground had already been covered by the Asquith and Elliot reports and because university policy in Africa is under constant review by the Inter-University Council. Furthermore, the development of higher technical education is excluded for similar reasons, and technical education is only considered in connexion with different types of secondary schools and with the needs of industry.

These limitations do not seriously detract from the interest of the report for the scientist as such. With the general approach rather from the point of view of what needs to be done than from that of the available resources and the best means of distributing them, the report is concerned above all with the foundations on which higher education, both at the university- and the technical school-level, can effectively develop. It is concerned, too, with the conditions in which the services of the technician, the technologist and the university graduate can be most effectively utilized and, by implication rather than by precept, it gives a good deal of guidance as to the right priorities to be adopted where means are straitened and some choice of objectives has to be made. The Binns report went so far as to suggest that the churches engaged in educational work in Africa should consider very seriously whether some of their thought, energy and control should not give place to a larger effort in the education of adults, and by this it included the preaching and practice of the Christian religion.

This suggestion that the churches should abandon their thousands of small scattered 'bush' or unaided schools and divert the money and energy thus freed into the channels of adult education was not endorsed by the conference. Nevertheless, it was generally agreed that more could be done to encourage and co-ordinate the work which the churches are doing in the field of informal education, either by association with official training schemes or by participation at the advisory level in national and regional planning. The suggestion, moreover, illustrates two dominant characteristics of both reports and of the subsequent conference discussions, namely, the belief in the necessity of a spiritual basis of all education, and the insistence that a fully comprehensive educational system cannot be developed in isolation from the development of central and local institutions of government.

The Binns report, for example, claims that the situation in Africa amounts to a moral crisis, and suggests that Governments in East and Central Africa should abandon their attitude of neutrality in relation to religion. A public statement on a belief in the necessity for a spiritual basis for education in its widest sense would encourage those already at work and provide inspiration for future development. Both reports, however, agreed in emphasizing the importance of building up moral leadership. The Jeffery report suggests, for example, that it would be a great contribution to progress at this critical stage if those upon whom the responsibility for moral leadership rests could come to a clearer realization of what they have in common in their appreciation of the fundamental human values. "If leaders in all branches of African thought could come together in a united and public testimony of fundamental values they would make a lasting contribution to education on the West Coast."

The Jeffery report urges further that the moral progress of any people depends partly upon the vision and vigour of its prophets, but more upon the example of those men and women who, by reason of consistent and faithful lives, are judged worthy by their fellows. This passage, insisting on the relation between morals and character training, was quoted with approval by one of the study groups at the conference; but the most impressive feature of the conference proceedings is the unanimity of all five study groups in their reports that education must not be purely secular but must have a spiritual basis. This basis can only be assured if religious bodies are formally associated with government bodies in the control of education, and furthermore if training colleges are staffed with those of such high moral character as will fit them to exercise a sound influence upon their students.

This first point, moreover, is linked up with the second, for, as the Jeffery report points out, character is trained in the exercise of responsibility, and in the developing society of West, East or Central Africa to-day, a prime problem is to determine the appropriate measure of responsibility that can be given at any particular moment in relations between child and teacher, between teacher and institution, and between institution and local or central government. To the extent to which this is wisely determined, the effectiveness of education both as an instrument of stability and of change largely depends. It is to be noted, for example, that the Binns report points out that education is inseparable from life, and urges the closest co-operation between the departments of education and agriculture at all levels; in consequence, while it recognizes that scholarship is of first-rate importance, it advocates recruiting an increased number of Europeans for the African education service primarily with the view of their ability to inspire in their pupils a deep and abiding affection for rural life and the things of the countryside. All practical work in the schools, moreover, should have a real meaning to the pupils, and should never be allowed to become mechanical drudgery.

The vision of education which inspires these reports is that of the united concern of a people for the right upbringing of its children and the improvement of its national life. Success depends upon the co-operation of parents, teachers, administrators, leaders in public affairs and of all who care for the future of their country. An essential element in it is to provide full opportunities for creative activity; and to the extent to which it inculcates also that respect for truth, which is the characteristic educational value of science, it can play an essential part in developing the sense of common citizenship—a sense which experience has already shown is developed not so much through political institutions themselves as from participation in some kind of leisure-time education or activity that exacts loyalty and demands enthusiastic endeavour. What is sought is, in effect, a more liberal education for Africans based on their own African environment and on their own way of life—an education, as the Binns report puts it, designed to enable Africans to understand their environment and to lead the most complete life that is possible in it.

The emphasis on the spiritual basis of education is strongly reflected in all that is said about the training of teachers. The importance of quality here is stressed as much as, if not more than, the need for keeping education keyed with the traditions and needs of the people concerned. The supply of teachers lies at the very heart of the educational problems of the West African coast regions; but the Jeffery report nevertheless maintains that raising the educational standard for admission to training is one of the most urgent educational needs. An increase in the number of really good teachers should be the spearhead of educational progress, and there is no single aim in which effort could be concentrated to greater advantage.

This reflects the conclusion of Lord Hailey's "African Survey", that the most pressing need in popular education in British territories is the improvement of standards of teaching and better means of control. The Binns report likewise suggests that in the teachers' training colleges is to be found the remedy for many of the serious weaknesses in African education at present. In the teachers' training colleges, as well as in schools, it suggests, a moral code should be inculcated by the active formulation of good habits and the development of a strong community life. The staffs of training colleges should be selected as examples of what their students should become, and morality should be presented to students as a matter of principle and of service to the community, while great attention should be paid to fostering "initiative and responsibility". The recruitment, conditions of service and training of teachers are discussed at some length in this report, and were also considered by one of the five study groups at the subsequent conference; nor was there difficulty in reaching agreement on the main aspects of policy.

The points which received general support were not, in fact, new, and what is most noteworthy about them is rather the sense that they are essential, and that if governments really wish to encourage the development of education they must break down whatever obstacles have hitherto prevented action along the lines indicated. Some of these points, notably that about continuity of staffing, are peculiarly matters for government action: attention is directed throughout this report to the harm which is done when teachers are moved to suit the administrative convenience of an education service without regard to the effect on the teacher or the institution concerned. Besides this, there is an equally noteworthy sense of the way in which the training of teachers should be in line with the needs and the development of the community. For example, it is recognized that any distinctive African contribution to the world must be based on the African's love and respect for the mental inheritance of his people, much of which is enshrined in language. There is warning against the danger of discarding good values from tribal life, while taking from Western culture, not its spiritual strength but its materialistic weakness. With the insistence on the necessity of a good general education as a basis for successful technical education goes that on the need for a close connexion between technical education and industry. Likewise, it is recommended that technological education should be developed to keep pace with industrial expansion and to enable Africans to make their maximum contribution as skilled workers in accordance with the opportunities available in each area; and in view of the great importance of agriculture in African life, agriculture should be strongly represented both in teaching and research at the university-level. Attention is also directed to the practical help which could be given to educational policy and practice by such university studies as those at Makerere College into the causes of wastage in the schools, or at the Institute of Education into intelligence testing as applied to East Africa.

In all this is implicit the belief that administrative advance must come to terms with political realities. If Africans are to find adequate expression for their new hopes and aspirations, they must have opportunities for serving the public interests of their country in their immediate communities. Real service, moreover, needs an element of responsibility, and participation in local affairs is both a present service and a preparation for the larger services which the future will require of them. Here there is also recognized the danger of a dichotomy between the literate young and illiterate elders. Some means must be found of ensuring that some at least of the older generation are carried along with the general movement.

This is one reason for the report's emphasis on what it terms 'informal' or adult education, rather than mass education, though the methods used may be both formal and informal; and its importance appears again in the report recently prepared by the Hansard Society* on problems involved in developing parliamentary institutions in Colonial territories. The other main reason for such emphasis appears in regard to finance. Both the Binns and the Jeffery reports urge that the proportion of government expenditure which is devoted to education requires increasing; but the study group at the conference at Cambridge which considered the expansion of the educational system paid little attention to the question of finance, and the conference as a whole did not appear to come to grips with the real issues here. It was left for one of the speakers in the discussion to suggest that in present circumstances the expansion of education is an emergency problem and must be treated on an emergency basis. Education should not be regarded merely as one among a number of services which compete for whatever share of the revenue remains after providing for justice, communications, administration, the national debt and other essentials.

Perhaps the great value of the whole report on African education may lie in its demonstration that education is an essential service and that, as the Binns report points out, "if it is deprived of the means to do its work well, all the departments will suffer". If education is to receive not merely its present ten or twelve per cent of the revenue but a greatly increased allocation, this point must be clearly understood both by the Government itself and also by the community on whose support that government rests. To the extent to which educational developments are supported from Colonial Development and Welfare Funds, it is important that public opinion in Great Britain should also understand what is involved. It is, however, of increasing importance that in those territories in which Africans themselves are associated with administration and government, there should be a clear understanding of the whole nature of educational policy and its relation to the needs of the community, and of the effort and sacrifices which are required to pursue consistently a policy of expansion which will meet African needs.

There is much else of great interest in this report. It is constructive as well as critical. It puts its finger firmly, as did Dr. G. B. Jeffery in an earlier report, on the weaknesses and dangers of the examination system, and it shows very clearly how valuable is the help which the British universities and individual teachers from Great Britain could give in meeting African needs in this field. It is as clear as from the Hansard Society's report already mentioned that, unless such help is forthcoming, and unless the governments concerned face the problems set out here with determination and a sense of urgency, there is little hope that parliamentary institutions will either develop or function in the Colonial territories of Africa. Political progress cannot be isolated from economic, social, cultural and spiritual progress. Even in such a comparatively advanced democracy as Britain, a primary lesson of a satisfying education, namely, that there are no civic rights without civic duties, and that liberty can only be earned, has been imperfectly learned. Educational policy and practice in Africa are of supreme importance, because their adequacy and efficacy determine both the standards of administration and the effectiveness of whatever forms of democratic institutions may be adopted, the functioning of the whole organization of government, the reality of co-operation in the tasks of government at local and at central levels, and equally the pace of economic and social development upon which the welfare of the society depends. The report on African education sounds the right note of urgency and indicates practical steps to be taken. That from the Hansard Society does not merely put the issue in its true perspective; it also indicates substantial reasons for believing that the parliamentary system may yet succeed in the Colonial world, and that the educational effort which Britain as well as the Colonial peoples is summoned to make in Africa may be undertaken with confidence.

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# PLASTICITY UNDER PRESSURE

## Studies in Large Plastic Flow and Fracture

With Special Emphasis on the Effects of Hydrostatic Pressure. By Prof. P. W. Bridgman. (Metallurgy and Metallurgical Engineering Series.) Pp. x+362. (London: McGraw-Hill Publishing Co., Ltd., 1952.) 72s. 6d.

DURING the past twelve years or so, Prof. P. W. Bridgman has been making experiments on the plastic flow and fracture of metals, and other solids, when these are subjected to large hydrostatic pressures (for example, 450,000 lb./sq. in.) superposed on the stress system that actually causes flow and failure. The starting-point for the work was his discovery, just before the Second World War, that the ductility of ordinary steels increases enormously in the presence of such high pressures, the reason for this being of course that, while the hydrostatic stress squeezes the atoms together, so that fractures cannot start inside the body, it does not stop the atoms sliding past each other. It appeared likely that this discovery would shed light on the unusual behaviour of armour plate under high-speed penetration, particularly since it was known that the stresses developed around the nose of a projectile during penetration are of a similar magnitude; and these considerations led Prof. Bridgman to begin a systematic investigation of the effect, under the sponsorship of the United States National Defence Research Committee and of the Watertown Arsenal.

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* Problems of Parliamentary Government in Colonies: a Report prepared by the Hansard Society on some of the Problems involved in developing Parliamentary Institutions in Colonial Territories. Pp. x+154. (London: Hansard Society, 1953.) 12s. net.

Much of this work was written up during the War in government reports. These have now been declared available to the public, but still remain largely unknown. As for the rest of the work, only a part of it has been recorded and published until now. A result of this poor publicity is that some of the experiments have already been duplicated by other people, unaware of their existence. To remedy this situation, Prof. Bridgman has written the present book, in which he has collected together the work into a coherent and easily accessible form.

It is an unusual book, not only for what it contains but also for how it is written. Presented in a very personal style, in which the first person singular is often used, it amounts almost to a highly polished log-book of the author's researches. In places there are accounts of historical details, not only of the ups and downs of particular experiments, but also of the negotiations surrounding their planning and publication. The general reader may feel that neither of these latter is meant for him, that the experimental details are only for those about to make similar researches, and that the negotiations have been brought in only because the author wished certain facts about them to be placed on record.

To set against the tedium of these passages, the general story of the experiments makes fascinating reading. Chapters are included on the tension of steel under hydrostatic pressure, on similar experiments with other metals and various mineral substances normally considered brittle, and on two-dimensional tension, compression, brinell indentation, punching, wire drawing and extrusion, all under hydrostatic pressure. The effect of external pressure on cavities is studied with several materials, and various other experiments are described dealing with large strains in one-dimensional and two-dimensional compression, and in torsion and shear. Finally, an account is given of the effects of prior deformation under one type of stress system on subsequent behaviour under other types. Theoretical analyses of stress distribution, including that at the neck of a tensile specimen, are made at various places throughout the text, and in these the author's exceptional physical intuition guides him surely over otherwise hair-raising routes to some very reasonable solutions.

Only a few of the many interesting points can be mentioned here. Chapter 4 describes an extremely ingenious method of making tensile tests, under hydrostatic pressure, which dispenses completely with shoulders at the ends of the gauge-length and so avoids their associated stress concentrations; this is essential when making tensile tests on brittle substances. In Chapter 5 it is shown that, under high compressive stresses, single crystals of alumina deform plastically on slip planes; the appearance of the deformed crystal in the photograph of Fig. 62 is strikingly reminiscent of that of a compressed zinc crystal that has been deformed by kinking. The great ductility which can be obtained under high hydrostatic pressures is demonstrated in numerous ways. One of the most interesting of these is in wire-drawing, where reductions in diameter and intensities of work-hardening can be achieved that far surpass ordinary experience; there is surely the basis of an important industrial process here.

To conclude, this is a book which will undoubtedly prove most valuable to those concerned with the mechanical properties of solids under extreme pressure, whether in a laboratory, a forge, a mineshaft or an armoured fighting vehicle. A. H. COTTRELL

# FOURIER SYNTHESIS OF CRYSTAL STRUCTURE

## Fouriersynthese von Kristallen und ihre Anwendung in der Chemie

Von Prof. Werner Nowacki. (Lehrbücher und Monographien aus dem Gebiete der exakten Wissenschaften, Chemische Reihe, Band 6.) Pp. 237. (Basel: Verlag Birkhäuser, 1952.) 34.30 Swiss francs.

THIS book, on the use of Fourier series in crystal structure analysis, is the outcome of lectures given by Prof. W. Nowacki to advanced students during the summer and winter sessions of 1948–49. The author presumes some knowledge of crystal structure analysis on the part of the reader, thus making it an advanced text-book on the subject. Although the information given is not more recent than 1949, there are copious lists of references to each section, which makes it an excellent reference book to the teacher, the research worker and the student in X-ray crystallography.

The book is divided into two parts, each of which might be brought under the more general headings of structure determination and technical aids for computation, respectively. The first seven sections of Chapter 1 are taken up by an introduction to Fourier syntheses and, by using Lonsdale's "Tables", the author derives the structure factors and the electron density expressions for the space groups $P2_1/c$, $P2_12_12_1$ and $Pna$. The accuracy of determining atomic positions is next taken up in relation to errors arising from the termination of series effects with appropriate corrections. The author, however, is not in favour of applying an artificial temperature factor to the observed $F$-values since, as he rightly points out, such corrections tend to introduce more errors than those they were intended to eliminate—namely, the diffraction effects of an abruptly terminated series. A discussion follows on methods of refinement which include Bragg–Lipson structure-factor graphs, molecular transforms, differential synthesis, and methods of least squares and steepest descent. The last two sections of the chapter, which should have appeared earlier, form the basis of structure analysis. Determination of absolute $|F|$-values are discussed, including the use of Wilson's very useful statistical method, and lastly a brief survey is carried out of the more usual methods of phase angle determination—namely, trial and error methods, the use of isomorphous replacements and the heavy atom technique, the use of Harker–Kasper inequalities, Buerger's implication diagrams and the 'fly's eye'.

Part 1 of the book is concluded by a detailed treatment of Patterson syntheses, with sections dealing with its extensions in the form of Harker and Buerger syntheses, respectively. A full description is given of space-group determination using Buerger syntheses, and Table 19, incorporated as a booklet, gives the hundred and twenty extinction groups useful for space-group determination. These two chapters form the basis of this book. It is rather unfortunate that it appeared at a time when some significant advances were being made in the technique of structure determination, three examples of which may be quoted. First, Wilson's statistical methods used as aids in space-group determination are now in general use and possibly supersede the methods suggested by Buerger syntheses. Secondly, $(F_o - F_c)$ syntheses and differential syntheses are likely to be used to a greater extent for the accurate location of atomic centres rather than the method of steepest descents. Thirdly, Lipson and Taylor's development of optical methods for viewing molecular transforms and for the determination of phases has given a new turn to our concepts of structure determination. Nevertheless, these recent developments do not in any way diminish the usefulness of this book.

The second part of the book deals with methods of calculating Fourier series and structure factors. There is a full description of the Beevers–Lipson method, and brief references are made to other electro-mechanical aids, of which the Hollerith punched-card technique has come to be widely used.

The book as a whole is well produced, well indexed and well referenced. It is to be hoped that Prof. Nowacki will bring out a second edition in which are incorporated the more recent advances, thus adding to the merit of an already useful book which can be fully recommended. C. H. Carlisle

# PHYSICS MONOGRAPHS FOR STUDENTS

### Fundamentals of Thermometry

By J. A. Hall. Pp. 48.

### Practical Thermometry

By J. A. Hall. Pp. 51.

### Soft Magnetic Materials used in Industry

By A. E. DeBarr. Pp. 62.

### The Magnetic Circuit

Powder Cores, Ferrites, Permanent Magnet Materials, and Miscellaneous Magnetic Materials. By A. E. DeBarr. Pp. 62. (Monographs for Students.) London: Institute of Physics, 1953. 5s. each.

THE Institute of Physics by its various publications, particularly the Physics in Industry series of monographs and the monthly journal, the *British Journal of Applied Physics*, has greatly advanced the study and development of applied physics and provides the industrial physicist and research worker with up-to-date factual information. The proper training of applied physicists, a matter of paramount importance, has also occupied the attention of the Institute, and it issues National Certificates in applied physics jointly with the Ministry of Education and the Scottish Education Department. However, the usual text-books on physics are not primarily concerned with the practical applications and with instruments, and thus the Institute has started to publish a new series of "Monographs for Students" which have been specially written for general reading by students attending courses for the Higher National Certificate in applied physics; these books constitute a valuable and important contribution to the literature of applied physics, and a stimulus and aid to the student.

The first four volumes in this series are remarkable for their excellence in content and production. The graphs are particularly clear and easy to read, though some diagrams have suffered from over-reduction. "Fundamentals of Thermometry" and "Practical Thermometry" are companion volumes: in the former attention is concentrated on the International Temperature Scale, and in the latter the instruments and techniques described are largely those recommended by, or used at, the National Physical Laboratory, where the author is a senior principal scientific officer and is actively engaged in the testing and development of temperature-measuring instruments. "Soft Magnetic Materials used in Industry" and "The Magnetic Circuit" are also companion volumes, and, in case the reader may be misled by these titles, it is perhaps well to add that the physical basis of, and introduction to, magnetic properties is given in the first of these two monographs, while in the other are details of powder cores, ferrites and other magnet materials. The domain theory of ferromagnetism, antiferromagnetism and ferrimagnetism all receive adequate treatment.

The monographs are short but handy booklets in stiff paper covers; they should have a wide circulation. S. Weintroub

# D.C. ANALOGUE COMPUTERS

### Electronic Analog Computers (D–C Analog Computers)

By Dr. Granino A. Korn and Theresa M. Korn. Pp. xv+378. (London: McGraw-Hill Publishing Co., Ltd., 1952.) 59s. 6d.

THIS book is concerned with electronic analogue computers of one class only, namely, those in which the variables are represented by voltages and in which the circuits are direct-coupled throughout. The authors are primarily concerned with the use of such machines for solving sets of ordinary differential equations in which time can be used for representing the independent variable. There is a section dealing with machines for solving sets of simultaneous algebraic equations, but this subject is not dealt with at length.

The authors are much too concerned with practical details of design to attempt to define the field in which D.C. analogue computers are of use, although they wax enthusiastic on p. 3 about a computer wired up from scrap parts on a 'bread-board' in two hours at negligible cost and ready to furnish needed information with fair accuracy. But it is clear from the book that the authors have been primarily concerned with the use of analogue computers in aircraft design, both for investigating the behaviour of servo systems, non-linear damped oscillators, etc., and also as simulators, for example, in the testing of autopilots when a computer can be used to simulate the behaviour of an aircraft. In these applications the main drawback of analogue computers—poor and uncertain accuracy which falls almost to nothing when the magnitude of the variable considered changes by a large factor—is not greatly in evidence. This is partly because the results are interpreted by engineers who understand the working of the computer and know when the results given are likely to be trustworthy. I am not sure whether the authors would agree that analogue computers are less useful for dealing with differential equations which arise in more mathematical contexts—for example, in theoretical physics.

The greater part of the book is concerned with theoretical and practical aspects of the design of D.C. amplifiers, integrators, differentiators, multipliers, function generators and other computing circuits. This part of the book is admirably practical and should be of use to anyone concerned with the design of electronic devices which include computing elements. The section on the choice of scale factors should similarly be of interest to users of analogue computers. M. V. Wilkes

### Semimicro Qualitative Analysis

By Prof. Paul Arthur and Prof. Otto M. Smith. (International Chemical Series.) Third edition. Pp. xi+285. (London: McGraw-Hill Publishing Co., Ltd., 1952.) 34*s*.

THIS book is intended to provide an elementary course in inorganic qualitative analysis on the semi-micro scale, covering the commoner cations and anions, but excluding separations in presence of phosphate. Ten chapters, roughly half of the text, give an outline of the theory involved, each being followed by a series of questions for the student, and including, where relevant, typical worked examples. The remainder gives a survey of experimental technique, clearly illustrated by diagrams, followed by analytical schemes for cations and anions. Each tabular scheme is preceded by a brief general survey of the reactions of the ions included, and followed by a series of notes on the experimental procedures.

The analytical schemes for the cations follow mainly the classical pattern, but a useful alternative method for the analysis of the iron group, based on a modified Ford–Williams separation of manganese and chromium, is given. This should minimize adsorption errors such as occur in the usual hydroxide–sulphide method for this group. The tabular schemes are clearly set out, and the accompanying notes cover most of the difficulties likely to be met with by students without overloading the text. Confirmatory tests for particular ions are based, as they should be, mainly on the correct carrying out of the separation procedures, but a short section lists alternative special reagents for use in doubtful cases.

The practical section is evidently based on laboratory experience of the methods described in the text, and this, together with the appended notes, makes the book a reliable introduction to the theory and practice of qualitative analysis. J. A. Mair

### Bibliographie des langues aymará et kičua

Par Paul Rivet et Georges de Créqui-Montfort. (Université de Paris: Travaux et Mémoires de l'Institut d'Ethnologie, Tome 51.) Vol. 1 (1540–1875); pp. xlii+500; 3,200 francs. Vol. 2 (1876–1915); pp. v+656; 3,500 francs. (Paris: Institut d'Ethnologie, 1951–52.)

THESE two volumes, which are a product of forty years of work, comprise a list, with short critical notes on each item, of practically everything which was printed in Quichua and Aymara from the Spanish Conquest down to 1915; and, although the authors invite additions and corrections, it is unlikely that they have missed anything of importance. The title pages of a good many of the more important works are reproduced in facsimile, and an index is promised but has not yet appeared, so it will presumably follow in a subsequent volume.

The introductory chapter is brief, and, besides describing the objects and scope of the work, it sets the stage by giving a short account of what the authors conceive to have been the general linguistic situation during the time of the Incas. In the course of this they repeat some statements with which many linguists disagree, but they themselves stress the immature state of linguistic studies of South America, so this need cause no surprise. Most of the material is connected with the evangelization and religious instruction of the Indians, and in the nature of things little can come from native sources, so a relatively large proportion of this chapter is devoted to a discussion of the original MSS. of the native drama Ollantay.

Having heard Prof. P. Rivet introduce and present these volumes to two recent international congresses —the Peruvianists in Lima, and the Americanists in Cambridge—I can testify to the enthusiastic reception which they have already received from many scholars, and have no doubt that they will be equally warmly welcomed by all who are concerned with the historical and linguistic study of South America.

G. H. S. Bushnell

### Automatic and Manual Control

Papers contributed to the Conference at Cranfield, 1951. Pp. xi+584. (London: Butterworths Scientific Publications, Ltd., 1952.) 50*s*. net.

EACH paper in this volume is a contribution to fundamental design technique, and as such would merit scientific publication, in one form or another, in the usual way. In considering a symposium of such papers, however, the questions which arise are: Is the publication of the collection, as a whole, worth while, and does it fulfil the objects which the editorial committee set itself? According to the preface, the volume is intended as a work of reference for those engaged in control equipment design, and also as a book which might valuably assist those possessing a general background knowledge to branch out into more specialist fields. It must suffer, as a work of reference, by its very structure, which makes it impossible to use as a normal referenced text-book; nor can it be particularly comprehensive, as much of the basis of design technique has to be taken for granted. To offset this, one has the advantage of the direct research experience of specialists, much of the material being a model of presentation, logical in sequence, lucid and well illustrated. Although a point has been made of covering specially the mathematical techniques employed in the theory, and though wide in its applied interests, the work must prove a difficult one for students. This does not detract from its inherent value, and in the class of published symposia it must certainly take a very high place. A. J. Kennedy

### King Solomon's Ring

New Light on Animal Ways. By Konrad Z. Lorenz. Translated from the German by Marjorie Kerr Wilson. Pp. xxi+202. (London: Methuen and Co., Ltd., 1952.) 15*s*. net.

WELL known in scientific circles for his elaboration of the 'releaser' and 'imprinting' mechanisms in animals, Dr. Konrad Lorenz is now seeking to interest a bigger audience in his life's work. In "King Solomon's Ring" he tells of insects, fishes, ravens, geese, jackdaws and dogs with rare insight arising out of great creative powers allied to direct observations often carried out in most painful and trying circumstances the like of which few naturalists have experienced. As a result, Lorenz has stories to tell which, because of their very truth, grip the reader in wonder and admiration. The accounts themselves are embellished by a style of writing which, while never less than scientific, is at once lucid and simple, as well as amusing thumb-nail sketches which have been contributed by the author himself. If the book has any blemish, it is that the remarkably fine chapter on jackdaws deserves a volume to itself. In the meantime, one gratefully welcomes this book which, of its kind, has known no peer for many a year. T. H. H.

# STOCK-TAKING ON AFRICAN EDUCATION

DURING the ten years of its existence, the Nuffield Foundation has made a signal contribution to the welfare of the British Commonwealth and Empire. Through its fellowship and scholarship schemes many promising young men and women have been assisted to travel abroad from their own countries, to improve their knowledge and enrich their experience, so that they may return home more capable of serving their peoples. During the Foundation's first five-year period, its main Colonial policy was to provide material and social aids to ensure that selected scholars obtained the qualifications which the Colonial Office deemed necessary for the specific posts in government service to which the scholars aspired. On their side, the Colonial administrations undertook to absorb all successful scholars. They did not always honour this pledge. So, it is particularly gratifying to note the successful co-operation between the Nuffield Foundation and the Colonial Office which has resulted in the document under review*.

The report on African education is in three parts, each representing a milestone in an endeavour which lasted two years. The first section is a record of the discussions and recommendations of the West Africa Study Group which spent the last six months of the year 1951 visiting the territories of Gambia, Sierra Leone, Gold Coast and Nigeria. The second part of the book deals with the deliberations of the team of educational experts which visited East and Central Africa at the same time. The work of these two study-groups culminated in a conference which was held in King's College, Cambridge, last September. The proceedings of that conference are chronicled in the third part.

Not since the Phelps-Stokes Commissions of the early twenties has so much thought been given to the vital matters of Colonial education, or so many illustrious educationists been involved in the process. The East and Central African group consisted of Mr. A. L. Binns (chairman), chief educational officer for the Lancashire County Council; Prof. B. A. Fletcher, director of the University of Bristol Institute of Education; and Miss F. H. Gwilliam, assistant educational adviser to the Secretary of State. The West African group consisted of Dr. G. B. Jeffery (chairman), director of the London University Institute of Education; Mr. F. T. Arnold, H.M. staff inspector for secondary schools; Dr. Josephine Macalister Brew, educational adviser to the National Association of Girls' Clubs and Mixed Clubs; and Mr. E. W. Woodhead, county education officer for the Kent County Council. The meetings at Cambridge were held under the chairmanship of Sir Philip Morris, vice-chancellor of the University of Bristol, who, as Mr. Oliver Lyttelton states in his foreword to this report, must be credited with a large share of the success achieved and the goodwill shared. A large delegation from the Colonial Office attended the Cambridge conference as visitors, and each of the Colonies and Protectorates affected sent official representatives and unofficial observers. Those from West Africa falling in the latter category were mainly politicians holding the newly created portfolios in education, and the value of their contribution must have lain in their immense goodwill and large-hearted co-operation.

An interesting feature of the conference at King's College was the small number of formal lectures delivered; and those that were given came from a strange combination of authoritative sources: Prof. Margaret Read, professor of education and head of the Department of Education in Tropical Areas, University of London, referred to world-wide implications of the African education movement; Prof. B. W. Bigelow, Columbia University, New York, stressed the need for co-operative action in solving the educational problems of Africa; and Sir John Maud, permanent secretary to the Ministry of Education, outlined the value of the British system of separating questions of party politics from those which are purely educational.

The terms of reference of the two teams of educationists which visited Africa in 1951 precluded them from considering in detail not only the political influences at work in the territories under study, but also university work and development. Higher technical education was also not to be emphasized. The points covered included teacher training, elementary and secondary education, the relationship between government and voluntary agencies, financing educational projects, and the curriculum. These aspects were emphasized in the 'working paper' which was drawn up by the Advisory Committee on Education in the Colonies, and dispatched to East, West and Central Africa, prior to the visits of the experts.

The Jeffery and the Binns reports are different in a number of fundamental ways; in one the emphasis is on broad principles, with occasional references to relevant details. The other consists of innumerable tiny dots placed together as in a half-tone reproduction of a photograph. Of course, the issues were not the same and could not possibly have been placed in the same perspective.

The East Africa group was faced with all the complexities of life in a British territory where Anglo-Saxons have made their permanent homes, side by side with Asiatics and Africans. Their hands were further manacled by being told to avoid educational matters appertaining to Europeans and Asiatics. Since Kenya, Uganda, Northern Rhodesia, Tanganyika and Nyasaland are no longer African lands, as such, but have been declared to be places where a life of partnership must be sought, as between members of the different races, any broad study of educational policy must take into consideration the different practices in vogue, and place them in a composite setting which alone can truly reflect the *status quo*. It is the absence of such an approach that makes the Binns report so frustrating to read.

The main thesis of the East Africa Study Group would appear to be that Africa is an agricultural country, and we must do our best to make it remain so. We must educate the Africans for life 'on the land'. So far as possible, the African must be made to pay directly for this education, in fees as well as in taxes. It does not matter if the central government spends several times as much money on European education than on his. It does not matter if European agriculture depends for its productivity on African labour.

If this is accepted as the line of argument, then the recommendations of the Binns report begin to make sense—the first phase of primary education should be curtailed from six years, as it is now, to four years; and the aim should be to give 50 per cent of all children of school-age four years schooling in the local vernacular. Swahili, which is the only indigenous lingua franca, should be discontinued in schools, and its place taken by relatively unknown local tribal languages. It should be the aim of the educational authorities to provide a further four-year course for 10 per cent of the school-age population, and four years secondary schooling for 2 per cent of all the children who should be at school. It is preferable to site African schools not too near the towns. European supervisors should be placed over trained African teachers, for the time being. The prerequisite of a university degree for highly paid European teachers should sometimes be waived to make it easier to recruit men with an agricultural bent, who, by their presence in African schools, would inspire the 'natives' to become good farming folk.

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* African Education: a Study of Educational Policy and Practice in British Tropical Africa. (Produced on behalf of the Nuffield Foundation and the Colonial Office.) Pp. xii+187. (London: Crown Agents for the Colonies, 1953.) 8s. 6d.

However, the report of Mr. Binns and his colleagues is valuable on account of the stress it lays on (*a*) the importance of research into those aspects, for example, wastage, of African education which now appear baffling; (*b*) founding teacher colleges of 100–200 students, with practising schools attached; (*c*) the encouragement of female education by relieving transport difficulties; (*d*) providing bedsheets, spoons, lavatories, and similar elements of prime necessity in boarding schools; (*e*) making teachers competent to teach Africans English in the intermediate and secondary schools; (*f*) erecting a suitable moral and religious basis to all education. Perhaps the most important—certainly the most wise—utterance in the entire report is the following: "The ideal school, if it were acceptable to parents, would be an interracial school. There are no insurmountable practical difficulties in the way of interracial education at any stage, but there are many difficulties in men's minds. Initiatives in this direction must therefore be the pioneer efforts of individuals who feel a call to experiment in this field . . . and because the task of government is eased as racial tensions are eased, such initiatives should receive moral and financial aid from the Government". One cannot help wondering why this does not appear in the official recommendations of the group.

Dr. Jeffery and his co-workers, who are convinced that "the potentialities of the West African have been demonstrated by actual achievement", had an easier task. The Phelps-Stokes Commission of 1920 had a Gold Coast member, Dr. Aggrey, on it; and the implementation of its recommendations have probably been pursued much farther in West Africa than elsewhere.

But there are still many problems awaiting solution. For example, the group expressed its anxiety over the possibility of the local governments taking over responsibility of recurrent expenditure for education when the Colonial Development and Welfare Funds come to an end. The question of raising capital for the great educational expansion that is called for is another cause of worry for those responsible for educational development in West Africa. About a third of the probable annual expenditure of £3 million by the Nigerian Government will be absorbed by higher education. Is this proportion too high, in view of the great need for extending the frontiers of elementary education in the rural areas? Is it wise, at this critical stage, to build up an extravagant medical school to train only a handful of clinicians annually?

On the perennial question of the relationship between voluntary and governmental agencies, the commission agrees that a functional amicable relationship is gradually being built up in West Africa. The system whereby government grants voluntary bodies financial aid in the running of their schools is commended here, as in East Africa. The group records a consensus of informed African opinion that an entirely secular education is undesirable; but does not insist that the religious basis should be Christian. West Africa has a considerable Moslem population, and there are other religious groups.

Although the Jeffery committee commends the "Accelerated Development Plan for Education in the Gold Coast" on both educational and administrative grounds, the bottleneck may prove to be the recruitment of staff. It is the same problem all over again. African graduates do not take up the teaching profession because the prospects of promotion are not great. Besides, expatriate staff receive much better emoluments, even under the African Governments which are emerging on the West Coast.

The Cambridge conference reconsidered all these questions under the following heads: *A*, Responsibility and Control; *B*, Expansion of the Educational System; *C*, Teaching Profession; *D*, Organization and the Curriculum; *E*, Education and the Adult. The reports of the five study-groups of the conference and the plenary discussions on them are printed in this volume in an edited form. Mr. W. E. Ward, editor of the Colonial Office journal *Overseas Education*, in his private capacity put the material together. On the whole, the conference appears to have favoured the Jeffery approach rather than the Binns; but many a reader will feel regret that the names of the speakers have been omitted from the dialogues.

As Sir Philip Morris states in his epilogue to the conference, its chief purpose was, obviously, in human relations. The whole purpose of education is in human relations; for, in the language of the West African study-group, "education is the complex of actions and reactions between persons by which a nation prepares itself for its future by the dissemination of knowledge and skills and valid ideas of human dignity and fellowship". OLUMBE BASSIR

# NUCLEAR PARTICLE LABORATORY AT QUEEN MARY COLLEGE, LONDON

THE inauguration on June 23 of the Nuclear Particle Laboratory at Queen Mary College, University of London, marks what is probably the first occasion on which applied nuclear physics has been officially instituted in Great Britain as part of the undergraduate engineer's education. The laboratory has, however, a dual function to fulfil. In addition to the provision of practical work for undergraduates in the field best described as nucleonics, it also makes available facilities for research work relating to accelerating machines and gas discharges, where high-voltage electrical engineering, electronics, and nucleonics have a common frontier.

Taking the undergraduate work first, the subject designated 'nuclear energy' is offered to third-year mechanical and electrical engineers as one of a number of options from which part of the final year's work is selected. (This is now usual in schools of engineering in North America.) The course is therefore somewhat superficial compared to the other aspects of engineering, which receive three years study. However, it would be wrong to allow greater specialization at this stage in the new subject, even though it may be expected to develop extensively during the active life of the present undergraduate population. The lectures are based mainly on the recently declassified information on nuclear reactor design, but also on general aspects of nuclear physics related to engineering. To obtain a suitable laboratory course to support such lectures, use is made of artificial radioactive sources, and particularly, antimony–beryllium neutron sources. These enable measuring techniques to be studied, which relate directly to engineering uses of radioisotopes as well as providing substance to some aspects of reactor theory, such as neutron distribution theory and calculations relating to cross-sections. It is hoped that it will eventually be possible to extend these experiments by the use of material enriched in fissile components. The whole subject is of general interest to engineers, as quite apart from the practical uses for which nuclear energy will become available, its development is an outstanding example of the logical and scientific processes by which the formulæ of theoretical physics can eventually be translated into engineering reality.

The research facilities offered by the Nuclear Particle Laboratory centre around the high-voltage equipment, which is not yet complete. A 1-MV. electrostatic generator has been in use, however, for examination of discharges in continuously evacuated systems, and similar work has been carried out at 100–200 kV. using rectifier sets. An impulse generator for 1 MV. shortly to be finished will at first be used on the same programme, though it is planned to develop, from this, a high-intensity electron accelerator. Interest has so far tended to be concentrated on the discharge phenomena at residual gas pressures, because this is often a practical engineering limitation in the design of accelerators, particularly D.C. accelerators of the electrostatic type. It has been found that preliminary discharges are obtained in such systems with characteristics which have not previously been investigated in any detail. Further apparatus in use includes a 5-MV. single impulse air-cored betatron which can be employed to give short X-ray impulses at higher voltages; but the intensity is, of course, much lower. An electron microscope is also in operation, providing both a further weapon for investigation of discharges (in so far as these originate in electrode surfaces) and an example of high-voltage equipment of interest to the biological faculties. Either a further D.C. generator or a radio-frequency accelerator will be installed next year, depending upon development of the present research groups.

The range of engineering activity has now extended over so wide a field that many feel that the undergraduate courses at universities may be in need of quite drastic modification. There is a wide divergence of opinion as to what form such modification should take; but perhaps a majority of critics believe that more emphasis on fundamental principles is needed, with less time spent on design study. The Nuclear Particle Laboratory at Queen Mary College, with an over-riding emphasis on the fundamental theory of matter, is a step in this direction.

# MECHANISM OF PROTOPLASMIC MOVEMENT

By Prof. WILLIAM SEIFRIZ
University of Pennsylvania

THE streaming of protoplasm and the apparently autonomous movement of particles within it have long been problems in biology, and many have been the theories to explain them. Protoplasmic flow has been attributed to every imaginable force, from surface tension to electro-osmosis, without much evidence to support any of the hypotheses.

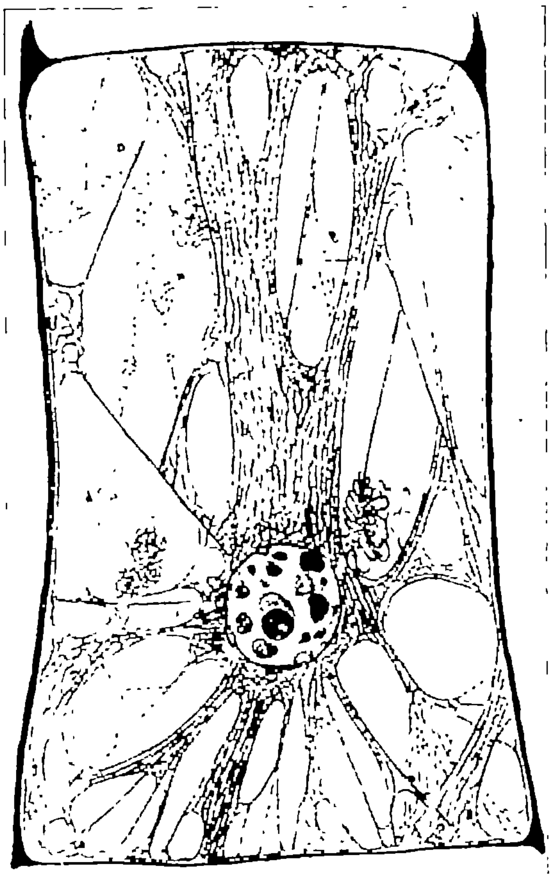
Early in college training, Prof. E. A. Andrews directed my attention to the movement of protoplasmic particles. He referred particularly to a form of activity which was neither cyclosis nor the "vulgar pedesis dance discovered by Brown in dead regions of plants. *These* particles", said Prof. Andrews, "are travelers, going places". In ciliated Protozoa of the closely related families Vorticellidæ and Stentoridæ there are particles less than 1 mμ in diameter which move ten to one hundred times their own length in a second or two. They may pass close to one another, proceeding in opposite directions[1].

In subsequent years my attention was centred on the flow of protoplasm. Recently, I again turned to the particles, hoping to find in their motion a clue to the mechanism of protoplasmic streaming. Isolated cells from cultures of plant 'cancers' served as material—kindly supplied by Dr. R. J. Gautheret.

Some years ago I[2] advanced a theory of protoplasmic flow based on the rhythmic pulsations of a slime mould. The peristaltic waves, when accelerated by time-lapse photography, are readily seen. They much resemble the trains of waves in a stimulated muscle fibre. There is no question of the presence of rhythmic pulsations; but, though synchronized with the fifty-second period in reversal of flow, they are not the cause of cyclosis. One of the weaknesses of the theory was its failure to explain the simultaneous flow of protoplasm in opposite directions in parallel currents. One occasionally sees in Protozoa, but better still in a sheet of protoplasm in some species of slime moulds, as many as nine channels of flow in which adjoining currents flow in opposite directions, 'rubbing shoulders' as it were, without mixing, and without an evident wall between the two (top centre in the accompanying figure).

All the foregoing difficulties were apparently solved by a 'new' theory of cyclosis which appeared several years ago in four articles from the pens of six authors[3-6]. Frey-Wyssling[3] deserves credit for the theory, though Meyer and Mark[6,7] claimed a twenty-year priority, in so far as the theory applies to muscular contraction. The suggestion made by all six authors is that within the protoplasmic stream polypeptide chains fold and unfold, the protein molecules moving forward like an army of caterpillars, carrying the surrounding medium with them.

The curling and uncurling of molecular fibres is an attractive mechanism by which to account for the flow of protoplasm. It is, however, a pure assumption, permissible only if certain conditions are met. Curling may be accounted for; thermic agitation will do it. Stretching, however, is another matter. At every point where folding occurs sufficient energy must be transmitted to stretch, or untwist, the folded chain in opposition to thermic agitation. The



A typical plant cell (after Heidenhain)

proponents of the theory present no evidence to show that this energy is available, and that there is also present the complex mechanism necessary to use the energy and accomplish the untwisting. In addition to this negative evidence, I offer the following observations on the movement of protoplasmic particles in disproof of the caterpillar hypothesis.

The first hint which ultimately led to a clarification of the problem came early in my work when I observed three independent rhythmic pulsations in a plasmodium. Kamiya[9] later increased this number, and referred to the plasmodium as a polyrhythmic system. This means that there are many excitation foci within one protoplast.

Plant cells often form delicate protoplasmic threads along which move particles of numerous kinds. The particles are frequently of greater size than the diameter of the thread which carries them. It is not possible, therefore, that the particles are moved by the feeble stream of endoplasm in the lumen of the protoplasmic thread, for they are embedded in the outer cortical layer. The situation is comparable to a 5-mm. sphere moving within a 5-mm. tube which has a 1-mm. bore and a 2-mm. wall.

Final proof that a synchronized migration of curling and uncurling protein chains within the stream is not the mechanism of protoplasmic flow is to be had in the occasional erratic activity of the particles. The movement of the particles, when they are of fat, cannot possibly be autonomous, and this holds for mitochondria as well. The Belgian school of cytologists is convinced that mitochondria are capable of self-repulsion. The French school, on the contrary, is opposed to such an assumption.

Protoplasmic granules along a strand usually move smoothly and continuously as if carried by the stream, each particle maintaining its position in line. Frequently, however, striking disturbances occur. Several particles will suddenly increase their speed and hurry away from the others. Sometimes one or two particles will reverse their course and proceed in the opposite direction; a collision more than likely resulting. Two or more momentarily quiet particles may suddenly assume activity and move rapidly away from each other. Occasionally, two particles will approach each other, collide, and then proceed in the opposite directions. None of these erratic movements can be accounted for by a protoplasmic stream, and, as I have said, it is quite impossible that fat droplets should have autonomous motility.

Certain of the behaviourisms described above are duplicated by the waves which traverse muscle fibres. Particularly striking is the approach and collision of two waves, precisely as in a protoplasmic thread, except that particle is substituted for wave. One is forced to the conclusion that the mechanisms are identical.

That the foregoing phenomena are not restricted to protoplasmic threads and muscle fibres becomes increasingly evident as one surveys the whole field of cellular activities. I shall refer only to those shown me by my colleagues at the Sorbonne and the Pasteur Institute. Dr. J. Comandon and Dr. P. de Fonbrune[10] demonstrated, in hyphæ of fungi, the three types of motion which I have described, namely, the passive transport of particles by the protoplasmic stream, Brownian movement, and an erratic activity here brought on by artificial irritation. The last of these is the type of motion which I believe to be due to nerve-like impulses emanating from excitation foci in the living cell.

A similar situation exists during mitosis of the *Triton* red blood cell[10]. Here, just prior to cell division, the nucleus commences to rotate, and continues doing so for some minutes. There is no cyclosis to account for it. The nucleus is apparently responding to a stimulus originating in the cytoplasm, that is, it is moved by excitation forces.

Very striking was the sudden assumption of activity by the centrosome, or centrosome area *en masse*, in polymorphonuclear cells from mammalian blood. During mitosis the centrosome oscillates half the length of the cell, with a rhythmic period of thirty seconds. Because of the motion, the surrounding cytoplasm is stretched, indicating high elasticity. There is no cyclosis. I had the pleasure of observing this behaviour of the centrosome in blood cells in the laboratory of Dr. A. Policard and Dr. M. Bessis[11].

With the exception of the passive movement of particles when carried by flowing protoplasm, all the foregoing activities in living cells are the result of stimuli arising at excitation foci.

Somewhat similar is the activity of chondriosomes described by Buvat[12].

Before attempting an analysis of the force responsible for protoplasmic movement, I should like to emphasize its universality by directing attention to the resemblance of the rhythmic phenomena which occur in nerve, muscle and the relatively undifferentiated protoplasm of the slime mould. The Myxomycetes, or Mycetozoa, are a very lowly form of life, yet they pulsate rhythmically and show peristaltic waves just as does the musculature of man. The pulsations in both cases are accompanied by a rhythmic rise and fall in electric potential. Kamiya[14] has measured this potential in the Myxomycete *Physarum*. Any statement on the nature of the force involved in protoplasmic movement must include the similar activities in muscle and nerve.

In explanation of protoplasmic movement one cannot turn to electrical currents such as are conducted along metal wires. Adrian[13] swept away all such analogies in reference to the nervous impulse as long ago as 1912. We must, therefore, seek a force which meets, so far as possible, all biological conditions and has the full recognition of the physical chemist. There are a number of attractive possibilities. Phase phenomena and the forces responsible for the stability of coacervates are active in living systems. In these fields Joly and Dervichian[15] have done much which has a direct and significant biological bearing. Dobry[16] directs attention to some extraordinary analogies between the behaviour of coacervates and protoplasm. Weissenberg[17] has described the flow of coacervates against gravity, which is a protoplasmic quality.

But it is to 'fields' that I wish to turn for an interpretation of the impulses which activate protoplasmic movements. Let me first say that, in rejecting the part which fibres are said to play in the streaming of protoplasm, I do not thereby ignore the obvious part which fibres play in living material where they are needed and can be used. In the cellulose framework of plants, in muscle, tendon and in nerves where the linear form serves well, Nature uses fibres. But a fibre is of no use for doing mechanical work if there is no place to attach it. Our present problem is not one of tensile strength but of propulsion.

Debye[18] has well interpreted fields such as surround polar molecules and colloidal particles. Molecules similar to $H_2O$, $NH_3$ and HCl are surrounded by static electric fields which convert them into dynamic systems, into electrically charged elementary particles. A second molecule coming within close range of such a dipole will acquire a field, or electric moment. Being thus polarized, it will interact with the first molecule. The work of Debye and others, notably London, has led to the now widely accepted fact that polar molecules are enveloped by electric forces which may be derived from pure coulombic interactions between charges. These are essentially short-range forces which do not extend beyond three or four molecular diameters. Long-range forces will accomplish more.

The total force with which a particle, consisting of many molecules, will act on a second particle may be ascertained by integrating over the first sphere and arriving at the reaction between this sphere and a molecule in the second sphere. In a similar manner may one integrate the molecules in the second sphere and thus arrive at the final total reaction. Such a procedure leads to the prediction that in appropriate circumstances short-range molecular forces may build up to appreciably strong long-range forces. Overbeek[19] has recently made direct measurements of the molecular attraction between parallel glass plates at distances of the order of the wave-length of visible light (5000 A.).

If we turn to the still larger particles of lyophobic colloidal suspensions, then we have additional forces, namely, the familiar electric charge on the surface, due to preferential adsorption or to dissociation at the surface of the particle. The range of the coulombic interaction of these colloidal charges is determined by the depth of the ionic cloud surrounding the particle.

If, now, we determine the total interaction energy between two colloidal particles, we find that under suitable conditions it shows a pronounced maximum at an appreciable distance. It is for this reason that some colloidal suspensions are so stable and their coagulation time so great.

With the foregoing background we can apply Szent-Györgyi's[20,21] hypothesis of muscular contraction. The double layer of ions which surrounds a muscle fibre will set up an electric field. If a wave of depolarization travels along the surface, this will have the same effect as if we had pulled electrodes along the axis. The precise mechanism is not known; but it is only necessary to assume that a local depolarization is generated which runs parallel to the fibre axis. If, instead of a muscle fibre, we have a thread of protoplasm within a cell, then a wave of depolarization giving rise to a field parallel to the axis would carry particles and fluids with it.

Whether we are dealing with a single isolated fibre (lower left in figure), or with 'fibres' separated by cortical layers of oriented molecules lying parallel to each other so as to form a sheet of protoplasm (upper centre in figure), is the same in the end. Impulses travel back and forth, rhythmically or spasmodically, moving the cytoplasmic fluid and the particles in it.

Whatever our assumptions and hypotheses may be, a few facts remain clear: that the folding and unfolding of protein fibres is an assumption without the support of an adequate energy; that there is no evidence that fibres can function mechanically in a free droplet of protoplasm; that the mechanism of protoplasmic streaming is situated in the cortical layer, not in the endoplasm; and that rhythmic impulses traverse fibres of muscle, nerve and elementary protoplasm alike, measurable as differences in potential and visible in muscle and protoplasmic threads as trains of waves; and that it is these impulses which carry nerve transmissions and move protoplasm.

I wish to express my thanks to Dr. R. J. Gautheret and Dean Albert Chatelet, of the Sorbonne, for the hospitality which made this research possible.

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# OBITUARIES

## H. A. P. Jensen

I FIRST met Hereward Jensen at the British Association meeting in Newcastle in 1949. We fell into conversation, and among other subjects we discussed the Nature Conservancy. Since he was clearly so interested in its work, I suggested to him that he might offer his services to the Conservancy as physiographer and naturalist. It was not for some considerable time after this talk that I realized that the then director-general of the Conservancy, Captain Diver, had a few weeks before asked me if I knew Jensen. Although he was only on the Conservancy staff for three years, he had made a name in that time and set a high standard of research and administration which will not easily be forgotten. His death at the age of thirty-two, the result of an accident in the train on his way home from a meeting of the Royal Geographical Society on May 11, was a tragedy. He leaves a widow and two small children.

Jensen was at school at Oldershaw (Wallasey), and took a degree under Prof. P. M. Roxby in the Department of Geography at Liverpool. On account of disability, he was not called up for active service in the War, but for nearly three years was a (temporary) civilian officer with the Intelligence Division of the Naval Staff at the Polar Research Institute, Cambridge, where he contributed to a number of the Admiralty geographical handbooks. In 1944 he was appointed to an assistant lectureship in geography at Manchester, and for the four years previous to his joining the Nature Conservancy he was a research officer at the Joint Intelligence Bureau, Ministry of Defence.

He was particularly interested in coastal studies, and had made intensive investigations in the Dee estuary. As a member of the Conservancy he extended his view, and had a remarkably good knowledge of much of the coast of Great Britain. Because of our common interest in the coast and our connexion with the Conservancy, we visited many parts of the coast together, and I soon realized how sound was his judgment and how reliable his mapping and investigations. Last year we worked together on Winterton Ness, and this year we visited part of the flooded areas together, and had made plans for a full investigation of the effects of the floods on the north Norfolk coast. He had also travelled in the Netherlands and Sweden, and had prepared the manuscript of a book on Sweden. Last year he was one of the delegates from the Nature Conservancy at the International Geographical Congress at Washington, and in America he was able to visit the south-eastern States and also make a tour of the eastern Nature reserves.

Hereward Jensen's death has been a grievous shock to his many friends, who will miss his cheerfulness and kindness of heart. Geographers and naturalists, whether they knew him personally or by reputation, will know that Nature conservation in its widest and best sense has lost a most able exponent. The members and staff of the Nature Conservancy mourn the loss of a valued friend and colleague.

J. A. STEERS

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WE regret to announce the following deaths:

Prof. Alexandre Bigot, formerly professor of geology in the University of Caen and *correspondant* for the Mineralogical Section of the Paris Academy of Sciences, on April 20, aged eighty-nine.

Prof. D. Hanson, professor of metallurgy and director of the Department of Metallurgy, University of Birmingham, on June 12.

Mrs. Cora Brooking Hodson, formerly secretary of the Eugenics Society, and later honorary secretary of the International Federation of Eugenics Organizations, on May 21.

Prof. H. Rein, a director of the Max-Planck Institute for Medical Research, Heidelberg, aged fifty-five.

Dr. C. E. Walker, formerly lecturer in histology in the University of Liverpool, on June 6, aged eighty-two.

# NEWS and VIEWS

### Physics in the University of the Witwatersrand : Prof. F. R. N. Nabarro, M.B.E.

DR. F. R. N. NABARRO, who has been appointed to the chair of physics in the University of the Witwatersrand, was educated at Nottingham High School and New College, Oxford. He took a first-class honours degree in physics in 1937, and a year later obtained the same degree with first-class honours in mathematics, with distinction. During 1938–39 he was senior scholar of New College. In 1939 he became research assistant to Prof. N. F. Mott at the University of Bristol, and later joined the Army Operational Research Group of the Ministry of Supply. During 1945–49 he was Royal Society Warren Research Fellow, working in the University of Bristol, and in 1949 he was appointed lecturer in metallurgy in the University of Birmingham, which post he now holds. He was awarded the M.B.E. in 1946, a Beilby Memorial Award in 1950, and the D.Sc. degree of the University of Birmingham in 1952. During the War, Dr. Nabarro worked first on the theory of radar aerials and then on the accuracy of radar and the effectiveness of anti-aircraft fire and searchlights. His studies of anti-aircraft shell fragmentation led to similar work on ground targets, and he organized the calculation of the theoretical effectiveness of shell-fire and bombing, and compared this with the observed correlations between fire support and British casualties in Army operations. Apart from his work during the War, he has concerned himself largely with problems in the physics of metals. He has been particularly interested in the dislocation theory of slip in metals, and has contributed a number of important papers to this subject in recent years. He is now engaged on a book summarizing the mathematical problems arising in this theory. He is the author of some twenty-five papers of high scientific quality, and he has made notable contributions to the modern theory of metals.

### American Geophysical Union : Award of the William Bowie Medal

DR. BENO GUTENBERG, director of the Seismological Laboratory, California Institute of Technology, Pasadena, California, has been awarded the William Bowie Medal by the American Geophysical Union (Committee on Geophysics of the National Research Council). Dr. Gutenberg, who was born in Darmstadt, Germany, is known for his many contributions in the broad field of geophysics and related fields. He studied at the Technische Hochschule of Darmstadt and the University of Göttingen, where he obtained the degree of doctor of philosophy in 1911. He went to the United States in 1930, and became an American citizen in 1936. He has been professor of geophysics at the California Institute of Technology since 1930, and director of the Seismological Laboratory since 1947. He is author or co-author of many outstanding work in geophysics, including "Grundlagen der Erdbebenkunde", "Seismicity of the Earth", and extensive contributions in "Internal Constitution of the Earth", of which he was also the editor. He is president of the International Association of Seismology and the Physics of the Earth's Interior, of the International Union of Geodesy and Geophysics.

## The Greenwich Meridian

WHEN the Octagon Room of the Royal Greenwich Observatory was taken over by the National Maritime Museum, it was felt that the old meridian marked on the pavement was too inconspicuous; the Ministry of Works has accordingly installed a new line consisting of a brass strip let into a band of white stonework laid across the pathway outside the Observatory. The Greenwich Meridian was adopted as the Prime Meridian by the world in 1884 at the suggestion of the United States Government, which had called an international conference to consider the matter. It was defined as the north–south line running through the Airy transit circle in the Observatory. In the past, many prime meridians have been used. Eratosthenes naturally used the meridian of Alexandria, of whose great library he had been appointed librarian in 240 B.C.; Ptolemy, to avoid the difficulty of having both east and west longitude, used that of the Fortunate (Canary) Islands, the most westerly land known, so that all longitude should be measured eastwards. At one time there was an attempt to mate the prime meridian with the line of no magnetic variation; but the impossibility of unifying two lines which were inclined to each other at an angle and the impracticability of tying down hypothetical meridians running through the Canary Islands or the Azores had by the nineteenth century led many countries to adopt the meridians of their principal observatories. At one time England commonly used the meridian of St. Paul's.

## Expedition to Mt. Wrangell, Alaska

A JOINT expedition is being made this summer by members of New York University and the University of Alaska with the purpose of establishing a scientific observing station, principally for cosmic rays, on Mt. Wrangell in Alaska. The expedition will be led by Prof. Serge A. Korff, professor of physics in the College of Engineering, New York University, who will be the scientific director and principal scientist, and by Dr. Terris Moore, president of the University of Alaska, who will act as administrative director and be responsible for establishing the station. Although Mt. Wrangell (14,006 ft.) is not the highest mountain in Alaska, being topped by a number of peaks, of which the highest is Mt. McKinley (20,269 ft.), it has been chosen because its unusually flat top makes it an excellent landing-place for aeroplanes fitted with skis. Incidentally, it is the only 'live' volcano in Alaska, and it may be possible to utilize the steam that issues at the north-west end of its summit. A preliminary party is at present climbing the mountain, and experimental landings will be made by Dr. Moore in his special Piper Super-Cub aeroplane at convenient spots as they are discovered by the climbing party. By this means it is hoped to build up a series of landing places at various heights, and eventually to establish a safe landing field on the summit by which the station can be supplied with huts and other stores and permanent equipment. The proposed station, which will be the most northernmost cosmic-ray station in the world, will be operated on an inter-university basis, whereby interested organizations, by contributing *pro rata* to its maintenance, may send observing personnel and equipment there.

## Royal Society's Depository of Unpublished Mathematical Tables

SINCE the publication of the first list (see *Nature*, 169, 526; 1952) the following tables have been accepted into the Royal Society's depository of unpublished mathematical tables: Table de factorisation des nombres $N^4 + 1$ dans l'intervalle $3000 < N < 6000$ (A. Gloden); solution of the equation $(y'')^2 = yy'$ and two other equations (Admiralty Research Laboratory); dictionary of Laplace transforms (J. Cossar and A. Erdélyi); tables of Fresnel's integrals (D. H. Shinn); tables of the error integral of a complex variable (J. K. Skwirzynski); table des solutions de la congruence $x^4 + 1 \equiv 0 \pmod{p}$, $600000 < p < 800000$ (A. Gloden); tables of the complex Jacobian zeta function (National Physical Laboratory); tables of binomial coefficients (National Physical Laboratory); tables of Multhopp's influence functions (National Physical Laboratory); integrals of Bessel functions ($J_0$ and $Y_0$) (National Physical Laboratory); table of $\int_0^{2\pi} J_1^2\left(2k\sin\frac{\theta}{2}\right)\cos^2\frac{\theta}{2}\,d\theta$ (National Physical Laboratory); tables of two functions occurring in the theory of the reflexion of electromagnetic waves from infinite cylinders (National Physical Laboratory); table of an integral used in calculating profiles of water waves (National Physical Laboratory); tables of the Langevin function and its inverse (A. Young and T. Murphy). Further information about these tables can be obtained on application to the Assistant Secretary, Royal Society, Burlington House, London, W.1.

## Political Activities of Civil Servants

FOLLOWING the announcement on November 1, 1949, that the Government would give immediate effect to those recommendations of the Masterman Committee in its report on the political activities of Civil servants which would free some 450,000 Civil servants from existing regulations, the Government indicated that, before taking final decisions on the general principles of the report, joint discussions through the machinery of the National Whitley Council were desirable. The report of the joint committee afterwards appointed has now been published as an appendix to a White Paper in which the Government's proposals are detailed ("Political Activities of Civil Servants" (Cmd. 8783). Pp. 16; London: H.M.S.O., 1953; 6*d*. net). The statement points out that the extent to which Civil servants should be free to take part in political activities must be considered in the light of two conflicting principles. The desirability, in a democratic society, of all citizens having a voice in the affairs of the State and of as many as possible of them playing an active part in public life has to be set against the imperative demand of the public interest for the maintenance of political impartiality in the Civil Service and for confidence in that impartiality. In other words, it is an essential part of the structure of government in Britain that the Civil Service should not only be impartial but also be seen to be impartial.

The Whitley Committee suggested that between the two classes proposed by the Masterman Committee an intermediate class should be created, and the Government has agreed that this could be done without detriment to the interests of the State or the reputation of the Civil Service for political impartiality. The problem is where to draw the line, and the members of the Whitley Committee are themselves unable to reach agreement. The Government proposes to draw the line so as to include the five groups which both sides of the Committee proposed to include, but excluding junior executive officers and analogous grades, and to bar canvassing to Civil servants restricted in their political activities while allowing it by permission only to those in the intermediate group. The decision, which will give substantial political freedom to a further two hundred thousand Civil servants, appears to be reasonably circumspect, while experience demonstrates that the increased freedom will be used with good sense and discretion. Some 62 per cent of the Civil Service is now completely free of restrictions, and only 16 per cent is barred from participation in national political activities; and to many of those who seek it, permission to participate in local government may be given.

## Standard Solutions of Phosphorus-32

It has been found by the Isotope Division, Atomic Energy Research Establishment, Harwell, that phosphorus-metabolizing moulds grow readily in solutions containing phosphorus-32 used as radioactive standards and may cause losses of specific activity in the solution of up to 50 per cent in one week. To inhibit their growth, an addition of 1 per cent formaldehyde is therefore made to such solutions before dispensing and measurement. All solutions thus treated are clearly marked and carry a poison label.

## Congress of the Universities of the British Commonwealth

The Seventh Quinquennial Congress of Universities of the Commonwealth will be held in Cambridge during July 13–17 under the presidency of Marshal of the Royal Air Force Lord Tedder, chancellor of the University of Cambridge. Practically every university and university college in the British Commonwealth will be represented by a delegation of teaching and executive officers led by its vice-chancellor or principal, making a total of more than four hundred persons, and in addition there will be observers from many learned bodies and a party of ten university presidents nominated by the Association of American Universities. The present Congress is the seventh of the series organized (except for interruptions caused by the two wars) at five-yearly intervals since 1912 by the Association of Universities of the British Commonwealth (formerly the Universities Bureau of the British Empire), the previous meeting having taken place at Oxford in 1948. The chairman of the organizing committee is Sir Philip Morris, vice-chancellor of the University of Bristol and chairman of the Association. The Congress provides an opportunity for the free exchange of views on matters of current importance to the universities of the British Commonwealth, and the following subjects will be discussed at the sessions: government and universities, administration and academic duties, academic mobility in the Commonwealth, higher-technological education, and admission and selection of students. A general symposium will also be held on the question: What subject or subjects to-day are best fitted to fulfil the role played previously in the university curriculum by the classics? By invitation of Sir James Duff, warden of the Durham Colleges in the University of Durham, there will be a meeting of vice-chancellors, presidents and principals of member universities of the Association of Universities of the British Commonwealth at St. Mary's College, Durham, during the week beginning July 6. This conference will be devoted to private discussion of inter-university relationships and problems of administrative and educational policy common to the various universities of the Commonwealth. Both the above meetings will be private; but further information can be obtained from the Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1.

## University of Birmingham

The following have been appointed lecturers in the University of Birmingham: Dr. G. W. Greenlees (physics), R. W. Murray (zoology), Dr. W. T. Pell-Walpole and S. G. Glover (metallurgy) and P. S. Gelling (ancient history and archæology). The title of reader in systematic bacteriology has been conferred on Dr. K. A. Bisset, lecturer in bacteriology in the University.

The University Department of Engineering Production has received a further gift of £57,400 (under seven-year covenant) from Joseph Lucas and Co., Ltd., the firm which originally endowed the Department, and it is intended that this sum be used for the establishment of a centre for continued studies in engineering production and management. The University has acquired a house at 16 Norfolk Road which is being altered and refurnished and which will shortly be opened as the University of Birmingham Institute for Engineering Production. The aim of the Institute, which will be directed by Prof. T. U. Matthew, Lucas professor of engineering production, is to develop a series of short residential courses in engineering production and management subjects for executives in responsible posts in manufacturing industries. The work of the Institute will be reviewed and liaison with industry maintained through an advisory board, on which a number of industrial leaders will sit with the vice-chancellor and members of the Faculty of Science. It is hoped that the Institute will be opened on July 16 with a fortnight's course on "The Application of Work Study".

## University of Leeds: Appointments

The following appointments have been made in the University of Leeds: Prof. T. L. Bywater, at present Strathcona Fordyce professor of agriculture in the University of Aberdeen, to be professor of agriculture and head of the Department of Agriculture; Prof. R. F. E. W. Peel, professor of geography in the University, to be head of the Department of Geography in succession to Prof. A. V. Williamson (see *Nature*, June 6, p. 1002). The title and status of reader have been conferred on the following members of the University: Dr. A. D.

Walsh (physical chemistry) and Dr. A. S. Leah (applied thermodynamics). E. W. F. Seymour has been appointed lecturer in the Department of Physics.

## Geological Society : Officers and Council

THE officers and council of the Geological Society have been elected for the ensuing year, as follows : *President*, Prof. W. B. R. King ; *Vice-Presidents*, Dr. O. M. B. Bulman, Dr. L. R. Cox, Prof. L. Hawkes and Dr. G. M. Lees ; *Secretaries*, Prof. S. E. Hollingworth and Mr. A. J. Butler ; *Foreign Secretary*, Prof. O. T. Jones ; *Treasurer*, Mr. P. Evans ; *Council*, Dr. S. Buchan, Dr. O. M. B. Bulman, Mr. A. J. Butler, Dr. G. F. Claringbull, Dr. L. R. Cox, Mr. H. G. Dines, Mr. P. Evans, Dr. W. F. Fleet, Prof. L. Hawkes, Prof. S. E. Hollingworth, Dr. R. G. S. Hudson, Prof. O. T. Jones, Prof. W. Q. Kennedy, Prof. W. B. R. King, Dr. J. F. Kirkaldy, Dr. G. M. Lees, Dr. W. A. Macfadyen, Prof. L. R. Moore, Miss H. M. Muir-Wood, Dr. J. S. Sandford, Prof. J. H. Taylor, Dr. H. D. Thomas and Dr. A. K. Wells.

## The Night Sky in July

NEW moon occurs on July 11d. 02h. 28m., U.T., and full moon on July 26d. 12h. 20m. The following conjunctions with the moon take place : July 7d. 13h., Venus 8° S. ; July 8d. 11h., Jupiter 5° S. ; July 12d. 15h., Mercury 3° S. ; July 19d. 01h., Saturn 8° N. At the beginning of the month Mercury sets at 21h. 30m. ; but it approaches the sun too closely to be seen for the greater part of the month and is in inferior conjunction on July 25. Venus is a morning star, rising at 1h. 30m. on July 1 and about 1h. 10m. at the middle and end of the month ; the visible portion of the illuminated disk varies from 0·54 to 0·67, and its stellar magnitude averages – 3·7 during the month. Mars is too close to the sun to be favourably observed. Jupiter is a morning star, rising at 2h. 05m., 1h. 20m. and 0h. 30m. on July 1, 15 and 31, respectively, and is moving eastward in the constellation Taurus. Saturn sets at 0h. 15m., 23h. 20m. and 22h. 20m. at the beginning, middle and end of the month, respectively, and is moving eastward in the constellation Virgo, stellar magnitude about 1. On July 11 there will be a partial eclipse of the sun, of greatest magnitude 0·201, but it is invisible at Greenwich. On July 26 there will be a total eclipse of the moon, also invisible at Greenwich ; the beginning will be visible generally in North America, South America, Antarctica, the Pacific Ocean, Australasia and the extreme north-eastern parts of Asia, and the end generally visible in the Pacific Ocean, the north-western tip of North America, Australia, Antarctica, the Indian Ocean, and eastern and central Asia. Occultations of stars brighter than magnitude 6 are as follows, observations being made at Greenwich : July 3d. 0h. 10·8m., 22 Pisc. (*R*), and July 30d. 3h. 12·1m., λ Pisc. (*R*) ; *R* refers to reappearance.

## Announcements

H.R.H. THE DUKE OF EDINBURGH has been pleased to accept honorary fellowship of the Institute of Welding.

THE Minister of Fuel and Power has appointed Sir George Thomson to be chairman of his Scientific Advisory Council in succession to Sir Alfred Egerton, who retires at the end of June when his term of office expires. He has also appointed Mr. Kenneth Gordon, director-general of ordnance factories, Ministry of Supply, to be a member of the Council.

DR. B. P. UVAROV, director of the Anti-Locust Research Centre, London, has been elected an honorary member of the Nederlandsche Entomologische Vereeniging, in recognition of his services to entomological science and for his contributions to the study of the Orthoptera in particular.

THE following have been appointed to lectureships in the University College of North Staffordshire : Dr. D. E. Davies (physics) and Dr. A. H. Wallace (mathematics).

THE annual Machinery and Implement Exhibition of the Sports Turf Research Institute (Bingley, Yorks) will be held on the sports grounds of Lever Bros., Port Sunlight, Wirrall, Cheshire, during July 1–2. A wide range of modern turf machinery, implements and ancillary equipment will be shown, as well as a display illustrating the scientific and educational work of the Institute. The Exhibition is only open to affiliated clubs and subscribers to the Institute.

THE thirtieth meeting of the Australian and New Zealand Association for the Advancement of Science is to be held in Canberra, during January 13–20, 1954. Further information can be obtained from the Association, Science House, 157 Gloucester Street, Sydney, New South Wales, or from Dr. C. Barnard, honorary local secretary of the Association, Box 109, City, Canberra, A.C.T., Australia.

THE Society for Experimental Biology is holding a symposium on "Active Transport" at Bangor, Caernarvonshire, during July 13–17. The speakers will include : Th. Rosenberg, H. Davson, J. A. Ramsay, J. R. Robinson, J. A. Kitching, D. C. Spanner, J. W. L. Beament, E. F. Gale, W. Wilbrandt, P. G. LeFevre, A. Rothstein, A. C. Frazer, F. W. R. Brambell, W. A. Hemmings, M. Maizels, E. J. Harris, J. F. Sutcliffe, H. Lundegårdh, R. Scott Russell, F. C. Steward, H. H. Ussing, R. D. Keynes, A. L. Hodgkin, E. J. Conway, R. E. Davies, H. B. Steinbach, J. F. Danielli. Those wishing to attend should write to Dr. D. J. Crisp, Marine Biological Station, University College of North Wales, Bangor, Caerns.

THE following conferences in physics have been arranged in England in the week following the meeting in London during July 8–9, 1954, of the General Assembly of the International Union of Physics : a conference on experimental and theoretical nuclear physics during July 13–17, 1954, in the University of Glasgow ; a conference on the physics of the solid state, with special reference to defects in solids, during July 13–17, 1954, in the University of Bristol. Both conferences are arranged in co-operation with the International Union of Physics. Further information will be published in due course.

THE Textile Institute is offering a bursary, of value £450, tenable at the Massachusetts Institute of Technology, for nine months from September next until May 1954. The bursary, offered under the terms of the Frank Wright Memorial Fund, is open to associates of the Institute of British nationality, and is intended to enable the successful candidate to undertake a broad programme of study and research into problems concerning cotton spinning, doubling and twisting. Particulars can be obtained from the General Secretary, Textile Institute, 10 Blackfriars Street, Manchester 3 ; completed applications must be received by July 9.

# PHOTOGRAPHIC SCIENCE AND TECHNIQUE

A CONFERENCE on photographic science and technique was held by the Scientific and Technical Group of the Royal Photographic Society on May 16 in the Arthur Worthington Hall of the University of Manchester. Dr. G. N. Burkhardt (Department of Chemistry, University of Manchester) opened the proceedings, and the chairmen of the morning and afternoon sessions were Mr. V. Gallafent (Scientific and Technical Group of the Royal Photographic Society) and Mr. C. W. Bradley (British Cotton Industry Research Association). The success of the conference was attributable in a large measure to the contributions from the Manchester area, and the self-restraint of speakers in keeping to their allotted times.

The first paper was not directly related to photography, but dealt with the legibility of print when projected from 3¼-in. square lantern slides. This clearly is a matter of importance to audiences, particularly at scientific meetings, for as Dr. R. Ollerenshaw (Manchester Royal Infirmary) pointed out there is evidence that the average eyesight of undergraduates is inferior to that of the eighteen-year-old National Service entrants and deteriorates during university residence. Whatever the form of the lettering, the illumination of the screen should be high, the contrast between the lettering and background strong, and preferably with the letters white on black. The greatest distance at which members of the audience should be seated should be six times the width of the screen (owing to the limited acuity of the eye) and the nearest distance twice the width of the screen (otherwise a tiresome rotation of the head itself must supplement the normal movement of the eyes). The seats should be grouped within a triangle of 60° angle with its apex at the centre of the screen.

A study of type faces shows that upper-case Gill Sans Bold is best for acuity, readability and speed of reading. The italic form is useful for ordinate legends to graphs. The individual characters should be not less than 2 mm. high on the slide, and lower-case type should be used only when this condition can be met. It has been found best to do all lettering with a small printing-press, a process which is at least as quick as good stencilling. The gap between lines of type should be equal to the body height of the type, and, as far as possible, each line should carry one item of the message. Diagrams and lettering in journals and books cannot well be used for lantern slides, or vice versa.

P. C. Smethurst (Smethurst High-Light, Ltd., Bolton) discussed the use of supplementary lenses with a telecentric stop. If a positive supplementary lens is arranged so that its rear principal focus is at the front nodal point of the camera lens, all the principal rays in the object space are parallel to the axis. The photograph then displays perspective such as would be obtained if the objects photographed were at infinity, and all measures of size on it are relatively correct, whatever the distances of the objects. The same device thus avoids the necessity for exact location of objects along the axis when it is important to measure sizes. Variations in perspective are obtained by placing the supplementary lens at other positions along the axis, so that the pencil of principal rays in the object space is divergent or convergent. A double system, sometimes useful, is obtained when a supplementary lens (a telescope objective) is used in the same way on each side of a camera objective.

The illumination of deep and narrow cavities by means of a concave mirror reflecting light from a lamp set to one side was then described by F. Wardlaw (Christie Hospital, Manchester). Photographs are taken through a central aperture in the mirror, the subject being observed by means of a two-mirror periscope of which the first mirror is a thin sheet of unsilvered glass. The aberrations of a concave mirror used at an angle help to smooth out the image of the lamp filament, and for the same reason high optical quality is not necessary, but care should be taken to keep light off the front edges of the cavity by suitable focusing.

Dr. H. J. J. Braddick (Department of Physics, University of Manchester) pointed out that the photography of tracks in cloud chambers involves contradictory requirements. For example, the minimum delay between the arrival of a particle and the expansion is 10 msec. Then a period up to 250 msec. is required for the water drops to grow. The shorter this period can be, the more nearly will the water drops represent the particle track; but the longer they are allowed to grow, the brighter will the track be. It is, of course, difficult to get adequate illumination because the camera lens must be stopped down to get a fair depth of the chamber sharp in the photograph. In order to get adequate illumination, high-power flash tubes or heavily over-run tungsten lamps are used. Practical trial indicates that prolonged development increases the effective speed of the photographic material—a result which, from the discussion following the paper, was not unexpected by the photographic experts. If the inevitable delay between the arrival of a particle and the expansion is increased, and an electric field is established across the chamber, the positive and negative ions separate, forming two parallel tracks from the intensities of which the relative concentrations of ions of the two signs may be estimated. This technique is not possible with nuclear track plates.

In discussing the distortion of tracks in plates for recording nuclear particles, J. V. Major (University of Manchester) said that measurements indicate that there are two components, one centrally symmetrical and the other like a shear across the plate. Uneven drying (from the edges inwards) can account for part of the distortion, but the origin of the remainder is not clear. Temperature gradients during development may be responsible.

E. W. H. Selwyn (Kodak, Ltd.) considered progress in the physics of the developed image. Our qualitative knowledge of the make-up of the characteristic curve, of granularity, graininess, resolving power and sharpness, is fairly good, though there are still outstanding problems, and little quantitative information is available. Fuller details are available in the *Journal of Photographic Science*, 1, 60 (1953).

Methods of high-speed photography, based on dissection of the image, were then described by Dr. J. S. Courtney-Pratt (University of Cambridge). If a plate embossed with a large number of lenses is placed near the focal plane of a camera, a series of images of the camera lens will be formed on the sensitive material, and these taken all together form a picture of what is in front of the camera, rather like a half-tone illustration. When a small aperture is moved across the camera lens, a continuous line of overlapping small images is formed behind each element of the lenticular screen, thus recording any movement in the objects in front of the camera. In practice, a series of apertures is used, like the original Baird scanning disk for television, and each lenticular element produces a 'raster'. The fundamental advantage of this system is that the speed of the scanning disk, being simple rotation, may be made very high, and with bright enough (for example, self-luminous) subjects records may be obtained at the rate of 4 million/sec. The same system reversed may be used for 'unscrambling' in slow motion or statically. A complete description, including variations on the above principle, is given in the *Journal of Photographic Science*, 1, 21 (1953).

C. Burns (British Iron and Steel Research Association) described how the problem of recording the very fast motion of lumps of material swirling round in the hollow just beyond the tuyères in blast-furnaces was dealt with. Stereoscopic motion pictures were made using two ports into a tuyère and a mirror system to produce the necessary pairs of pictures side by side on each frame of a 16-mm. film. When the pictures are projected, individual lumps of material can be recognized, against the very heterogeneous background. The location (along the axis of the tuyère) is measured by a quadruple projector arrangement of which the movements are linked. First, the two beams of a pair are made to coincide on some fixed detail in the tuyère, one on each of the projected pictures. The other two beams are then made to cross in space at the distance of the fixed detail in question, and the second pair of beams locked to the first pair. If the first pair of beams is now made to coincide with some other detail, the second pair follows its movements and intersects in space at the original distance of the new detail.

A. J. Insall (Shell Petroleum Co., Thornton le Moors) described the functions and some of the equipment of an industrial photographic section of a laboratory. One of the most important duties of such a section is to be able to repeat record photographs exactly; for this purpose arrangements must be made to locate any object precisely, to be able to duplicate the lighting arrangements and to be able to set the camera to given conditions. Records of all these settings must be kept, for it is commonly the case that photographs (for example, of pistons) require to be repeated, for comparison to be made to detect changes, sometimes at long intervals. Artistic quality (but not the technical quality) is usually unimportant, so that for recording deposits on elements of mechanisms, for example, use may be made of completely diffused lighting. Colour photography is very useful in such cases, since the additional information (on the colour) is valuable.

# LIBRARY CO-OPERATION IN GREAT BRITAIN

UNDER the title "Library Co-operation in Great Britain", the report of a critical survey of the working of the National Central Library, London, and the Regional Library Bureaux, made by Mr. R. F. Vollans, deputy city librarian of Westminster, for the joint working party of the executive committee of the National Central Library and the National Committee on Regional Library Co-operation has been published*. The working party's original terms of reference were to consider methods of dealing with areas of union cataloguing at the Regional Bureaux and at the National Central Library; means of improving the efficiency of the system and its comprehensiveness; the financial requirements for coping with the present system and sources from which money can be obtained; what would be reasonable current budgets for the bureaux if this re-organization were effected; and the relationship of the union catalogues of the bureaux and the national union catalogue of the National Central Library. In deciding that the survey should be undertaken by a single individual on its behalf, the working party extended these terms of reference and instructed Mr. Vollans to deal with the coverage by each system of the libraries within its own area, co-operation within each region, the national inter-lending system, union catalogues, the recruitment, qualifications and superannuation of bureau staff, the financing of the regions, and adult education.

In accordance with these instructions, which were further detailed, Mr. Vollans, following an admirable historical survey, reviews in successive chapters the working of the regional library systems, inter-library loan procedure, the scope of service and reasons for non-availability of books, the provision of books to adult classes, union catalogues, subject specialization, bibliographical information, staff and finance. His generous tribute to the efficiency and enthusiasm of the staffs concerned in inter-library loans and his conviction as to the importance of such work do not prevent Mr. Vollans from frank criticisms of the weaknesses or defects he has detected, whether of abuse of procedure, of inappropriate rules or woodenness or unimaginative interpretation of either rules or procedure. To the man of science the report is of interest mainly as an account of the background against which the evolution and organization of a national or regional lending library in science and technology must be considered; but the scientist who reads it may well be led also to a keener appreciation of the difficulties and waste of time which may be caused by inaccuracy or carelessness in making requests for books or periodicals.

The survey shows that all libraries appear to be playing their part in this national inter-lending service, and the small libraries appear to contribute just as much as the larger libraries; nor is it always the unduly large library system which provides the more expensive and more out-of-the-way books. Twenty-one university libraries and seventy-eight special libraries participate in the regional schemes, and these libraries lend more than they borrow, in that they have more specialized resources which would not find a place on the shelves of the ordinary public library. The present regions are based on geographical considerations, and are regarded as acceptable and workable units, with the exception of the regional library bureaux of Aberystwyth and Cardiff, which, it is recommended, should be merged to form a Regional Library Bureau of Wales. Except in the London area, the report recommends that all university and special libraries located within the area of a regional library bureau should become participant members of that bureau, and the bureau should be the agency, when necessary, for forwarding applications to the National Central Library. Within the London and Home Counties area, however, university libraries should make application direct to the National Central Library in respect of inter-library loans, and special libraries remain, as at present, outlier libraries of the National Central Library, membership of the London and South-Eastern Library systems remaining restricted to the public-library authorities of the area.

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* Library Co-operation in Great Britain: Report of the National Central Library and the Regional Library Bureaux. By Robert F. Vollans. Pp. xii+189. (London: National Central Library, 1952.) 5s.

As regards the suggestion that the Science Library, London, might be in a position to screen scientific and technical applications before passing them to the National Central Library, Mr. Vollans recommends no deviation from the present practice. He points out that three distinct aspects of the Science Library service should be considered here: first, the Science Library is a reference library serving some twenty-two thousand readers; second, it operates a loans requisition service for books and periodicals to firms, institutions and libraries (through the medium of the National Central Library), satisfying in 1950 more than forty thousand of 72,295 requests*; and thirdly, it operates a photocopying department which last year satisfied 20,348 out of 29,660 requests. In addition, some 230 of the 1,300 corporate bodies, mostly business firms, on the loans list provide details of their own holdings for incorporation in a supplementary union catalogue at the Science Library, and through this supplementary scheme 4,799 requests were satisfied last year. At present, however, the Science Library is not in a position to supply all the books required, and, though its periodical holdings are extensive, Mr. Vollans suggests that it would be wiser in the interests of consistency if the National Central Library continued to act as the clearing-house for all national and international loans. Ultimately, however, he visualizes the National Central Library as ceasing to concern itself with British publications; and, though he gives no clear indication of his views as to the future of the Science Library or its place in the new regional system, it seems possible that the new scheme whereby the Treasury gives a grant for the purchase of extra copies of special types of books and periodicals, which could be held originally but which would be available for loan, in extension of the idea of regional reference libraries for commerce and technology, would apply to the Science Library also.

Besides current periodicals, fiction and some other categories, Mr. Vollans would exclude from inter-library lending books in print costing 25*s.* or less, so far as the National Central Library is concerned, and those costing 12*s.* 6*d.* or less from the scope of the regional bureaux. He also recommends that the National Central Library should cease to purchase books for use in the system of inter-library loans, and that it should transfer to the various local education authorities the provision of books to adult classes. Both these steps would liberate staff which could be used on other activities, particularly in bringing the present national catalogues up to date and in compiling the new foreign union catalogues which, he suggests, should be the main responsibility of the National Central Library in this field.

The survey proves that the Union Catalogue is a necessary adjunct in the nation-wide service of inter-library loans, and the duplication of entries is not as heavy as might have been expected. Mr. Vollans recommends that the existing regional and national union catalogues, as at present compiled, should only continue until an agreed specified date; after this, the regional union catalogues should contain entries for British books as they appear in the British National Bibliography notified by libraries to the Bureau, using the British National Bibliography numbers, and entries for all other books should be reported either directly on sheaves or by slips, only the latter entries being sent also to the National Central Library. The practice of producing the catalogues in sheaf form will no longer be necessary, and Mr. Vollans makes other proposals for achieving economies in procedure. Much stress is laid on the question of staff, which he regards as a decisive factor in increasing administrative efficiency and reducing the present excessive costs of the inter-library loan service. Apart from the question of qualifications and adequate salaries, he points out that seconding or the adoption of a superannuation scheme which allows interchange of staff between libraries of all kinds is essential for providing the security of tenure and overcoming the difficulty of pension rights which will otherwise hinder the recruitment of staff of the requisite experience.

As regards finance, he recommends an approach to the Treasury with the view of obtaining a grant, to be spread over three years, for the purpose of bringing the regional union catalogues up to date. If this grant is not forthcoming, it is suggested that the National Central Library should direct to the bureaux some of the money saved by discontinuing the purchase of books for its own stock and for adult classes, for the same purpose of bringing the catalogues up to date and thus enabling the National Central Library's own catalogue to be brought up to date.

In an introduction to Mr. Vollans's report, Mr. W. A. Mumford indicates that the report of the joint working party, of which he is chairman, will owe much to Mr. Vollans, although the working party is not in agreement with all the latter's findings.

# BRITISH ELECTRICAL AND ALLIED INDUSTRIES RESEARCH ASSOCIATION

## REPORT FOR 1952

THE thirty-second annual report of the British Electrical and Allied Industries Research Association (usually referred to as the Electrical Research Association) records the maintenance of the activities of the Association at a high level and their expansion in certain directions*.

At the outset, it is noted that the Association has operated this year under new terms of grant from the Department of Scientific and Industrial Research, and it was in relation to these new grant conditions and to the projected building of new laboratories at Leatherhead that the council of the Association last year launched an appeal for an increase in members' subscriptions and for capital contributions. The response to the appeal has been very gratifying, and as a result the Department grant has not only been maintained but slightly increased. Capital contributions amounting to nearly £200,000 have already been promised, subject to the institution of building operations, and part has already been paid.

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* Thirty-second Annual Report of the E.R.A. for the Period ended 31st December 1952. Pp. 102. (Leatherhead: British Electrical and Allied Industries Research Association, 1953.)

The whole range of the research activities of the Association is summarized in nineteen separate sections in the report. It is, however, a little difficult to form from the report an adequate picture of the relative scale of effort devoted to the various branches of work. Much emphasis is evidently placed, as in previous years, on the work on dielectrics; part of this work being carried on at the Association's laboratories at Perivale, and part under the extra-mural programme at the National Physical Laboratory and in the Universities of Oxford, Durham, Bristol, Liverpool and London. This research ranges from fundamental theoretical work on the physics of insulating materials to directly applicable investigations concerned with the production of stabilized capacitors. On magnetic materials, fundamental work on the production and properties of electrical sheet-steel is in progress in the laboratories of the British Iron and Steel Research Association, this work being under the control of a joint committee of this Association and the Electrical Research Association. Measurements on magnetic sheet-steel and work on permanent magnet materials are being pursued largely as extra-mural researches.

Work on circuit breakers and circuit-breaking phenomena continues at a high level, and progress is reported in multiple break switches for high voltages. The report mentions, in passing, that "This year is the 25th anniversary of the gas-blast and the 21st anniversary of the baffle side-blast switchgear inventions of Dr. Whitney and Mr. Wedmore. The vital arc-control element in most modern high-power switchgear throughout the world, embodies in whole or some essential part their ideas and inventions". A model D.C. transmission link simulating high-voltage operation is now practically complete, and it is mentioned that "On the full-scale trial scheme a specific proposal has emerged relating to the cross-Channel power link and is being considered".

The network analyser, which has been under construction for some time, has been in operation on a limited basis, and additional sections of network elements are being incorporated as components are delivered. The analyser has already proved its value in a number of researches, particularly that of re-striking transients on the 132-kV. system of the British Electricity Authority. In the field of power generation, the most important problem is to raise the working temperatures of steam turbines. Extra-mural work at the Imperial College of Science and Technology, London, includes a programme for the measurement of the properties of steam up to 6,000 lb./sq. in. and 1,400° F. Work is also in progress at the National Physical Laboratory on steels suitable for components operating at 1,100° F.

During the past few years, the Electrical Research Association has been investigating the potentialities of wind-power in the British Isles. The experimental station in Orkney has been operated but is not yet in full commission, and arrangements are in hand with the College of Aeronautics for the testing of prototype equipment. Efforts are also being directed towards the development of the fuel cell, and a new research team for work on the gas cell has been established.

In the agricultural field, the Association has met with considerable success in the development of grain-drying equipment, and further work is in hand on soil warming in open ground and on soil sterilization by *in situ* electrodes. The experimental heat pump has been in use for some time, and a direct comparison has been made between the performance of the heat pump and that of a gas boiler installation.

Mention is made of the close liaison which the Electrical Research Association maintains with the professional institutions concerned with its spheres of work. A new departure has been made in the establishment of a programme of colloquia which are held at the Association's laboratories and to which guest speakers are invited from time to time. This year, the Association has issued ninety-four reports to members. Twenty reports have been published as papers in the technical press, together with a number of articles written by members of the staff and extra-mural research workers.

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# SCIENCE IN GOVERNMENT SERVICES

IN a recent address to the American Chemical Society (see *Nature*, June 13, p. 1055) Dr. L. A. DuBridge, president of the California Institute of Technology, was somewhat critical of the United States Government's organization for research, and, apart from the Los Alamos Scientific Laboratory, which is operated for the Atomic Energy Commission by the University of California, expressed the opinion that the Government is not getting full value from its many existing military laboratories. Dr. O. H. Wansbrough-Jones's review of the situation in Great Britain in his William Jackson Pope Memorial Lecture, "The Scientist's Place in the Services", before the Royal Society of Arts on April 29, struck a much more confident note. He gave substantial reasons for believing that in Britain we have found means of ensuring that science, especially when devoted to defence topics, can really flourish in peace-time under government control. The position which scientists gained in the stress of war has been retained, and the scientist has now a favoured and honourable place in the Services, including the Ministry of Supply, in which he no longer has to fight for opportunities to collaborate closely with the Services in such of their problems as the scientific approach might further. He has become conscious rather of the responsibilities being imposed upon him and is wondering how far they can be discharged.

Dr. Wansbrough-Jones began by reviewing the way in which the attitude of the Services to scientific men has changed, so that in the Second World War they were no longer limited to giving the Services what they wanted rather than what the Services needed, which, as Sir Henry Tizard pointed out, is not necessarily the same thing. Apart from the influence of scientists like Tizard, Fowler and others, who had been brought intimately into the defence picture before the War, the preparation of the Technical Register and the urge to help the war effort from every scientific laboratory in the country, Dr. Wansbrough-Jones thought that there were three main factors responsible for scientific men achieving a position in which their powers are being fully exercised. The first is the dominant position in fields of defence science that the Government Establishments have achieved. The real knowledge of radar, service communication problems, explosives and propellants and chemical warfare is to be found in the Service Establishments, and at first even the most eminent outside scientists would be able to contribute relatively few ideas. The second factor is the increasing realization that a major scientific profession exists which might have its own contribution to make in its own terms. The third and most compelling factor of all is the practical and experimental proof, well exemplified in radar, that the scientist can contribute so much in non-technical and semi-technical fields. By the end of the War, all three Services had their own operational research teams at work in the field and at various headquarters, and in the Service Ministries and at many major commands there were senior scientists, of such rank and status that they could discuss, on equal terms with senior serving officers, the Services' problems from a scientific point of view. The general programme for research and development was evolved by such joint discussions, later to be carried out by the Ministry of Supply or of Aircraft Production, and by the Royal Naval Scientific Service. The arrangement really worked very well: the great step forward was the integration of the two disciplines, service and scientific, at a high level, so that the real problems were isolated, studied by the best scientific means available, and the results checked in the field by the method of operational research.

Generous tribute was paid by Dr. Wansbrough-Jones to the contribution of the Services themselves to science: progress would not have been possible had not the technical and scientific knowledge and appreciation within the Services been greater than is commonly admitted. Moreover, since the War, the Services have also made advances in their own technical education. The old scientific isolation of the Government scientist has gone, and there is a good interchange both of people and results. Nor does Dr. Wansbrough-Jones think that a turnover of young scientific men, due to the attraction of higher salaries in industry, is a bad thing, provided it is not overdone. Many men who could command far higher salaries outside the Government service remain within it on account of the excellent facilities provided. Equipment in the Government Research Establishments is first-class, and he thought that much of the research and development carried out on behalf of the Services are also of great value to British industry as a whole and to science itself. Provided recruitment of scientific men of the right quality and the scientific education of the Services continue, he believes that the harmonious working of the Service and scientific staffs will continue, and that the best use will be made of weapons, and the very difficult task of selecting the right problems to attack will be well done. Research in these fields is admittedly expensive, and though Dr. Wansbrough-Jones agreed that the scientist working for the Services has no easy task in seeing that costs are kept down without lowering the standard of the work, he appeared to be satisfied that Great Britain is getting good value from the average cost for fully-trained research worker, scientist or engineer—an average cost materially smaller than the latest American figures.

# THE CONCEPT OF PHOSPHATE BOND-ENERGY

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DURING the past twenty years, it has become apparent that phosphorylation is one of the most fundamental processes occurring in living tissue. The role in metabolism of substances which bring about phosphorylation, such as adenosine triphosphate (ATP), is currently interpreted in terms of concepts first elaborated by Lipmann[1], who divided biologically important phosphoric acid derivatives into two groups depending on whether their standard free energy of hydrolysis is large ($c.$ $-$ 12,000 cal. mol.$^{-1}$) or small ($c.$ $-$ 2,000 cal. mol.$^{-1}$). Compounds in the first group are said to contain an 'energy-rich' or 'high-energy' O—P or N—P bond; those in the second group an 'energy-poor' or 'low-energy' O—P or N—P bond. Cleavage of 'high-energy' bonds is imagined to liberate large amounts of free energy which may be used by the organism either to carry forward energetically unfavourable reactions or for the production of work. Catabolic processes are said to be so organized as to lead to the production of 'energy-rich' compounds (for example, phosphocreatine and phosphoarginine), which function as stores of readily available energy. Anabolic processes then proceed by utilizing this energy through the mediation of adenosine tri- and di-phosphates.

This concept of 'energy-rich' phosphate bonds (which is frequently used in its literal sense) is irreconcilable with physicochemical principles. Furthermore, since the theory is actually based on free energies of hydrolysis, the relevance of classical thermodynamics to the interpretation of the detailed mechanisms of biological systems requires scrutiny.

When separate atoms combine to form molecules, that is, when chemical bonds are formed, the total energy of the system *decreases*. The reverse process, the dissociation of a molecule into its constituent atoms, therefore requires an expenditure of energy which is referred to as the heat of atomization. For a diatomic molecule, the bond-energy of the only bond present is defined as being equal to the heat of atomization, that is,

$$\Delta H \text{ for the process } X_2 \rightarrow 2X.$$

A high bond-energy, that is, a large value for $\Delta H$, indicates a strong bond and, conversely, a low bond-energy indicates a weak bond.

In a polyatomic molecule it is usually assumed that the bond-energy of a given bond is independent of its molecular environment[2], and that individual bond-energies are strictly additive. Bond-energies defined in this way, however, are no more than a convenient, although arbitrary, method of dividing up the total heat of atomization. A more useful quantity is the bond-dissociation energy, which is equal to the heat content change $\Delta H$ for the reaction $R:S \rightarrow R\cdot + S\cdot$, where $R\cdot$ and $S\cdot$ are free radicals or atoms. This quantity, unlike the bond-energy, depends on the molecular environment (cf. the O—H bond in HO, $H_2O$ and $H_2O_2$)[3], but can be measured for bonds in polyatomic molecules only in a few special cases and under special conditions.

However, the important point for our present discussion is that bond-energies are always *positive*, that is, energy is always required to break a chemical bond. It is impossible for any simple bond-dissociation process to be energy-producing, and the concepts of 'energy-rich' bonds and the storage of energy in bonds are physically meaningless. It must also be pointed out that even if the correctly defined bond-dissociation energies of different O—P and N—P bonds could be measured, which at present is not the case, they would not, in general, bear any simple relationship to the free energies of hydrolysis, since other quantities such as the energies of formation of new bonds, the heat of ionization and solvation of all the reactants and products and the total entropy change accompanying the reaction, are also involved.

As an example of the current literal use of the term 'phosphate bond-energy' we may quote the following extract: "The removal of the elements of water from phosphoglyceric acid results in structural alterations within the molecule. These are attended by a redistribution of the intrinsic free energy of the system leading to a 'concentration' of free energy in the neighbourhood of the phosphate radical; in other words, to the generation of a new energy-rich bond. The free energy of this new bond has been estimated at about 16,000 cal., i.e., rather more than is required to form a new bond in ATP. This new bond energy, together with the phosphate radical, is then transferred to ADP and a new molecule of ATP is thereby produced"[4]. It is clear, however, that it is impossible for energy to be stored in a bond in this way, since what is meant by a chemical bond is inseparable from the idea of energy release on its formation. Clearly it would be less misleading and more correct to avoid the terms 'energy-rich' and 'energy-poor' bonds and refer simply to high and low free energies of hydrolysis.

In discussing the real significance of the free energies of hydrolysis of biologically important phosphoric acid derivatives, it must first be emphasized that there seems to be little justification for the customary division of these free energies of hydrolysis into two sharply defined groups. Not only is there a wide scatter in the quoted values[5], but also many of them have been obtained by indirect calculations[1] the reliability of which is difficult to assess.

Considerable confusion seems to have arisen in the biochemical literature from a misunderstanding of the significance of the thermodynamic functions, heat content $H$ and free energy $G$, and much of this is directly due to the use of the 'energy-rich phosphate bond' nomenclature. We shall consider some typical examples. The first concerns certain experiments by Lipmann[6], who observed that under particular conditions the condensation of amino-acids to give peptides is accompanied by the hydrolysis of adenosine triphosphate. Citing this as an example of the energy from an energy-rich bond promoting biologically important synthesis, Lipmann concludes that, since only one peptide linkage (free energy of hydrolysis c. − 3,000 cal.) is formed for every molecule of adenosine triphosphate hydrolysed (free energy of hydrolysis c. − 12,000 cal.), the utilization of the phosphate bond-energy is only 25 per cent, the remainder (that is, −9,000 cal.) being 'spilled over' and dissipated as heat. Let us examine the real significance of these figures. The two free energies of hydrolysis quoted are, in fact, standard free energy changes, and from these, assuming for the purposes of this discussion that they are correct, can be calculated the standard free energy change associated with the overall reaction (c. − 9,000 cal.). This will not in general be equal to the actual free energy change $\Delta G$ associated with the reaction as it occurs in an organism, because this quantity is dependent on the concentrations or, more correctly, on the activities of the reactants and products, and is related to the standard free energy change $\Delta G^0$ (reactants and products in their standard states) by the relation

$$\Delta G = \Delta G^0 + RT \log J,$$

where $$J = \frac{(a_M)^M (a_N)^N \ldots}{(a_B)^b (a_C)^c \ldots}$$

for the general reaction

$$bB + cC + \ldots = mM + nN + \ldots$$

where $a_b$ is the activity of $B$, etc.

In any event, even if the actual free energy change were − 9,000 cal., the heat of reaction would in general have a different value. If the reaction occurs under such conditions that the only work done is work of expansion against a constant pressure, then the heat absorbed will be given by the heat content change $\Delta H$, but not by the free energy change $\Delta G$. Unless the entropy change $\Delta S$ is zero, these two quantities will have different magnitudes and may even be of opposite sign. In the more general case where other forms of work than expansion against a constant pressure are done, the heat absorbed will not be given by the heat content change but will depend on the reaction path. Clearly it is incorrect to conclude that the standard free energy change of − 9,000 cal. for this reaction corresponds to the heat liberated, or that it is the actual free energy change associated with the reaction as it occurs in a biological environment. It is difficult to attach any meaning to the statement that the efficiency of utilization of phosphate bond-energy is only 25 per cent. This implies that the reaction might in principle be carried out with a much smaller free energy decrease. However, a different free energy change will only be possible if the reaction has a different stoichiometry and therefore a different mechanism. Whether or not such an alternative process would be possible under any given conditions can only be decided by kinetic and not by thermodynamic considerations.

Some of the confusion in the use of the thermodynamic function $G$ can undoubtedly be attributed to its rather misleading name, free energy, which has led to it being erroneously identified with the energy function $E$. For example, some authors appear to think, possibly because free energy changes are usually expressed in calorie units, that the free energy change associated with a chemical reaction must in some way 'appear' either as work or as heat liberated or as both. The standard free energy change of a chemical reaction $\Delta G^0$ is probably best thought of as a disguised equilibrium constant, the two quantities being related by the expression:

$$- \Delta G^0 = RT \log_e K.$$

Since, in the case we are considering, the standard free energy change for the overall reaction is − 9,000 cal., we may conclude that the position of equilibrium lies well over on the side of the products. However, in deciding whether or not a reaction will, in fact, proceed under any given conditions, thermodynamic considerations are largely irrelevant. Thus, although the position of equilibrium of a reaction may be very favourable, it will only proceed if it has a sufficiently low activation energy; this is not related to the free energy change and will, for example, be considerably influenced by the presence of catalysts. If a reaction has a positive standard free energy change, that is, if the position of the equilibrium is unfavourable, it may still proceed readily if the concentrations (or activities) of the products are kept very small[7]. This may occur, for example, if the reaction is followed by another very fast reaction which removes the products as soon as they are formed, or if they are removed by diffusion through a membrane, or in any of many other possible ways.

It is difficult to understand why it should be considered on the basis of thermodynamic considerations alone that a substance such as adenosine triphosphate, which is said to contain an 'energy-rich' phosphate bond, is necessary to promote the synthesis of a peptide linkage when it is evident that any phosphate with a free energy of hydrolysis more negative than − 3,000 cal. would give an overall reaction with a negative free energy change, that is, with a favourable position of equilibrium. Although thermodynamics shows that the position of equilibrium in the supposed synthesis of a peptide linkage by adenosine triphosphate lies well over on the side of the products, it does not, and in fact cannot, tell us why adenosine triphosphate is particularly effective in this reaction. The reason for this must be sought in terms of kinetic rather than thermodynamic considerations.

Among other types of reactions which should be considered in kinetic rather than in thermodynamic terms is, for example, the enzyme-catalysed transphosphorylation of glycerol by glucose-1-phosphate. In this system, in the absence of the acceptor molecule, the enzyme causes rapid hydrolysis of the glucose-1-phosphate. To quote: "It might have been anticipated, therefore, that hydrolysis rather than transfer, would always occur in the presence of a transferring phosphatase. Apparently, however, the available free energy is not lost all at once; rather does it seem that free energy tends when possible to escape in stages"[8]. Presumably the true explanation here is that the rate of phosphorylation of glycerol by glucose-1-phosphate is greater than the rate of hydrolysis of the latter. To explain the phenomena in terms of a hypothetical desire of free energy to escape in small amounts is a necessarily sterile approach and can contribute nothing to a real understanding of the reaction.

It is often stated that the synthesis of adenosine triphosphate from adenosine diphosphate, which is associated with a standard free energy change of approximately − 12,000 cal., must be coupled with another reaction, which is said to drive the adenosine triphosphate synthesis, for which the standard free energy change is negative and numerically equal to or greater than 12,000 cal. Any difference between the two values is said to be dissipated as heat. It should be clear from the preceding discussion that the synthesis of adenosine triphosphate from the diphosphate does not require immediate coupling of this reaction with another having a greater negative standard free energy change; but rather must the activities of all the reactants and products be such that the movement of the system towards equilibrium will cause the reaction to occur, and that suitable catalysts must also be present so that paths are open by which the reaction can proceed sufficiently rapidly. It will obviously lead to incorrect conclusions if one attempts, as is often done, to link the synthesis of adenosine triphosphate with only those reactions which have a sufficiently large negative free energy change. For example, it has been concluded that, since the standard free energy change accompanying the oxidation of β-hydroxybutyrate by diphosphopyridine nucleotide is of the order of 1,000 cal., phosphorylation of adenosine diphosphate to the triphosphate cannot occur simultaneously with the former reaction. In fact, this may not be the case. The standard free energy change, and indeed thermodynamics in general, gives little information on this point.

In conclusion, we should like to stress the present need for a kinetic approach to the whole problem of phosphorylation reactions. It is clear that substances such as adenosine triphosphate are able to induce phosphorylation rapidly and selectively under a wide variety of conditions. The mechanisms by which these processes occur appear to be largely unknown. It is, however, by the study of these mechanisms, particularly in relation to the enzymes involved, and not by the invention of fictitious kinds of bond-energy, that the role of adenosine triphosphate in phosphorylation reactions will be understood.

We wish to thank Profs. E. D. Hughes and C. K. Ingold for their help and encouragement, Prof. R. A. Morton and Dr. J. Glover for helpful criticism of the manuscript, and Drs. C. A. Bunton, E. M. Crook, P. B. D. de la Mare, Allan Maccoll and P. J. Syrett for many valuable discussions. [Feb. 13.

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# β-FORMS OF FIBROUS PROTEINS AND SYNTHETIC POLYPEPTIDES

By Dr. C. H. BAMFORD, L. BROWN, Dr. A. ELLIOTT, W. E. HANBY and I. F. TROTTER

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We have recently examined the X-ray reflexions from the shorter spacings in some synthetic polypeptides and fibrous proteins, with the view of determining as accurately as possible the axial repeat distance, particularly for the extended polypeptide configuration.

Silk suture or a bunch of fibres from *Bombyx mori* photographed with a cylindrical camera with the fibres horizontal and tilted at about 42° to the X-ray beam gives a diagram in which there is an exceedingly strong arc corresponding to a spacing of 1·156 A. in the direction of the fibre axis. This is probably similar in origin to the 1·2 A. reflexion which Bunn and Garner[1] found by the same technique in oriented fibres of nylon 66, and owes its intensity to the approximately constant succession of scattering atoms along the extended chain. It is the sixth order of the axial repeat in silk (7·04 A. according to McNicholas[2]). On this basis, a more accurate value of the axial repeat is obtained from the 1·156 A. spacing than from other reflexions on layer lines. We consider, therefore, that the best value for the c-axis in our specimens is 6 × 1·156 = 6·94 A. For tussah silk the corresponding reflexion is at 1·153 A., which gives a c-axis repeat of 6·92 A.

The 1·156 A. reflexion should be characteristic of all extended or nearly extended polypeptide chains, and we accordingly looked for it in swan quill and in steam-stretched bristle and hair and in several synthetic polypeptides in the β-configuration. The expected reflexion, weaker relatively than in silk, was found in stretched pig bristle at 1·104 A., giving an axial repeat of 6·62 A. in agreement with Astbury and Street's value for stretched hair[3]. A somewhat diffuse reflexion was observed in stretched horse hair, corresponding to the same spacing. However, no indication whatever of the 1·1 A. reflexion in swan quill (or of one at 1·5 A.) was found on heavily exposed photographs taken under similar conditions to those which showed these reflexions in other polypeptides and proteins.

The synthetic polypeptides, polyglycine, poly-L-alanine and poly-γ-methyl-L-glutamate, have given results of great interest. In poly-L-alanine (β-form) the orientation was good, and a strong meridional reflexion appeared corresponding to 1·147 A. The c-axis repeat for poly-L-alanine is therefore 6·88 A. In polyglycine the orientation was insufficient to show whether the reflexion at 1·16 A. was on or near the meridian, but we consider this very likely in view of the almost identical meridional 1·156 A. spacing in silk. In the β-form of poly-γ-methyl-L-glutamate a meridional reflexion at 1·138 A. was found, giving a c-axis repeat of 6·83 A. The values of the c-axis repeats for the various polypeptides and proteins are collected in the accompanying table, which also gives the mean residue weights.

| Material | c-Axis (A.) | Mean residue weight |
|---|---|---|
| Polyglycine | 6·96–7 05 | 57 |
| Poly-L-alanine (β-form) | 6·88 | 71 |
| Poly-γ-methyl-L-glutamate (β-form) | 6·83 | 143 |
| Silk (*Bombyx*) | 6·94 | 77 |
| Silk (tussah) | 6 92 | * |
| Pig-bristle (stretched) | 6 62 | 107–116 |
| Swan quill | 6·2 (?) | * |

* The mean residue weights do not appear to be known accurately; that of tussah silk is probably not very different from that of *Bombyx*, while that of swan quill is probably similar to that of wool (c. 110)

Calculations show that for a fully extended polyglycine chain the (006) reflexion has a large structure factor; consequently a strong reflexion on or near the meridian at about 1·2 A. should appear. The 1·16 A. reflexion is the only one in this region which we have observed. If the 1·16 A. reflexion in polyglycine is near the meridian, consideration of possible unit-cell structures strongly suggests that the c-axis has a length between 6·96 A. and 7·05 A. The latter figure corresponds to the maximum stagger between neighbouring chains, leading to a triclinic cell, and the lower figure is for a cell the base of which is normal to the chain axis (this appears to be the case in silk and in poly-L-alanine). If we assume that the chain of polyglycine is fully extended (and hitherto no reasons have been advanced against this assumption), it follows that a fully extended polypeptide chain should have an axial repeat of 6·96–7·05 A., about 4 per cent less than the value 7·23 A. based on measurements on small peptides[4]. An alternative explanation of our results is that the crystallites of polyglycine are composed of *parallel* rather than the conventional anti-parallel, polypeptide chains. In order to form satisfactory hydrogen bonds the chains (assumed in this explanation to have a repeat of 7·23 A. when fully extended) may have to contract so that their identity period becomes about 7 A. or less. We might expect, however, that this arrangement is less stable than the fully extended anti-parallel one, since the full contribution from the 'staggering' of single bonds around Cα is not obtained. A partially collapsed anti-parallel chain configuration is also a possibility, but seems open to the same objection.

Pauling and Corey[5] have stated their view that polypeptide chains will take up specific configurations corresponding to minimum energy of the chain. The fully extended chain is one such configuration; if this has a repeat length of 7·23 A. the next stable configuration (the pleated sheet) has a repeat of 6·68 A., and configurations of intermediate repeat length should be unstable. This point of view, however, does not take any account of energy from interchain forces other than those involved in hydrogen bonds.

If a fully extended polypeptide has a repeat of about 7 A., the next stable configuration should have a repeat about 6·4 A. It is quite certain that poly-L-alanine (which according to Pauling and Corey should form a pleated sheet by reason of steric hindrance of the methyl groups) has a c-axis repeat of 6·88 A. (or a multiple of this), and cannot therefore take up the pleated-sheet configuration. The small contraction compared with polyglycine suggests that steric hindrance is accommodated, but that no contraction to a specific configuration (involving staggering of single bonds around the Cα atoms) takes place. This may mean that the effect of methyl-group steric hindrance has been over-estimated by Pauling and Corey, and also that the energy of the whole crystalline system may be at a minimum even though the individual chains are not in the position of lowest energy. The alanine content of tussah silk is reported to be higher than that of *Bombyx mori*, and it is therefore interesting to note that the c-axis repeat in tussah is intermediate between that of poly-L-alanine and *Bombyx*.

The result obtained with swan quill is surprising. This material shows infra-red dichroism of the type associated with a β polypeptide[6], but very much less marked than in silk. It might be thought that part of the structure consisted of α-chains at right angles to the fibre axis, but we have been unable to detect a 1·5 A. reflexion either on the meridian or the equator. The large number of sharp reflexions in the centre of the diagram (similar to sea-gull quill[7]) shows that parts of the structure are highly oriented. If the 3·1 A. meridional reflexion in swan quill indicates a unit cell with c = 6·2 A., then calculation shows that the 1·03 A. reflexion in such a contracted structure would be weak. This may perhaps explain our failure to observe such a reflexion. If this explanation be correct, it furnishes some evidence for planar or nearly planar amide groups in feather keratin, for the low calculated intensity of the 1·1 A. reflexion for a slightly contracted chain is a result of rotation assumed to be around the Cα single bonds only. The effect of this rotation is to destroy the approximately equal succession along the chain axis of atoms in the backbone.

The table shows that the fibre repeat-distances in the β-forms of the synthetic polypeptides and in the silks are surprisingly similar considering the wide variations in the size of the side chains. Such variations as are found may be attributed to the presence or absence of a β-carbon atom, rather than to the total bulk of the side chains. It is therefore surprising that the *c*-axis repeats of the β-keratins are so much smaller, and we conclude that the character of the side chains is more important in this respect than their mere size.

In conclusion, we consider that the observations briefly set out above suggest that we are not yet in a position to calculate with precision the arrangement of the polypeptide backbone of these large molecules. If this is the case when we are concerned with regions of high crystallinity, it is still more true of the amorphous parts which make up by far the greater part of many fibrous proteins, and of all proteins in solution. [March 24.

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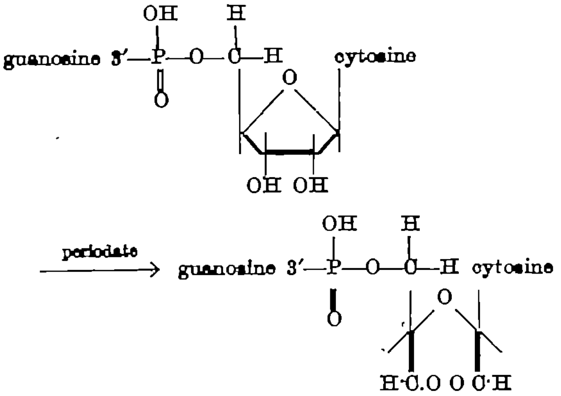
# NATURAL CONFIGURATION OF THE PURINE NUCLEOTIDES IN RIBONUCLEIC ACIDS

## Chemical Hydrolysis of the Dinucleoside Phosphates

WHEN hydrolysed by means of cold alkali or acid, the ribonucleic acids give rise to mixtures of isomeric nucleotides, the *a* and *b* nucleotides of Carter[1] and Cohn[2], which are the 2′- and 3′-phosphates of the four nucleosides, probably in that order which we shall assume for convenience. In the intact nucleic acids, these substances are linked to each other largely or possibly entirely by phosphate diester bridges also involving the 5′ OH group in the nucleosides. It is known, however, that acid or alkaline hydrolysis effects the degradation of ribonucleic acid through intermediate cyclic phosphate compounds involving both the 2′- and 3′-positions in the nucleoside residues[3,4], so that the final position of the phosphate residue in the nucleotide liberated is no certain guide to its position in the intact nucleic acid. Similarly, in ribonuclease digestion, the fact that the pyrimidine nucleotides liberated are all of the *b* (3′)-type[5] is not definite proof that the 3′-link is involved in the intact nucleic acid, because the enzymic degradation also goes through a cyclic step and so phosphate migration may also take place in this case.

The original object of this work was to degrade relatively simple compounds derived from ribonucleic acid in order to determine the actual configuration in the internucleotide link, and the dinucleotides resulting from exhaustive ribonuclease digestion[6] seemed to be the most profitable substances to investigate. These are composed of a purine nucleoside joined at C 2′ or 3′ by a phosphate diester bridge to the 5′-group of a pyrimidine nucleoside 3′-phosphate. This type of compound is resistant to snake venom phosphodiesterase, but if the pyrimidine nucleotide residue is dephosphorylated at C 3′, this enzyme then breaks the resulting dinucleoside monophosphate to give a pyrimidine nucleoside 5′-phosphate and a purine nucleoside. Our aim was to attempt to induce the enzyme to break the other end of the phosphate bridge, so as to leave the phosphoric acid joined either at C 2′ or C 3′ without the intervention of a cyclic intermediate. At this point we should state that we did not succeed in this object, but instead we discovered a chemical method for accomplishing this degradation.

As an example of this degradation we shall take the case of the dinucleotide of guanine and cytosine. This was dephosphorylated by prostate phosphomonoesterase to give a dinucleoside monophosphate.



On treatment with sodium periodate, the cytidine residue was split between C 2′ and C 3′ to give a dialdehyde derivative. This substance may be isolated from excess periodate and iodate by chromatography in *iso*propanol – ammonia[4].

When treated at *p*H 10 with Russell viper venom for 6 hr. at 37° C. and rechromatographed in the same solvent, two substances were detected. The one with the higher $R_F$ value was eluted and found to have an absorption spectrum similar to, but not identical with, that of cytosine. The slower-moving compound, which had the same $R_F$ as guanylic acid, was eluted, and on chromatographing in an ammonium sulphate – sodium acetate – *iso*propanol – water solvent[4] was found to be guanylic acid *b* exclusively, and its identity was confirmed by an examination of its absorption spectrum.

Control experiments, however, gave the same result; that is, it was possible to obtain guanylic acid *b*, together with the cytosine-containing compound (which, incidentally, does not seem to be identical with the substance obtained by the action of periodate on cytidine), from the dialdehyde derivative of the dinucleoside monophosphate of guanine and cytosine without the addition of snake venom, but simply by incubation at *p*H 10. Further experiments confirmed that this action was independent of a diesterase and occurred under conditions in which cyclic nucleotides are completely stable. Apparently the dialdehyde derivative of a dinucleoside monophosphate is unusually unstable to alkali, and we find that a certain amount of splitting actually takes place even on chromatographing in *iso*propanol – ammonia.

This method has also been applied to the degradation of the dinucleoside monophosphates obtained from guanylyl uridylic acid, adenylyl cytidylic acid and adenylyl uridylic acid, and in each case the dialdehyde derivative yielded, on mild alkaline treatment, either guanylic acid *b* or adenylic acid *b*. Thus both purine nucleotides occur in the dinucleotides (and presumably in ribonucleic acid) as the *b* isomers, which are probably the nucleoside 3′-phosphates.

The possibilities of this procedure, by means of which the phosphate terminal nucleotide of a dinucleotide may be removed, are at once apparent. The conditions under which the experiment is carried out are so mild that any polynucleotide would be quite stable, and by a repetition of the procedure it should be possible to determine the nucleotide sequence in a polynucleotide chain. As the next step we intend to apply the method to the investigation of trinucleotides.

One of us (P. R. W.) wishes to thank the Commonwealth Government of Australia for a Commonwealth Scientific and Industrial Research Organization Studentship.

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## Enzymatic Splitting of Purine Internucleotide Linkages

THE nature of the phospho diester internucleotide linkages involving purine residues of ribonucleic acid has not been previously demonstrated. In the preceding communication, it was decided that purine nucleotides occur in ribonucleic acid as the *b* isomers. We have reached the same conclusion from enzymatic studies with a spleen fraction. Volkin and Cohn[1] had already isolated *b* nucleotides of all the bases after digestion of ribonucleic acid with a crude spleen extract[2]. However, this did not establish the position of the phosphoryl group (2′- or 3′-) in the original diester, since the occurrence of nucleoside 2′ : 3′-phosphates as intermediates was not ruled out. These cyclic compounds, if formed in the course of hydrolysis, would allow the possibility of phosphoryl migration. In the present investigation, we have found that guanylic acid *b* and adenylic acid *b* resulted from the digestion of the ribonuclease-resistant 'core' with a fraction from spleen, and no cyclic compounds were observed at any time. Furthermore, it has been shown that the cyclic mononucleotides were quite slowly attacked by the enzyme and therefore would have accumulated, had they been intermediates.

The enzyme preparation was one of several fractions previously separated from calf spleen[3]. Fresh tissue was homogenized in cold 8·5 per cent sucrose, adjusted to *p*H 5 and centrifuged. The precipitate was washed with 8·5 per cent sucrose and then with acetone (— 10°). From the dry acetone powder it was possible to extract the enzyme activity in soluble form with 0·2 *N* acetate buffer, *p*H 6. The extract was fractionated with ammonium sulphate at *p*H 5 and again at *p*H 8.

This fraction was incubated with 'core' prepared from ribonucleic acid by exhaustive digestion with ribonuclease followed by dialysis against tap water. Both yeast and turnip yellow mosaic virus were used as sources of ribonucleic acid. At least 90 per cent of the purine residues of 'core' were liberated as *b* nucleotides, as determined by paper chromatography[4]. No cyclic intermediates were found at any time during the digestion.

Now it was necessary to establish that our failure to observe cyclic mononucleotides was not due to their being rapidly hydrolysed. Accordingly, we compared the rate of formation of purine mononucleotides from 'core' with the rate of hydrolysis of cyclic guanylic and adenylic acids. The incubations were carried out at 37° in a total volume of 1 ml., containing 80 μmoles of potassium phosphate buffer, *p*H 7·4, 0·3 mgm. of spleen fraction and substrate. As an example, 9·6 μmoles of guanylic acid *b* were derived from 5 mgm. of 'core' in 1 hr. During this time, 1·8 μmoles of guanosine 2′ : 3′-phosphate were hydrolysed to the extent of only 16 per cent, and 0·3 μmole was split to the extent of 70 per cent. Clearly, the guanylic acid was not formed by way of guanosine 2′ : 3′-phosphate. Under these conditions, the cyclic compound would be expected to accumulate because of its slow rate of hydrolysis, but none was detected. In parallel experiments 0·3 and 0·6 μmole of guanosine 2′ : 3′-phosphate was actually added to a mixture of 'core' and enzyme. Hydrolysis of 'core' proceeded, and most of the added cyclic compound survived an hour's incubation. Cyclic adenylic acid was somewhat more rapidly split by the spleen preparation, but its accumulation could also be expected, had it been formed as an intermediate.

Similar observations were made with the dinucleotides of guanine and cytosine, guanine and uracil, adenine and uracil, and adenine and cytosine. Preparation of these compounds is described elsewhere[5]. All were split to give *b* nucleotides of purine bases, without the appearance of cyclic mononucleotides. Again, as an example, 1·25 μmoles of the dinucleotide of guanine and cytosine were hydrolysed to the extent of 85 per cent in 1 hr., with no accumulation of guanosine 2′ : 3′-phosphate. Under similar conditions, 1·3 μmoles of guanosine 2′ : 3′-phosphate were incubated with spleen fraction and 50 per cent still remained after 3 hr.

From these findings we conclude that the purine nucleotide residues in ribonucleic acid occur largely in the *b* form.

One of us (L. A. H.) is on leave from the National Institutes of Health, Bethesda, Maryland.

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April 10.

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# LETTERS TO THE EDITORS

*The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications*

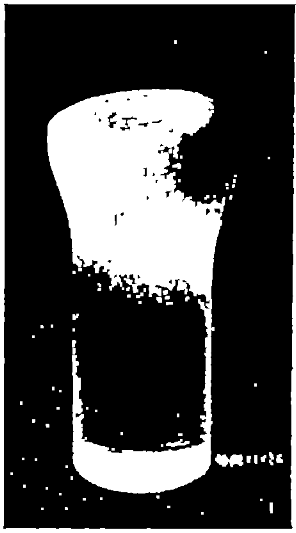
## Breakdown of Methyl Methacrylate Polymer by High-Energy Radiation

THE behaviour of polymethyl methacrylate ('Perspex') when exposed to high-energy radiation is markedly different from that of many other long-chain polymers such as 'Polythene' and polystyrene[1]. These latter develop cross-links forming a thermosetting material, whereas polymethyl methacrylate shows rapid breakdown after relatively short radiation doses. The nature of the changes produced is complex, and appears to vary with the temperature as well as the radiation dose.

Most of the irradiation work was carried out in the BEPO atomic pile at Harwell, at a temperature of about 70° C. Unit radiation dose is defined as a flux of $10^{17}$ slow neutron/cm.$^2$ plus the associated fast neutrons and gamma-rays. After exposure to some two units of radiation 'Perspex' loses its transparent appearance, expands and forms a white brittle material, consisting of a mass of bubbles. Higher radiation doses produce a white powder. If shorter radiation doses are given, there is no obvious change in the 'Perspex', apart from a yellowish tint which occurs in many organic compounds exposed in the pile. When these specimens are afterwards heated, internal bubbling occurs and the material expands to six to eight times its original volume. The temperature at which this change occurs is determined by the radiation dose—the nearer the radiation dose approaches 2 units, the lower the subsequent temperature needed to produce bubbling. Thus a radiation dose of only 0·1 unit is needed for bubbling to occur at a temperature of 140° C. This phenomenon is ascribed to the breakdown of the side-chains, releasing mainly carbon monoxide and dioxide and hydrogen. These are maintained under pressure inside the material until the temperature rise weakens the material sufficiently to allow bubbles to form.

An interesting observation is that bubbling does not occur within a distance of about 1 mm. from the free surface of a specimen. In this region 'Perspex' remains transparent, and tough. The expanded material therefore consists of an internal network of bubbled material surrounded by a thin and tougher coat. To explain the losses of weight observed in 'Polythene' on irradiation[2], it was necessary to assume that certain gases produced by radiation can only escape from the polymer if they are liberated within a small distance from the surface. In the present work on polymethyl methacrylate, this assumption has been justified. Thus a specimen irradiated for 1·1 units, and afterwards heated for a short time to produce a small amount of bubbling, had a 'free zone' (without bubbles) about 1 mm. in thickness and following the surface contours. This free zone is not due to some form of low-penetrating radiation nor to the presence of oxygen. The assumption of diffusion over a limited distance must therefore be accepted.

The same effect has been produced by irradiation with pure gamma-radiation from a cobalt-60 source. Fig. 1 shows a rod of 'Perspex', irradiated in a non-uniform γ-flux, and afterwards heated to produce bubbling. The end of the rod subjected to the highest radiation dose shows considerable expansion, whereas the opposite end is apparently unaffected. If the radiation takes place at 20° C., considerable doses can be absorbed without any obvious effects on the specimen. If it is then left standing for several months, intense cracking appears in the specimen, but no bubbling (Fig. 2). It would therefore appear that temperature above the second-order transition is needed for large-scale gas diffusion to take place.



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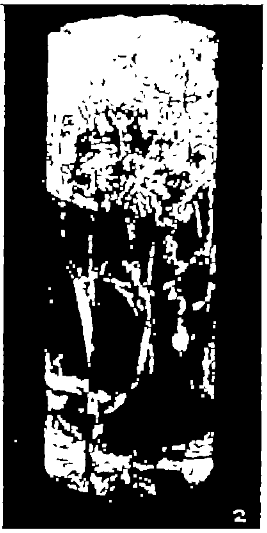

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One may perhaps envisage irradiated 'Perspex' being used as a heat-insulating material. Small blocks of the polymer can be placed inside a vessel and, by heating, expanded *in situ* to give a bubbled material filling the required volume.

Fuller details will be published elsewhere[3].

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M. ROSS
Atomic Energy Research Establishment,
Harwell, near Didcot, Berks. April 9.

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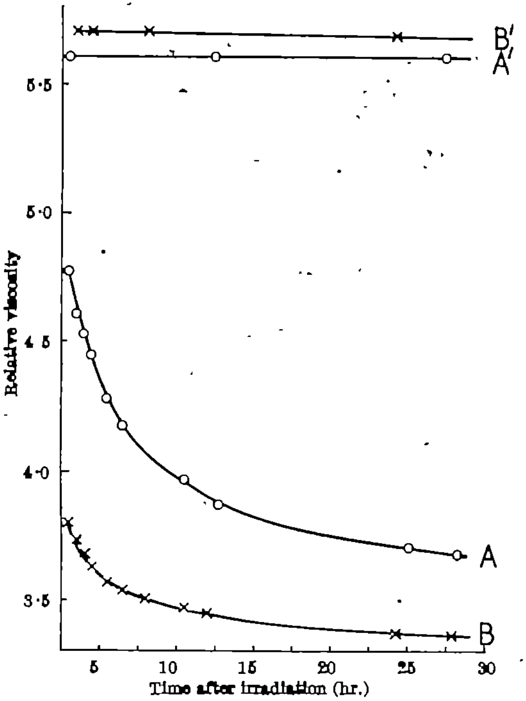
## 'After-effect' in Aqueous Solutions of Deoxyribonucleic Acid Irradiated with X-Rays

IT has been known for some time that the irradiation of aqueous solutions of deoxyribonucleic acid with X-rays leads to a loss of viscosity[1]. However, apart from any drop in viscosity during the irradiation, it has been observed by several workers[1,2] that there is also an 'after-effect' in these solutions, namely, a slow decrease of viscosity which continues for some time after the actual irradiation.

Although recent work[3] has to a large extent clarified the nature of this after-effect, a certain amount of confusion still exists with regard to its extent under different experimental conditions. Butler and Conway[4] have stated that the after-effect is only observed when molecular oxygen is present in the solution during the irradiation, and they have suggested that the effect is due to a slow decomposition of a peroxidic derivative of the deoxyribonucleic acid which is formed by the $HO_2$ radicals present under these conditions. At first these authors concluded that the substance formed was similar to a dialkyl-peroxide. However, in a subsequent



Change of viscosity of 0·1 per cent aqueous solutions of thymus deoxyribonucleic acid (Signer) after irradiation with X-rays (200 kV.). Total dose, 6,000 rep. (dose rate, 1,000 rep /min.). Curve *A*, Irradiation in the presence of atmospheric oxygen; curve *B*, irradiation *in vacuo*. *A'* and *B'* refer to the corresponding unirradiated control solutions

publication[4] they reported the presence of hydrogen peroxide and suggested that hydroperoxides were formed by the reaction between deoxyribonucleic acid and $HO_2$ radicals and that the latter are solely responsible for the after-effect.

Contrary to this view, we have always considered that the after-effect in deoxyribonucleic acid solutions is due to a slow hydrolysis of labile substances (for example, labile phosphate esters) which are formed from the deoxyribonucleic acid, particularly by the oxidizing radicals produced in the irradiation process. However, on this basis it would be difficult to understand that the after-effect should only occur in the presence of molecular oxygen, because it is well known[5] that (oxidizing) OH radicals are also present in evacuated solutions, as they are formed by the action of the ionizing radiation on water (equation 1).

We have therefore irradiated deoxyribonucleic acid solutions, under oxygen-free conditions, and have, in fact, observed a definite after-effect on the viscosity. The accompanying graph shows the results obtained for a highly polymerized 'Signer' deoxyribonucleic acid specimen, relative viscosities being determined in an Ostwald viscometer; very similar results were obtained with a number of different samples of nucleate.

In all cases the after-effect *in vacuo* was about one-third of that obtained in the presence of oxygen. Thus, the effect of oxygen is only one of enhancement, and this observation is in complete agreement with experiments on a number of other substances[6] (for example, the formation of acetaldehyde from alcohol, of pyruvic acid from lactic acid and from alanine, etc.), where the ratios of the yields in the absence and presence of oxygen were always found to be between one-third and one-sixth, depending on the substances and on the experimental conditions.

In general, the reaction, in the absence of molecular oxygen, can be explained by the following mechanism ($RH$ = solute):

$$\text{Primary radiation process}^5: H_2O \rightsquigarrow H + OH \quad (1)$$

$$RH + OH \rightarrow R^\cdot + H_2O \quad (2a)$$

$$R^\cdot + OH \rightarrow \text{product} \quad (2b)$$

$$\text{Back reactions}\begin{cases} H + OH \rightarrow H_2O & (3) \\ R^\cdot + H \rightarrow RH & (4) \end{cases}$$

In the presence of molecular oxygen, however, one will have the reactions:

$$H + O_2 \rightarrow HO_2 \quad (5)$$

and

$$R^\cdot + O_2 \rightarrow RO_2^\cdot \rightarrow RO_2H \rightarrow \text{product} \quad (6)$$

Thus the back reactions (3) and (4) may be largely inhibited, leading to an increased yield.

It is therefore clear from the reactions outlined above that, although molecular oxygen is not a decisive factor, nevertheless its presence can enhance very considerably the attack on the nucleic acid.

Our views on the after-effect have been confirmed already to some extent by our recent experiments[7] substantiating our earlier suppositions that labile compounds are formed; we have, in fact, been able to demonstrate the presence of labile phosphate esters in irradiated nucleic acid solutions.

A full account of this work will be published elsewhere. Our thanks are due to Prof. R. Signer for supplying several samples of deoxyribonucleic acid.

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## Effect of Nitric Oxide on the Thermal Decomposition of Ethyl Nitrate

We have noted with interest the recent communications of Style *et al.* regarding the reaction between diethyl peroxide and nitric oxide in the gas phase, and the inhibition of the thermal decomposition of diethyl peroxide[1]. It has been customary to assume that nitric oxide inhibits reactions in the gas phase by the removal of active free radicals with the formation of compounds of the type $R$.NO, where $R$ is the radical. As Style points out, however, inhibition by nitric oxide may not necessarily indicate a free radical mechanism.

We have recently made observations in the course of experiments on the thermal decomposition of ethyl nitrate[1] in the presence of nitric oxide which would tend to support this idea. During these experiments, the maximum pressure of nitrogen dioxide attained is never more than 10 per cent or so of the initial pressure of ethyl nitrate. However, if nitric oxide is present initially, the nitrogen dioxide produced is considerably increased and the time at which maximum pressure occurs is markedly reduced. This is illustrated in the accompanying table.

| Pressure of ethyl nitrate (mm. Hg) | Pressure of nitric oxide (mm. Hg) | Max. pressure of nitrogen dioxide (mm. Hg) | Time of nitrogen dioxide max. (min.) |
|---|---|---|---|
| 54·2 | 0·0 | 6·0 | 28 |
| 47·9 | 6·1 | 6·5 | 12 |
| 53·6 | 12·9 | 11·5 | 8 |
| 52·4 | 25·1 | 16·0 | 7 |

These figures are supported by gas analyses at the maxima, and calculation shows that the nitrogen dioxide could not result solely from the thermal fission of the ethyl nitrate. Hence we are led to the conclusion that nitric oxide itself reacts directly with ethyl nitrate, thus:

$$C_2H_5ONO_2 + NO \rightarrow C_2H_5ONO + NO_2 + 5 \text{ k.cal.}$$

In contrast to earlier claims[2], the initial rate of pressure increase in the experiments above is decreased by the same order of magnitude as is observed when nitrogen dioxide is added. This is to be expected, since ethyl nitrate is to some extent rapidly converted to ethyl nitrite, which is known to decompose appreciably slower in the same temperature-range, lowering the overall rate. Some independent evidence that ethyl nitrite is present comes from the work of Levy[3], who, from an infra-red examination of the products of ethyl nitrate decomposition, claims the existence of up to 70 mole per cent of ethyl nitrite.

Full details of our work will be published elsewhere; but it is clear that the above type of reaction involving nitric oxide will have importance not only in nitric ester decomposition, but also in other allied investigations.

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## Oscillating Droplets

An increasing amount of work is being carried out on the behaviour of drops of solvent rising or falling in water, in order to investigate the rate-determining steps involved in solvent extraction. Previous work in these laboratories using mutually saturated phases demonstrated that in packed columns the statistical mean volume-surface diameter is proportional to $(\gamma/\Delta\rho g)^{1/2}$ when the packing size is above a critical value[1]. Later experiments have now shown that if the dispersed solvent phase contains an undistributed solute, for example, acetone, the droplets are larger than predicted, whereas no effect is observed if the solute is in the aqueous phase. A smaller increase in size is also obtained when the phases are pure but not mutually saturated.

Since the increase in size could have been caused by an increase in the interfacial tensions in these systems, measurements of the interfacial tensions were made using the pendant-drop method of Andreas *et al.*[2]. The drop was formed with a hypodermic syringe and an enlarged image was projected on to a screen; ciné-photographs were also taken. It was observed that the surfaces of the drops were invariably disturbed by rippling and the drops themselves were subjected to erratic pulsations; in addition, the change in the interfacial tension, if any, measured between pulsations, was in the wrong direction to account for the increased droplet size. It was possible to follow the flow pattern from the refraction lines, and it could be seen that the pulsations were apparently associated with 'shock waves' originating within or on the surface of the drop. These waves passed through the interface, each causing a noticeable amount of transfer. When aluminium powder was suspended in the droplets a violent circulation was seen at the surface of the drop. This behaviour also occurred when the drops were completely detached from the capillary tip and was therefore not due to diffusion of solute from the bulk of the solvent into the drop.

A further investigation of solute transfer to and from droplets was then carried out using as solutes acetone, ethyl alcohol, acetic acid, nitric acid, hydrochloric acid, ferric chloride, cobalt chloride, ceric ammonium nitrate and uranyl nitrate. As solvents, diethyl ether, benzene, toluene, ethyl acetate, methyl *i*-butyl ketone, dibutyl carbitol and nitrobenzene were used. When these solutes passed from a solvent droplet to water, oscillations of the drops were observed in every case except with uranyl nitrate. Oscillations of water droplets suspended in a solvent phase were also observed when the transfer was into the droplets. With uranyl nitrate, oscillations were only obtained when the transfer was in the reverse direction. This suggests that the phenomenon is associated with the heat evolved in transfer, since heat is absorbed when uranyl nitrate passes from a solvent phase to water, whereas heat is evolved by the other solutes. The presence of surface-active materials such as proteins and detergents reduced the effect; this may indicate that the effect of the heat of transfer is to cause local variations in the interfacial tension, thereby disturbing the equilibrium of the droplet.

No oscillations were observed when droplets of pure unsaturated solvents were suspended in water. A slight effect was observed in some cases when organic solutes passed from water to a suspended solvent drop. McBain[3] has earlier reported a somewhat similar behaviour at plane liquid–liquid interfaces, which gives rise to micro-emulsification at the interface.

The present results indicate that the non-turbulent layers adjacent to the interface, postulated by Whitman[4], may be absent in certain conditions, and that the pulsations may be more effective in promoting transfer than molecular diffusion. Since the effect varies considerably from system to system, a comparison of transfer-rates for different systems must be carried out with circumspection.

Thanks are due to Mr. A. S. White for his interest and encouragement in this work, and to the Director,

Atomic Energy Research Establishment, for permission to publish this communication.

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# Electronically controlled Spectrographic Spark Source

In the past two decades, various types of high-voltage spectrographic spark sources have been developed, such as the so-called uncontrolled[1], mechanically controlled[2,3], auxiliary spark gap controlled[4,5] and electronically controlled[6-8] types.

In my laboratory a new electronically controlled spectrographic spark source system has been constructed, the wiring diagram of which is shown in Fig. 1. $T$ denotes a high-voltage transformer charging the condenser $C$ through the vacuum diode $V2$. $G1$–$G2$ is a twin spark gap to control the discharge of the condenser $C$.

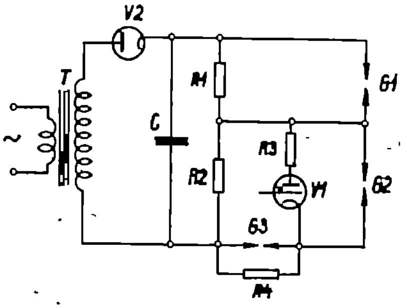

Fig. 1. Wiring diagram of the high-energy electronically controlled spark source. $C$, condenser; $G1$–$G2$, controlling twin spark gap, $G3$, analytical spark gap; $R1$, $R2$, $R3$, $R4$, ohmic resistors; $T$, high-voltage transformer; $V1$, gas-filled triode (thyratron); $V2$, rectifier tube

By means of resistors $R1$ and $R2$, the voltage appearing on the terminals of the condenser $C$ is uniformly distributed to the twin controlling spark gap $G1$–$G2$. $G3$ is the analytical spark gap, shunted as usual by the resistor $R4$. $V1$ is a gas-filled triode (thyratron) normally closed by a negative bias. The spark gaps $G1$ and $G2$ must be adjusted so that their breakdown is safely prevented before applying the firing pulse to the thyratron grid. The role of the ohmic resistance $R3$ will be dealt with later.

The system operates in the following manner. Condenser $C$ being charged to the maximum voltage produced by transformer $T$ during one half-period of the A.C. voltage wave, in the following half-period a positive voltage pulse is applied to the grid of the tube $V1$ closed by the negative bias, in consequence of which the tube fires. Thus, $R3$ being much smaller in value than $R1$ and $R2$ respectively, the lower electrode of spark gap $G1$ comes practically to cathode potential. As the common electrode of the twin spark gap $G1$–$G2$ is at cathode potential, the entire charging voltage of condenser $C$ appears on the electrodes of $G1$, which will break down owing to the approximately double voltage obtained. Then condenser $C$ begins to discharge through $G1$, the ohmic resistors $R3$ and $R4$ and the tube $V1$. As $G1$ is practically short-circuited owing to the breakdown previously mentioned and the resulting current flow, the greater part of the voltage on the terminals of condenser $C$ appears on the terminals of $R3$ and the spark gap $G2$ respectively, in consequence of which the latter also fires. $R3$ is assumed to be much larger in value than $R4$. After the breakdown at $G2$, the voltage on the terminals of condenser $C$ appears on those of resistor $R4$ and the analytical spark gap $G3$ respectively, so that the latter also breaks down. Now the discharge of condenser $C$ continues through $G1$, $G2$ and $G3$. The spark gaps $G2$ and $G3$ being broken down, the voltage on the terminals of the ohmic resistor $R3$ consists only of the arc voltage of $G2$, where the current flow will be quite negligible. Tube $V1$ is extinguished either at the end of the discharge of condenser $C$ or, if the frequency of the circuit is low, before the end of the discharge. This depends on the electrical characteristics of circuit $C$–$G1$–$G2$–$G3$ where, according to the requirements of the analysis, a self-inductance and an ohmic resistor can also be inserted.

The positive voltage pulses necessary to control tube $V1$ are supplied by means of a mechanical switch or electronically[8]. In the arrangement of Fig. 1, sparks can be produced at the rate of the mains voltage frequency or at a lower rate. Controlling the grid of $V1$ by means of a pulse generator, the number of sparks per second can be any subharmonic frequency of the mains. If the circuit in Fig. 1 is appropriately adjusted, the number of discharges per second can be twice as great, or more than the frequency of the mains voltage.

While the electronically controlled spark source in Fig. 1 has been especially devised to produce high-energy sparks, the apparatus in Fig. 2 is used to provide low-voltage condensed sparks and interrupted arcs. $T$, $V2$, $V3$, $C1$, $C2$ are the components of a conventional voltage doubler. Condenser $C3$ producing the actual spark energy is charged through resistor $R4$ from condensers $C1$ and $C2$. The remaining part of the circuit is the same as that of Fig. 1, with the difference that the spark gap $G3$ of Fig. 1 as well as resistor $R4$ are omitted. Condenser $C$ discharges through the spark gap $G1$–$G2$ and the Tesla transformer $A$, the voltage of which ignites the interrupted arc or the low-voltage condensed spark. The grid of the thyratron tube $V1$ can be controlled by any frequency desired.

More detailed descriptions of spark sources of similar design will appear elsewhere at later dates.

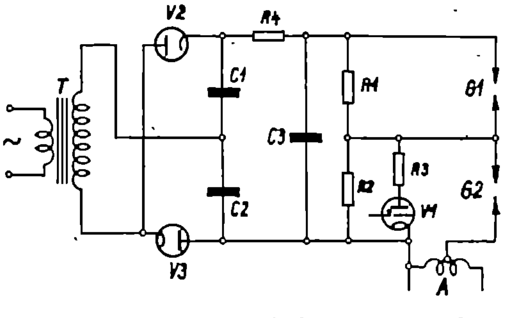

Fig. 2. Low-energy electronically controlled spark source. $A$, Tesla transformer; $C1$, $C2$, $C3$, condensers; $G1$–$G2$, controlling twin spark gap; $R1$, $R2$, $R3$, $R4$, ohmic resistors; $T$, transformer; $V1$, gas-filled triode (thyratron); $V2$, $V3$, rectifier tubes

The contribution of Á. Klatsmány to this work is gratefully acknowledged.

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## Effect of Continued Iron Administration on Growth

During studies on the effects of repeated parenteral administration of iron to mice, rabbits and guinea pigs, various toxic manifestations were observed[1]; but in general there was little effect on growth with either colloidal or diffusible forms of iron. One diffusible iron preparation, namely, 'ferric hydroxide ferrous ascorbate', however, depressed growth markedly. The results obtained with three iron preparations are summarized below.

(*a*) *Colloidal iron.* When iron in colloidal form is given in repeated sub-lethal doses, a large quantity may accumulate in the body before serious harm results. Mice lived two to three months after twelve weekly intravenous doses of 180 mgm. iron per kgm. of saccharated iron oxide, that is, a total dose of 2·16 gm. iron/kgm. There was no loss of weight in these animals until death supervened. The ultimate cause of death is not clear; but severe damage was noted in the lungs, liver and kidneys. Four one-week old mice injected daily with 40 mgm. iron/kgm. of saccharated iron oxide by the subcutaneous route gained weight normally until they reached adult size (seven weeks), the total dose given being 0·9 gm. iron/kgm. of their final body-weight (20 gm.). Two three-day-old guinea pigs injected daily with 40 mgm. iron/kgm. of the same preparation subcutaneously also continued to gain weight much the same as two control guinea pigs.

(*b*) *Diffusible iron.* Diffusible iron preparations behave differently both as regards toxicity and fate in the body, the results obtained depending on the nature of the non-ionized whole molecule of the iron compound[1,2]. Seven young guinea pigs, varying in age from two days to a few weeks and in weight from 75 to 320 gm., were given large doses of diffusible preparations of iron by repeated subcutaneous injections. Four of these received 11·25 mgm. iron/kgm. daily in the form of 'ferric hydroxide ferrous ascorbate', while the remaining three had 30 mgm. iron/kgm. daily in the form of 'ferric chloride caramelate'[1]. The latter group grew and gained weight without obvious deviation from the normal, during the whole period of the injections which lasted 63 days, their final weights being 496, 450 and 465 gm. The first four, however, died after 17, 27, 43 and 63 days respectively. Their growth was interfered with appreciably, and although they continued to increase in weight for a while, the rate of increase soon slowed down. In the case of guinea pigs 3 and 4, serious loss of weight was noted in the last few weeks of life, their final weights being 180 and 175 gm. There were hæmorrhages in the lungs and histological damage in the adrenals in all four guinea pigs.

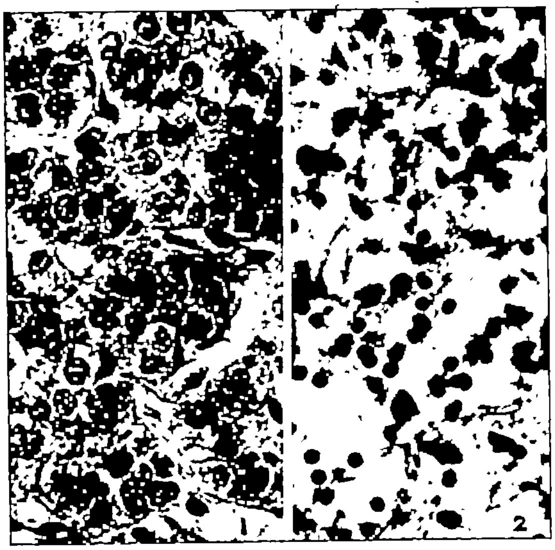

Fig. 1. Anterior pituitary of normal guinea pig showing large vesicular nuclei and abundant cytoplasm. Stained with carmalum. × 500

Fig. 2. Anterior pituitary of guinea pig 4, injected with 'ferric hydroxide ferrous ascorbate'. Section shows numerous pyknotic nuclei and wide spaces between atrophied cytoplasm of cells. Stained with carmalum. × 500

Growth retardation after injections of 'ferric hydroxide ferrous ascorbate' may be secondary to adrenal and lung damage, and could be caused through interference with the normal functioning of ascorbic acid. On the other hand, a direct interference with the functions of the pituitary seems likely. Sections of the pituitary in guinea pig 4 revealed iron staining in the cells of the anterior pituitary—a finding which is recorded in the experimental animal for the first time—and there was histological damage with atrophy of cells and pyknosis of nuclei in guinea pigs 3 and 4 (Figs. 1 and 2). Neither iron staining nor histological injury was detected in the pituitaries of animals receiving saccharated iron oxide or 'ferric chloride caramelate'.

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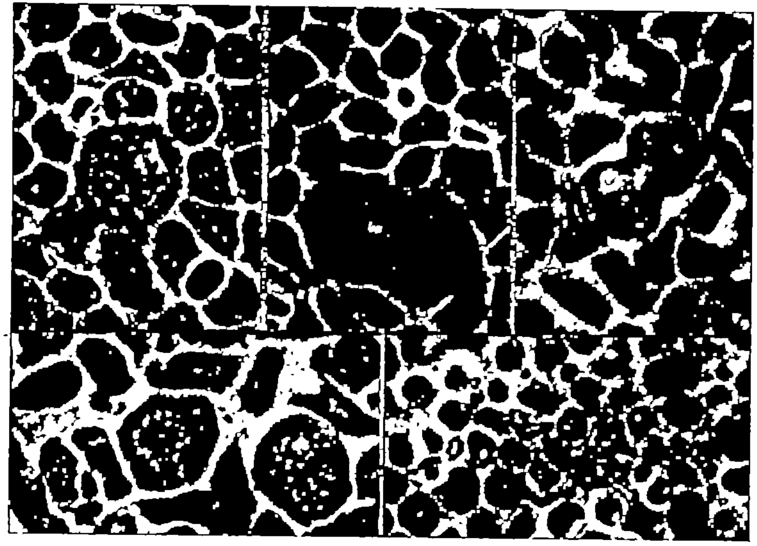
## Effect on Lymphocytes of Ionizing Radiation

The increasing use of radioactive material makes the biological assay of the effects of ionizing radiation of importance. Lymphocytes are agreed to be the most sensitive mammalian cells available for the study of such effects; Trowell[1] has recently published his findings using whole animals and organs. Elsewhere, one of us[2] has described a method whereby human cells can be maintained alive for periods up to fourteen days without the elaboration of traditional tissue culture technique. All that is needed is 3 per cent agar in distilled water, of which 1 c.c. is added to 2 c.c. of equal parts of human serum



All photographs are of living serum agar cultures of human lymph glands. Phase contrast. × 1,400

Figs. 1-4. Mitosis in non-irradiated cultures, the photographs are of different cells

Fig. 5. Culture 24 hr. after irradiation with 90 r.

and Tyrode's solution. Small squares of agar are cut out of poured plates, and mounted on microscope slides. If human lymph glands are scraped with a scalpel, the resultant juice may be planted on this agar; a cover-slip is applied and the preparation is sealed with paraffin wax. The lymphocytes move actively at 37° C., and several types of cells may be recognized; some of these proceed readily to mitosis.

A small radium applicator mounted in lead has been used so that 350 r. of gamma radiation could be administered per hour to the culture. Within one hour of the application of 350 r., marked nuclear changes occur in the small lymphocytes; larger cells, probably from the reticulo-endothelial system, are not affected. The lymphocytes become progressively less motile, and most of them necrose within twenty-four hours after a series of nuclear changes. Controls survive and move actively for at least five days.

Normal lymph glands are readily obtained from the omentum in cases of gastrectomy for peptic ulcer.

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## Effect of Acetoacetate on the Succinic Acid Oxidase System

The effect of alloxan, a well-known diabetogenic substance, on blood glutathione[1] and enzymes[2] indicates that it is possible that its diabetogenic action may be through its effect on enzyme systems. Lazarow[3] has discussed this possibility at length, and has also suggested that acetoacetic acid or a related compound may have a direct toxic action on the enzymes in the beta-cells of the pancreas and may thereby have an alloxan-like action. The recent findings reported from this laboratory that blood glutathione is lowered by acetoacetate injection may serve as an additional indication of acetoacetate acting adversely on sulphydryl enzymes. In a preliminary observation on a simple —SH enzyme papain[5], it was noticed that acetoacetate could completely inactivate the enzyme at a concentration of 16 m*M*.

We have now investigated the effect of acetoacetate on the succinic oxidase system. This system was chosen for investigation because: (i) it is the simplest —SH enzyme known to be present in almost all tissues, including the beta-cells of the pancreas; and (ii) it is an important member of Krebs's tricarboxylic acid cycle.

Succinic oxidase activity was estimated in a Warburg apparatus by the method of Schneider and Potter[6], using rat liver homogenate as the source of the enzyme, the substrate being at a concentration of 0·03 *M*. When both the enzyme and acetoacetate were added simultaneously to other reactants, it was observed that acetoacetate effectively inhibits the enzyme only in concentrations comparable to that of the substrate. Thus acetoacetate in a concentration of 0·04 *M* was found to inhibit the activity to the extent of 79·2 per cent. Only 18 per cent inhibition was noted in presence of 0·0024 *M* acetoacetate. The effect of intermediate concentrations of acetoacetate showed that its action is progressive, the inhibitory effect depending on the time of incubation as well as on the concentration of the inhibitor.

When the tissue homogenate is subjected to preliminary incubation in the side-arm with acetoacetate prior to its addition to other reactants in the main compartments of the Warburg flask, extremely small amounts of the inhibitor are found to be effective. Thus $2 \times 10^{-4}$ *M* concentration of acetoacetate completely inhibited the enzyme activity. The least concentration of acetoacetate to obtain observable inhibition (8 per cent) is $0 \cdot 4 \times 10^{-4}$ *M*.

*Protection of the enzyme with glutathione.* It was found that glutathione protected the enzyme only when it was present prior to the addition of acetoacetate to the enzyme. When added after the action of the inhibitor on the enzyme was complete, it usually failed to reverse the inhibition. Protection to the extent of only 80 per cent activity was afforded by $2 \cdot 6 \times 10^{-3}$ *M* glutathione. It will thus be clear that the enzyme cannot be completely protected even when the concentration of glutathione is more than several times the molecular equivalent of acetoacetate; $3 \cdot 2 \times 10^{-4}$ *M* glutathione gives 12 per cent protection to the activity of the enzyme. All experiments on protection with glutathione were conducted in presence of that concentration of acetoacetate which completely inhibits the enzyme.

Probably the carbonyl function of the acetoacetate molecule reacts with the active sulphydryl group of the enzyme, thus making it impossible for the substrate succinate to form the enzyme-substrate complex.

The results presented here indicate that an accumulation of over-production of acetoacetate may upset the normal carbohydrate metabolism. It may interfere either directly, inhibiting the —SH enzymes, or by affecting the glutathione content of the cells. Glutathione, the naturally occurring tripeptide, serves to protect the —SH enzymes of the cells and thus maintains them in an active state. Several enzymes in the beta-cells of the pancreas may also require active sulphydryl groups[6]. If these are involved in insulin synthesis, then acetoacetate at high concentration may inhibit the production of insulin also. Certain observations by Nath and Brahmachari[7] indicate that some such disturbances can be induced by acetoacetate in the production of insulin in the living system.

A detailed report regarding these investigations will be published elsewhere. We are grateful to the Indian Council of Medical Research for the award of a research grant to one of us (V. G. H.).

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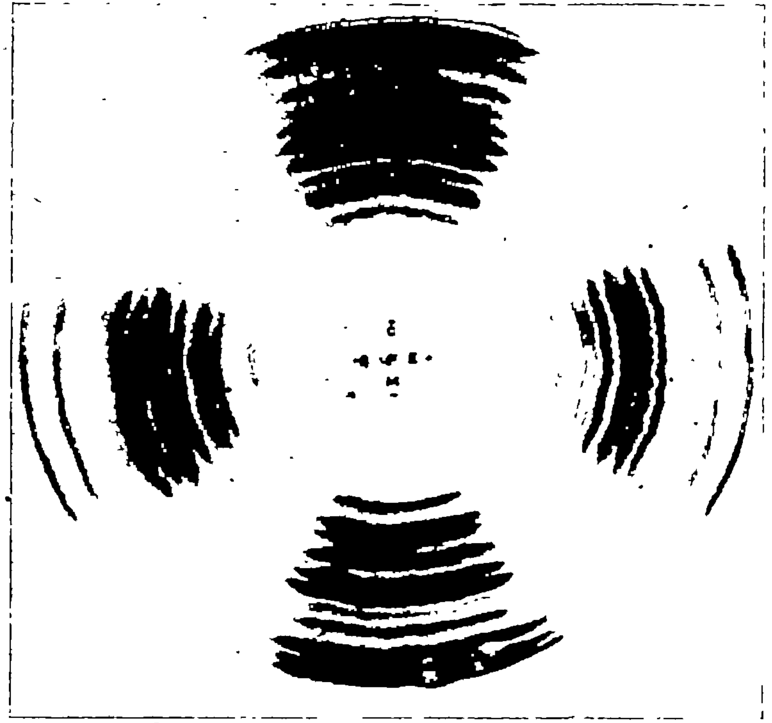
## Filter-Paper Disk Chromatography

In a recent communication by Proom and Woiwod[1] commenting on circular paper chromatography, they state: "although the method is admirable for the separation of two or three substances, it is not a satisfactory substitute for large-scale paper chromatography in the separation of more complex mixtures such as protein hydrolysates".

A brief description of this technique was communicated on October 4, 1951, and first published in the November 1951 issue of *Current Science*[2]. A modification of this technique for the separation and identification of amino-acids was communicated to *Nature* on November 19, 1951, and published in *Nature* of May 31, 1952[3]. The paper by Proom and Woiwod[4] was published in the October 1951 issue of the *Journal of General Microbiology* and was received in India early in 1952. We could not, therefore, notice this paper before we communicated ours for publication. It is obvious that our technique was developed independently of Proom and Woiwod's report.



Chromatogram showing the separation of amino-acids present in the hydrolysates of casein (*C*), gelatin (*G*) and edestin (*E*). *M*, mixture of known amino-acids. Whatman No. 1 filter paper (18¼ in. × 22¼ in.), *n*-butanol – acetic acid – water (40 : 10 : 50), solvent used. 20 µl. of hydrolysate (12·5 per cent nitrogen) spotted

Our experience with this technique for the past one and a half years and the results so far obtained by the application of this technique to the separation of amino-acids in protein hydrolysates show without any doubt that it is well suited to the separation, identification and even quantitative estimation of most of the amino-acids present in protein hydrolysates, as is evident from the papers published by us[5]. The failure to achieve separation of a large number of amino-acids present in protein hydrolysates by this technique as reported by Proom and Woiwod is probably due to the use of solvents such as *m*-cresol and small-size filter papers (12·5 cm. diameter) in the investigations reported in their paper. We have been able to separate all the amino-acids present in protein hydrolysates by using *n*-butanol – acetic acid – water (40 : 10 : 50), pyridine – water (80 : 20); and pyridine – amyl acetate – water as solvent mixtures. The use of large-size (35 cm. diameter) filter papers is found to be more advantageous for better resolution. The accompanying photograph is of a typical chromatogram showing the separation of amino-acids present in casein, gelatin and edestin hydrolysates into as many as eleven distinct bands on a large sheet of filter paper (22¼ in. × 18¼ in.).

The wide application of this technique to the investigation of many problems in this laboratory indicates its value in chromatographic analysis.

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## Use of Unneutralized Hydrolysates in Paper Chromatography of Sugars

IN preparing hydrolysates of polysaccharides for paper chromatography, it has always been considered necessary to neutralize the sulphuric acid with barium carbonate before applying the solution to the paper, as the acid causes disturbing stains. Indeed, when using an ammoniacal silver spray, white stains appear at the place where the spots of glucose and galactose should be; but the flow of the sugars does not seem to be disturbed.

It occurred to me that an acid spray as, for example, aniline phthalate or phosphate, would not be impeded by the acid of the hydrolysate. In order to examine this, I carried out some experiments with (1) a simple solution of some sugars in *N* sulphuric acid; (2) a polysaccharide hydrolysate.

From both solutions chromatograms were made without previous neutralization, using benzene–butanol–pyridine–water (1–5–3–3) as a solvent and aniline phosphate as a spray. All sugars and uronic acid showed up clearly at their usual places, whereas no stains of the acid could be detected.

Quantitative determinations were also made on both solutions before and after neutralization, using rhamnose as a reference sugar. The sugar zones were eluted under reflux and the sugars estimated colorimetrically[1].

The results were as follows:

SOLUTION OF SUGARS IN *N* SULPHURIC ACID

| | mgm. added | mgm. found: in acid solution | mgm. found: in neutral solution |
|---|---|---|---|
| Galactose | 10 | 10·0 | 10·4 |
| Glucose | 10 | 9·6 | 9·4 |
| Arabinose | 20 | 20·2 | 19 8 |
| Xylose | 40 | 39·8 | 39·0 |

POLYSACCHARIDE HYDROLYSATE

| | Acid hydrolysate | Neutralized hydrolysate |
|---|---|---|
| Galacturonic acid | 2·6 per cent | 2·8 per cent |
| Galactose | 1·2 ,, | 1 5 ,, |
| Glucose | 3·8 ,, | 3·6 ,, |
| Arabinose | 8·7 ,, | 8·6 ,, |
| Xylose | 67·1 ,, | 65·6 ,, |

The results obtained show clearly that it is not necessary to neutralize the hydrolysates of polysaccharides before applying them to paper chromatograms, provided an aniline phosphate or phthalate spray is used.

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## Detection of some Precursors of Adrenaline by Paper Chromatography

DURING studies on the biosynthesis of adrenaline, both *para*- and *meta*-hydroxyphenylethanolamine have been found to form noradrenaline following ultra-violet irradiation in the presence of air[1]. Whereas the *para* compound has been identified in *Octopus vulgaris*[2], the *meta* compound has not hitherto been found occurring naturally. Their detection in biological materials is a major problem. With the aid of paper chromatography, using a solvent of butanol (4 vol.), glacial acetic acid (1 vol.) and water (5 vol.), we have found that the *meta* compound exhibits an intense violet fluorescence under ultra-violet light when the developing agent is a mixture of 9 vol. of a solution of either potassium ferricyanide or dichromate (0·66 per cent) and 1 vol. of formaldehyde (40 per cent), followed by exposure to heat (100° C.) for 5 min. As little as 0·5 μgm. ($R_F$ value 0·56) can be identified by this test. Development with the *p*-nitraniline reagent[3] results in a dark red spot (similar to that produced with the *para* compound), but this test is only sensitive to 5 μgm.

Using the mixture of ferricyanide (but not dichromate) and formaldehyde as developer, followed by heating at 100° C., we have now found that noradrenaline ($R_F$ value 0·28) exhibits a turquoise fluorescence in ultra-violet light, and as little as 0·2 μgm. can easily be detected on chromatography paper. Under similar conditions, adrenaline ($R_F$ value 0·36) shows a yellow-green fluorescence if a minimum of 0·4 μgm. is present. Adrenaline in simple alkaline solution develops a transient green fluorescence, and Gaddum and Schild[4] in 1934 directed attention to the specificity of this reaction at low concentrations. Many substances chemically related to adrenaline (for example, noradrenaline and dihydroxyphenylalanine) produce the same green fluorescence only in much stronger concentrations. For example, West[5] found that noradrenaline is about thirty-three times less active than adrenaline in this test.

Using chromatography and the new developer (ferricyanide and formaldehyde mixture), noradrenaline is twice as active as adrenaline, so that very small amounts of noradrenaline can be detected in the presence of much larger quantities of adrenaline. Under similar conditions, both hydroxytyramine ($R_F$ value 0·39) and dihydroxyphenylalanine ($R_F$ value 0·19) show a yellow fluorescence if a minimum of 1·0 μgm. is present.

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## Occurrence of Hydroxylamine in Lake Waters as an Intermediate in Bacterial Reduction of Nitrate

THE occurrence of hydroxylamine as an intermediate of the enzymatic reduction $NO_3^- \rightarrow NH$ or oxidation $NH_3 \rightarrow NO_2^-$ has recently interested many biochemists[1]. Thus certain authors have been able to confirm the formation of this compound in the process of the oxidation or reduction of nitrogen compounds[2,3].

The following observations (see table) show that hydroxylamine occurs in the water of Kizaki-ko, a mountain lake in Central Japan, mesotrophic in nature and with a maximum depth of 29·5 m. In this lake, in the middle of autumn, there appears every year a very pronounced stratification of inorganic nitrogen compounds. At the beginning of summer, the nitrate increases with increasing depth and as the period of stagnation proceeds, the oxygen content decreases in the bottom layers. In these layers, the activities of nitrate-reducing bacteria

Vertical Distribution of Oxygen and Inorganic Nitrogen Compounds in Lake Kizaki-ko

(1) June 3, 1952. Bottom reached: 29 m.

| Depth (m.) | Water temperature (° C.) | Dissolved oxygen (c.c./l.) | Nitrate nitrogen (mgm./l.) | Nitrite nitrogen (mgm./l.) | Hydroxylamine nitrogen (mgm./l.) | Ammonia nitrogen (mgm./l.) |
|---|---|---|---|---|---|---|
| 0 | 16·25 | 6·69 | <0·02 | <0·001 | <0·001 | 0·018 |
| 2·5 | 15·78 | 7·07 | ,, | ,, | ,, | 0·012 |
| 5 | 15·68 | 6·83 | ,, | ,, | ,, | 0·016 |
| 7·5 | 13·71 | 6·83 | ,, | ,, | ,, | 0·030 |
| 10 | 9·93 | 7·04 | ,, | ,, | ,, | 0·016 |
| 12·5 | 8·83 | 6·84 | ,, | ,, | ,, | <0·01 |
| 15 | 8·08 | 6·02 | ,, | 0·0075 | tr. | ,, |
| 17·5 | 7·36 | 6·02 | 0·04 | <0·001 | <0·001 | 0·012 |
| 20 | 6·81 | 6·03 | 0·04 | ,, | ,, | <0·01 |
| 22·5 | 6·60 | 5·99 | 0·06 | ,, | ,, | 0·018 |
| 25 | 6·42 | 5·83 | 0·05 | ,, | ,, | 0·018 |
| 27·5 | 6·40 | 5·22 | 0·05 | ,, | ,, | 0·018 |
| Above the bottom* (cm.) | | | | | | |
| 20 | | 4·63 | 0·06 | <0·001 | <0·001 | 0·018 |
| 10 | | 4·63 | 0·06 | ,, | ,, | 0·022 |
| 5 | | 4·79 | 0·07 | ,, | ,, | 0·030 |
| 0 | | 5·07 | 0·04 | ,, | ,, | 0·030 |
| (2) September 5, 1952. Bottom reached. 28·5 m. | | | | | | |
| 0 | 24·8 | 5·77 | <0·02 | <0·001 | <0·001 | <0·01 |
| 2·5 | 24·71 | 5·67 | ,, | ,, | ,, | 0·018 |
| 5 | 24·60 | 5·45 | ,, | ,, | ,, | 0·018 |
| 7·5 | 18·90 | 5·71 | ,, | ,, | ,, | 0·018 |
| 10 | 13·82 | 4·86 | ,, | ,, | ,, | 0·016 |
| 12·5 | 10·76 | 4·33 | 0·08 | ,, | ,, | 0·016 |
| 15 | 9·74 | 4·30 | 0·07 | ,, | ,, | 0·018 |
| 17·5 | | 4·08 | 0·15 | ,, | ,, | 0·018 |
| 20 | | 1·98 | 0·20 | ,, | ,, | 0·016 |
| 22·5 | | 1·78 | 0·16 | ,, | ,, | 0·018 |
| 25 | | 0·56 | 0·28 | ,, | ,, | 0·018 |
| 26 | | | 0·28 | 0·004 | 0·004 | 0·018 |
| 27·5 | | | 0·19 | 0·012 | 0·007 | 0·016 |
| 28 | | | 0·11 | 0·014 | 0·011 | 0·016 |
| Above the bottom* (cm.) | | | | | | |
| 40 | | 0·42 | 0·09 | 0·016 | 0·011 | 0·020 |
| 20 | | 0·31 | 0·08 | 0·019 | 0·011 | 0·020 |
| 5 | | 0·49 | 0·06 | 0·019 | 0·011 | 0·020 |
| 0 | 6·60 | 0·39 | 0·05 | 0·015 | 0·021 | 0·023 |

* These samples were collected by a special sampler devised in our laboratory.

become vigorous, and stratification of nitrogen compounds results. A regular decrease in nitrate from the layer at 26 m. down to the bottom corresponds to a regular increase in nitrite and hydroxylamine. Thus it seems that these two compounds are produced by the bacterial reduction of nitrate, favoured by an environment poor in oxygen.

Determination of hydroxylamine was carried out using the modification proposed by R. Novak and P. W. Wilson[2]. Details of the present investigation will be published elsewhere.

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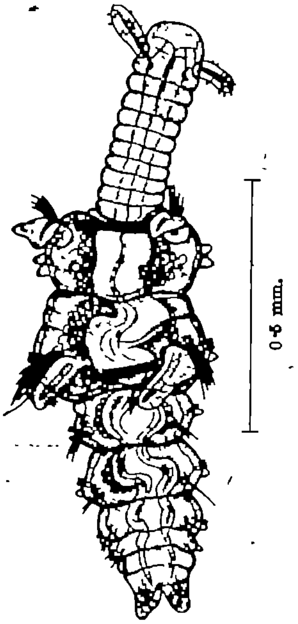
## Asexual Reproduction in *Pygospio elegans* Claparède (*Polychaeta sedentaria*)

DURING the course of an ecological investigation of the polychaete annelid *Pygospio elegans* Clap., a remarkable mode of asexual reproduction was noticed. The species were collected at the small island of Vorsø in the Horsensfjord (East Jutland, Denmark) and the phenomenon was first observed in April 1949.

*Pygospio* lives in quite shallow water, where its thin tubes are found vertically in the sandy bottom. Normally, it has sexual reproduction with pelagic or non-pelagic larvae according to different quantities of nurse eggs[1]. It has now been found able to reproduce asexually. The bodies of the adults, both males and females, divide into pieces consisting of varying numbers of segments, generally about three or four, sometimes up to seven; several times fragments consisting of one segment only have been observed. Fission takes place in any part of the body. When just separated, the single fragment looks as if it had been cut off with a knife. After the division, the series of fragments will stay in the tube until each has developed into a new animal. The fragments are very active and move up and down in the tube, which they never leave, however, until regeneration is completed. Every single fragment is able to form a new individual exclusively from its own tissue. The rate of regeneration is very high, and at 20° C. the regeneration of a new animal was completed in eight days; then the asexually formed individual will start a new division process. The original fragment is so closely incorporated into the new animal that no difference between old and new segments can be seen. So far as I know, this is the first case of asexual reproduction described in a species of the family Spionidae.

At Vorsø, asexual development can be found at any time of the year; as a rule only a few adult individuals are seen dividing. In the early spring, however, just after normal sexual reproduction has ceased (at Vorsø sexual breeding occurs in winter), asexual reproduction rises to a maximum.

In 1949, the asexual period was rather short (from the end of April to the beginning of May) and nearly all adult animals examined were dividing.



In 1950 the period was much longer (from the middle of March to the end of April), and only a minor part of the adult population was dividing.

Preliminary experimental work has shown that temperature significantly influences the asexual reproduction. Outside the natural period of asexual reproduction, it is possible to induce fission and regeneration by exposing adults to temperatures of 4–5° C. Weather observations from the spring periods of 1949 and 1950 seem to confirm the importance of temperature. In 1949 the break of the frost occurred very suddenly and in a short time the average temperature of the day period increased to about 10° C., while in 1950, the rise of temperature occurred very slowly; this may explain the differences in the asexual breeding in 1949 and 1950.

The mode of reproduction described above, when occurring generally, may have interesting ecological effects. Thus if the organism is decimated by a severe winter, asexual breeding will make possible a rapid recovery of numbers.

Further investigations of *Pygospio elegans* have been made at other Danish localities, especially the Isefjord (Zealand), and at various seasons; but so far asexual reproduction has only been observed at Vorsø in the Horsensfjord.

The accompanying drawing shows two segments of a mature male *Pygospio* with regenerated head and tail part, the head being the younger section. The investigations are being continued, and later on a more detailed report will be published elsewhere.

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## A Gene for Photoperiod Sensitivity in Rice linked with Apiculus Colour

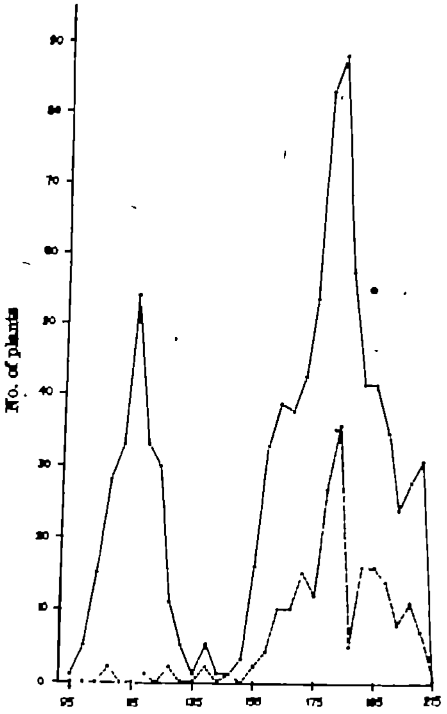
LACK of appreciation of the importance of length of day in determining the onset of flowering has vitiated much of the earlier work on the inheritance of age in rice. No genetic analysis of photoperiod response in this plant has yet been published. In the past two years, I have investigated the inheritance of photoperiod sensitivity. The Ceylon pure line, Vellai Ilankalayan 28061, which blooms approximately one hundred days after sowing, and is relatively insensitive to the photoperiod, was crossed with the Burma lines, *MLYC* 401 and *HMC* 12, which have, in the short days of the North-East Monsoon season, about the same sowing-to-flowering interval as the former, but are, to a high degree, sensitive to the photoperiod. The annual variation in length of day in Ceylon (lat. 5°-55′–9° 50′ N.) is less than one hour, but this variation exerts a profound influence on the flowering of the sensitive varieties. The growing of segregating progenies in the long days of the South-West Monsoon season makes the separation of sensitive and day-neutral forms possible. The parents and the $F_1$ and $F_2$ generations were sown at the same time, namely, May 1, 1952, at the Rice Research Station, Batalagoda. The mean intervals from sowing to panicle emergence for the parents and the $F_1$ are shown in Table 1.

Table 1

| Generation | Mean No. of days from sowing to panicle emergence |
|---|---|
| Parents { Vellai Ilankalayan 28061 | 105 ± 2·65 |
| Parents { *MLYC* 401 | 164 ± 2·29 |
| $F_1$ | 169 ± 1·87 |

Sensitivity shows complete dominance in the $F_1$ generation. The apparent heterosis is not significant. The segregation of the $F_2$ is illustrated in the accompanying graph, and is seen to be bimodal. The first mode corresponds to the emergence of the day-neutral segregates, and the second to the sensitive segregates. The numbers in the two classes fit well, as is shown in Table 2, into a monohybrid ratio, and indicate the determination of sensitivity by a single pair of genes to which I propose assigning the symbols, *Se se*.

The analysis of the $F_2$ segregation revealed the linkage of sensitivity with apiculus colour, *Ap ap*. The genes enter the cross in the repulsion phase, *Se ap/se Ap*; Vellai Ilankalayan 28061 is homozygous for the dominant purple apiculus, and *MLYC* 401 for the recessive white apiculus. The distribution of



Segregation in $F_2$ for sensitivity and apiculus colour. ——, total plants; – – – –, plants with white apiculus

Table 2

| | No. of plants in $F_2$ segregation | | |
|---|---|---|---|
| | Sensitive | Day-neutral | Total |
| Observed | 666 | 216 | 882 |
| Expected on 3 : 1 ratio | 661·5 | 220·5 | 882 |

$\chi^2 = 0·122$; $P = 0·95 - 0·50$.

plants with a white apiculus is illustrated in the graph. The observed numbers of plants in the $F_2$ classes and the expectations based on independence are given in Table 3.

Table 3

| | No of plants in $F_2$ segregation | | | | |
|---|---|---|---|---|---|
| | Sensitive, apiculus purple | Sensitive, apiculus white | Day-neutral, apiculus purple | Day-neutral, apiculus white | Total |
| Observed | 470 | 196 | 211 | 5 | 882 |
| Expected on 9 3·3:1 ratio | 496·1 | 165·4 | 165·4 | 55·1 | 882 |

$\chi^2 = 197·276$, $P < 0·01$.

The cross-over value for the two pairs of genes estimated from the $F_2$ is 16·3 ± 3·26 per cent.

Photoperiod sensitivity showed similar $F_2$ segregation and linkage with apiculus colour in crosses with *HMC* 12.

A full account of this work will be published elsewhere.

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## Contamination of *Azotobacter chroococcum* by Gram-negative Bacterial Rods

IN a recent investigation, it proved virtually impossible to obtain a pure culture of *Azotobacter chroococcum*. After initial isolation from soil in flasks containing 2 per cent mannitol and 0·02 per cent sodium phosphate in tap water, progressive subcultures were made on solid nitrogen-free medium containing washed agar and the same percentages of mannitol and phosphate in distilled water—a recognized procedure for purifying *Azotobacter*[1]. Characteristic colonies of *Azotobacter* were obtained in about a month, and stained smear preparations of these colonies revealed only the characteristic large cells of the organism. If, however, colonies were inoculated into peptone water (in which *Azotobacter* will not grow[2]) a faint haze due to growth of small Gram-negative rods appeared after 24–48 hr. incubation at 22° C. A more abundant growth of these rods was obtained in 24 hr. on nutrient agar containing 0·1 per cent whole milk, whereas on this medium the growth of *Azotobacter* was very poor after three to four days. Subculture of *Azotobacter* on solid nitrogen-free medium (above) was therefore extended up to periods of four months, and 0·1 per cent sodium silicate, 0·002 per cent iron ($FeCl_3$) and boron, 0·00004 per cent sodium molybdate, soil extract and hay-infusion were incorporated in some cultures to heighten the resistance of *Azotobacter*. In practically all cases, however, the contamination persisted. On the one or two occasions on which it appeared to be absent, growth of *Azotobacter* was very poor, marked by absence of the characteristic mucilage, and ceased within seven to fourteen days; nor could it be restored by incorporation of any of the above substances. Fourteen strains of contaminants were isolated the cultural characters of which proved conclusively they were not pleomorphic forms of *Azotobacter*, the majority being strains of *Pseudomonas* (fluorescent and non-fluorescent) with one or two species of *Achromobacter*. In the absence of *Azotobacter*, they grow well up to four weeks in flasks of the above liquid mannitol medium, reducing its reaction to a pH of 4·0 in a fortnight although growth was still vigorous. Their source of nitrogen in such cultures is obscure. They grew in liquid media, distilled water with 1 per cent glucose and ammonia (0·1 per cent $(NH_4)_2HPO_4$) as the sole source of nitrogen; but only feebly in 1 per cent glucose only. Incorporation of whole killed cultures, extracts or filtrates of cultures improved growth of *Azotobacter* on solid nitrogen-free media and improved its mucilage production.

Large numbers of contaminants depressed the growth of *Azotobacter* in nitrogen-free liquid media when they were grown in association. Fluorescent strains of *Pseudomonas* destroyed the *Azotobacter* cells.

All the contaminants were freely ingested by soil ciliate protozoa which multiplied in their presence. Fluorescent *Pseudomonas* inhibited growth of *Colpoda* sp. but not, for example, *Urostyla grandis*, which fed upon it.

*Azotobacter* is reported to be accompanied in Nature by a small Gram-negative rod *Radiobacter*[3] the relationships of which are ill-defined. The present findings suggest that association with common Gram-negative rods may persist unsuspected in laboratory cultures regarded as pure.

These observations were carried out when I was serving as senior bacteriologist in the National Agricultural Advisory Service of the Ministry of Agriculture, and thanks are due to C. D. Oxley, provincial bacteriologist, and F. W. Catton, assistant bacteriologist, for material advice and assistance.

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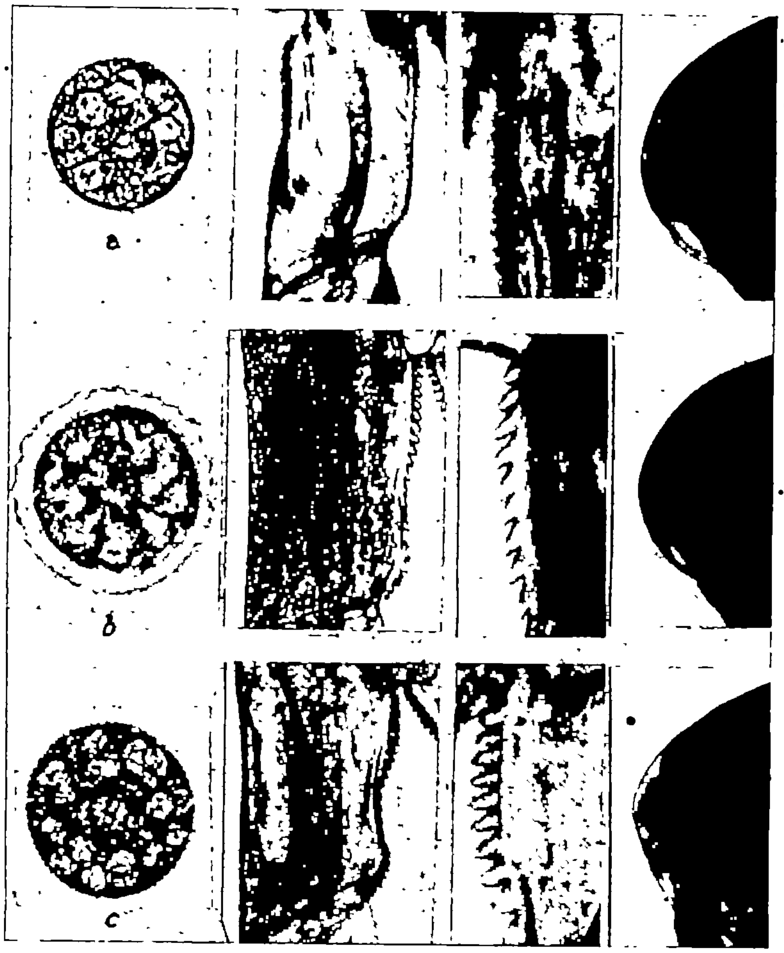
## *Calanus finmarchicus* and Related Forms

THE copepod *Calanus finmarchicus* has been more thoroughly investigated than any other marine plankton organism. Some systematists have recognized in the material from European[1] and eastern American waters[2] two distinct species, *C. finmarchicus* and *C. helgolandicus*; but the distinguishing characters given have been too uncertain to receive universal acceptance[3]. In consequence, it has been assumed in most studies of the copepod—its population changes, physiology, behaviour, etc.—that the material used consists of a single species. Recently[4], it was pointed out that two forms, corresponding to the two species, could be readily distinguished in the female and copepodite stage V by the structure of the basipod of the fifth swimming feet, though their status, whether species or sub-species, remained



Typical eggs, the basipod segment of the left fifth legs, the proximal teeth of the basipod of the right fifth legs and the foreheads of females of (*a*) *Calanus finmarchicus*, (*b*) the *Calanus* from Tromsø, and (*c*) *C. helgolandicus*

undecided. It has also been shown[5] that the eggs of *helgolandicus* are bigger (165–180 μ in diameter) than those of *finmarchicus* (135–155 μ). Following upon the more definite means of identification, it is becoming recognized that in future research the two forms should be distinguished[6].

In the early spring of 1952, in Tromsø Sound, northern Norway, the majority of female *Calanus* caught were *finmarchicus*; no *helgolandicus* was found. About 10 per cent, however, laid eggs of the same size as *helgolandicus*; but these, shortly after laying and before the first cleavage, produced a rugose membrane with a clear space between it and the egg, varying in width (see photographs). These eggs were viable and hatched into nauplii slightly larger than those of the normal *finmarchicus*.

Out of well over a thousand females observed laying eggs in the laboratory at Millport, two have produced similar eggs with membranes; but in neither case were the eggs healthy and unfortunately neither of the females was examined in detail.

Some of the Tromsø females which laid these eggs were later examined and compared with typical examples of *finmarchicus* and *helgolandicus* (see photographs). In *finmarchicus* the teeth of the basipod of the fifth legs are arranged along the edge of the segment and are numerous and small; the forehead is evenly round. In *helgolandicus* the tooth line curves round to the posterior side of the segment, giving a marked concave appearance to the inner margin of the segment, the teeth being fewer and larger than in *finmarchicus*; the forehead is more or less pointed. The *Calanus* from Tromsø show mixed and intermediate features of the two forms so far recognized. The tooth line is curved, but the curvature is small and more like *finmarchicus* than *helgolandicus* in this respect; but the teeth are similar to those of the latter in number and size; the forehead resembles *finmarchicus* in being evenly round.

Morphologically, the Tromsø *Calanus* are sufficiently distinctive to constitute a third form. Two possible interpretations immediately present themselves. The first, and the more likely, is that they have the same status as *C. finmarchicus* and *C. helgolandicus*, be this species or sub-species. The second is that they have arisen through interbreeding of the two other forms. This seems less likely, for in the areas where these two forms are commonly found together, the Tromsø form is extremely rare or absent, whereas it formed up to 10 per cent of the catch in the Arctic where *C. finmarchicus* predominates.

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## Life-history of *Fasciola gigantica* Cobbold 1856

FOLLOWING the elucidation by Thomas[1] of the life-history of *Fasciola hepatica*, numerous investigations have established the important aspects of the relationship between the fluke and its snail hosts. By contrast, knowledge of the related *F. gigantica* is extremely limited, and in many parts of the world even the identity of its vectors has not been confirmed.

During the course of a recent field survey which was initiated by the Food and Agriculture Organization of the United Nations as part of a programme of liver-fluke control in Pakistan, the Veterinary Laboratory of the Ministry of Agriculture at Weybridge was used as a central laboratory for experimental work for which facilities did not exist in Pakistan. At Weybridge, the use of laboratory techniques which had been developed for work on *F. hepatica* and its host *Lymnaea truncatula* made it possible readily to observe the development of *F. gigantica* under controlled conditions both in molluscs and in mammalian hosts.

Snails which had been collected near Rawalpindi in Pakistan were kept under observation in shallow earthenware dishes of water at the Central Laboratory of the Animal Husbandry Department, Peshawar. Egg-laying commenced within three weeks. On February 2, 1952, two egg masses were sent by air to England. Snails from these egg-masses were exposed to infection with the miracidia of *Fasciola gigantica* (also of Pakistan origin) on March 24. Development of the parasite proceeded to completion at laboratory temperatures, emergence of mature cercariae being first observed on June 10, 78 days after infection.

Starting on July 3, a lamb (aged fifteen weeks) was given a total of two hundred cercariae over a period of nine days. On October 21 (110 days later), eggs of *Fasciola gigantica* were recovered from the fæces. An identical period of time proved necessary for the full development of the parasite in a calf. This may be compared with an average of about seventy days necessary for the development of *Fasciola hepatica* both in sheep and in calves.

The snails used in these observations have been identified for us by Mr. G. L. Wilkins, of the British Museum (Natural History), as *Lymnaea rufescens* Gray (a species considered by Hubendick[2] to be merely a race of the well-known *L. auricularia*). *L. auricularia rufescens* (Hubendick[2]), showing great variation in shell morphology, occurs widely throughout east and west Pakistan, where field observation suggests that it is the principal vector of *Fasciola gigantica*. Most shells are similar to the forms of *L. acuminata* described by Annandale and Rao[3]. The snails are often found as true aquatics in large bodies of permanent water, the frequent connexion with deep pools possibly having an association with a negatively phototropic reaction which we have observed in the miracidia of *F. gigantica*. This response, although not noted by Alicata[4] in Hawaii, is, under our laboratory conditions, most marked and in direct contrast to the strong positive phototropism of the miracidia of *Fasciola hepatica* which in Pakistan, as in Europe, parasitizes the amphibious *L. truncatula*.

At Weybridge *L. auricularia rufescens* has readily accommodated itself to a restricted habitat. Management very similar to that recommended by Taylor and Mozley[5] for the culture of *L. truncatula* has proved satisfactory, although it has been found necessary to maintain a depth of one to two inches of water in the culture dishes.

Further observations on the life-history are being made and will be recorded at a later date. In particular, we are interested in the possibility of the British *L. auricularia* (L.) proving susceptible to infection with *Fasciola gigantica*.

S. BRIAN KENDALL
J. W. PARFITT

Ministry of Agriculture Veterinary Laboratory,
New Haw, Weybridge,
Surrey.
Jan. 14.

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[1] Thomas, A. P. W., *Quart. J. Micro. Sci.* (N.S.), 23, 99 (1883).

[2] Hubendick, B., *K. Svenska Vetenskapsakad. Handl.*, 3, 1 (1951).

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[4] Alicata, J. E., Hawaii Agric. Exp. Sta., Honolulu, Bull. 80 (1938).

[5] Taylor, E. L., and Mozley, A., *Nature*, 161, 894 (1948).

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## A Method for the Bulk Growth of a Parasitic Protozoan

THE biochemical study of protozoan species has been hampered by the difficulty of obtaining large quantities of clean, dried organisms to serve as starting material for investigation. The solution of the problem of bulk growth of the protozoan cattle parasite, *Trichomonas foetus*[1], made possible an immunochemical study of the organism[2].

*Trichomonas vaginalis*, a protozoan parasite of man, presents a similar problem. Strains isolated in a bacteria-free state by the use of antibiotics[3] can be grown in culture media in current use, but in the best reported conditions only about $2 \times 10^6$ organisms per ml. are obtained after three to four days in 5 or 10 ml. quantities of medium. For the practical harvesting of dried organisms, litre quantities of culture containing $4–5 \times 10^6$ organisms per ml. are desirable[2]. A further drawback of most published media for *T. vaginalis* is the inclusion of particulate matter (agar or rice starch), which makes it difficult or impossible to collect the organisms in the pure state.

The starting point for the current investigation was the agar-free modification by McEntegart[4] of the C.P.L.M. medium of Johnson and Trussell[5]. It was determined that a Liverpool strain of *T. vaginalis*, which had become adapted to McEntegart's medium, would grow in it at $1–1{\cdot}5 \times 10^6$ per ml. when subcultured at 48-hr. intervals. Stepwise modification of this medium led to the following formula for a medium in which this Liverpool strain will attain a growth-level of $4–6 \times 10^6$ per ml. within 24 hr. and which will support such growth in bulk volumes.

| | |
|---|---|
| Ascorbic acid | 3·7 gm. |
| L-Cysteine hydrochloride | 2·5 gm. |
| Proteolysed liver B.P.C. (ref. 6) | 1·0 gm. |
| Glucose | 10·0 gm. |
| Distilled water | 1,200·0 ml. |
| Bovine serum | 160·0 ml. |
| Douglas's digest broth, double strength (ref. 7) | 1,000·0 ml. |
| *M* Sodium hydroxide to *p*H 5·8–6·0 | |

The medium is sterilized by passing through a Seitz filter and should be used within fourteen days. For tube-growth, 10-ml. amounts are inoculated with 0·5 ml. of an actively growing culture and incubated at 36–37° C. Sub-culturing is done daily.

Bulk growth is carried out in 80-oz., narrow-necked, round bottles, using 2 litres of medium per bottle. The necessary inoculum for each bottle is obtained by successive 24-hr. subcultures in (*a*) a tube and (*b*) 100 ml. of medium in an 8-oz. flat medicine bottle. The medicine bottle receives 5 ml. inoculum from the tube and contributes 100 ml. inoculum to the bulk bottle. All bottles are warmed in the incubator for 24 hr. prior to inoculation.

The organisms from the bulk cultures are collected and thrice washed by centrifugation and re-suspension in saline. After the final centrifugation they are suspended in a small quantity of distilled water, frozen and dried from the frozen state. The yield is 1·1–1·5 gm. dried organisms per bottle.

The suitability of this culture medium for *T. vaginalis* has been further demonstrated by the successful isolation of two new bacteria-free strains from clinical material, using 1,000 units penicillin and 500 units streptomycin per ml. Initial growth was slow; but after several passages the strains (Whitechapel 1 and 2) adapted themselves to the medium and are now growing at 4–5 × $10^8$ per ml. A single attempt at bulk growth with Whitechapel 1 yielded 1 17 gm. from one bottle.

Of special interest is the observation that proteolysed liver B.P.C.[6] can replace the 'Difco' liver infusion called for in the C.P.L.M. medium[4,5]. Attempts to grow the organisms without liver (or a substitute infusion of human red blood cells) were unsuccessful. Proteolysed liver B.P.C. is a completely soluble, inexpensive material and may prove useful as a substitute for liver infusion or as a growth-promoting inclusion in media for the culture of other micro-organisms.

A fuller account of this investigation will be reported elsewhere. I am indebted to Dr. M. G. McEntegart, Liverpool City Bacteriological Laboratory, for his original culture and medium; to Dr. Claude Nicol, Whitechapel Clinic, for clinical specimens; to Messrs. Paines and Byrne, Ltd., Greenford, Middlesex, for generous quantities of 'Pabyrn' brand proteolysed liver B.P.C.; and to Mr. C. D. Bevis, Lister Institute, for technical assistance.

JOSEPH G. FEINBERG*

Lister Institute of Preventive Medicine,
London, S.W.1.
May 12.

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* U.S. Public Health Service Research Fellow of the National Microbiological Institute.

[1] Kerr, W. R., and Robertson, M., *J. Comp. Path.*, 57, 301 (1947).
[2] Feinberg, J. G., and Morgan, W. T. J., *Brit. J. Exp. Path.*, 34, 104 (1953).
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## Excess of Molybdenum in Herbage as a Possible Contributory Factor in Equine Osteodystrophia

DEFECTS in nutrition which predispose to osteodystrophic conditions in the horse include a dietary deficiency of phosphorus[1] or disturbance in the vitamin D – calcium – phosphorus relationship. With regard to the influence of trace minerals, Davis[2] found that the presence of small amounts of molybdenum, ranging from 2 to 25 p.p.m. in young growing herbage, was associated with defective bone metabolism in herbivora, consequent on the effects of molybdenum on the utilization of both phosphorus and copper. More recently, Arrington and Davis[3] in limited phosphorus metabolism studies with rabbits reported that molybdenum decreased phosphorus absorption while at the same time increasing the excretion of phosphorus.

On some twelve farms where we have investigated the occurrence of clinical rachitis in one or more of the foals or yearlings, we have found that the molybdenum content of the grazing herbage has been within the range 5–25 p.p.m. The soils on these farms are mainly derived from limestone, being of a similar nature where soil type, manurial treatment and management are concerned to those on which molybdenum-conditioned copper deficiency has previously been identified by us[4]. In addition, readily available molybdenum determinations on these soils have shown values in the region where excess levels of molybdenum in herbage are likely to occur. While it has been impossible so far to ascertain to what extent molybdenum may be an etiological factor, we suggest that a foal running with its dam on such pastures would receive an excessive intake of molybdenum from the mare's milk and from the herbage. In view of the work referred to above, such a foal would be more susceptible to osteodystrophic conditions as a result of the influence of molybdenum on the metabolism of both phosphorus and copper. Consequently the extent to which molybdenum in moderate excess in pasture may predispose to the development of poor bone in the young horse and afterwards to poor performance in later life is raised.

T. WALSH

Soil Laboratory,

L. B. O'MOORE

Biochemistry Section,
Veterinary Research Laboratory,
Department of Agriculture,
Ireland.
Jan. 27.

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[1] Akerblom, E., *Nord. Vet. Med.*, 5, 471 (1952).
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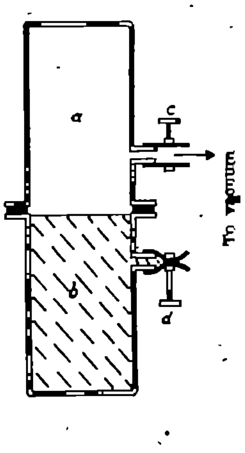
## Apparatus for Infiltration of Liquids into Leaves

VACUUM infiltration of liquids into leaves is a technique that has been used for many years. So far as I am aware, the usual procedure is to keep the leaf under liquid while reducing the pressure. Air bubbles then escape from the stomata, and any adhering when the lowest pressure has been attained are dislodged, often with difficulty, by shaking the container; for when the vacuum is afterwards released the adherence of these bubbles would spoil the efficiency of infiltration. The difficulty of bubble removal is greatly increased when a number of leaves are simultaneously infiltrated, so that it is desirable to use as few leaves as possible, or even to treat them singly. To overcome such difficulties it is best to reduce the pressure while the leaves are in air, releasing pressure only after putting the leaves under liquid. A convenient way of doing this is described below.

Two glass or metal containers of suitable strength, each with a side-arm and flange, are stood one upon the other, separated by a wet rubber washer. The leaves are held in chamber *a*, and the infiltrating fluid in *b*; *c* and *d* are clips on rubber pressure-tubing (glass stopcocks could be used) attached to the side-arms of the chambers. To evacuate the apparatus, *c* is opened, and when the desired degree of evacuation, read on a gauge, is reached, closed again. The whole arrangement is now inverted so that the infiltrating liquid runs on to the leaves. Then *d* is opened so



as to release the vacuum gently, and infiltration takes place.

Generally eight to ten leaves of *Atropa belladonna*, L., each 6·5 in. long and 3–3·5 in. at the widest, were simultaneously infiltrated. They were first rolled in a springy, spiral, piece of celluloid-like material 1–1·5 in. wide, and secured if necessary with a loose rubber band. The leaves so compacted were held in chamber *a* with their petioles at the bottom, by means of a suitable spring-clip.

The method gives complete infiltration with minimal reduction of pressure, and if a good rate of evacuation is obtainable the leaves need not be kept under reduced pressure, even with the relatively large chambers used, for more than a minute.

The quantity of infiltrating liquid required depends, of course, on the volume necessary to cover the leaves. For the number of leaves and dimensions given, nearly a litre was required, of which less than 15 ml. was retained by the leaves: this extravagance of the method is sometimes a drawback.

Arwyn Charles

Oxford Medicinal Plants Scheme,
Department of Botany,
South Parks Road,
Oxford.
Feb. 4.

## Inheritance of Minor Colour Vision Variations

A considerable amount of attention has been given to the inheritance of major colour vision defects, namely, red-green blindness and anomalous colour vision[1–5], and the view most favoured at present is that there are two groups of totally sex-linked alleles with three members in each group (together with dominant normal genes) which determine major red and green defects. Walls has recently put forward the view that there might be a third locus, also with three alleles, and totally sex-linked, which determine blue vision defects[6].

Total sex-linkage of minor blue and yellow vision defects is not supported by the fact that these variations are as frequent in women as in men[4]. A study of forty pedigrees which reveal the inheritance of blue and yellow minor colour vision defects, collected in the course of testing 649 men and 546 women, strongly suggests that some of their more extreme forms are due to the action of partially sex-linked multiple allelomorphs. Partial sex-linkage is difficult to distinguish decisively from autosomal inheritance, but seems likely.

The minor defects of blue vision are defined as: (1) blue deviation, (2) blue weakness, and (3) blue-yellow weakness with darkened violet. The distinction between 'deviation' and 'weakness' has been explained fully elsewhere[4]. It is suggested that the appropriate genes might be called: $B$ (normal and most dominant), $b_1$, $b_2$ and $b_3$ (most recessive). The segregation of these genes is clearly apparent in the pedigrees, two of which suggest the dominance order and four suggest crossing-over between genes in the blue series.

The minor defects of yellow vision are defined as: (1) yellow deviation, (2) yellow weakness and (3) extreme yellow-blue weakness. The appropriate genes might be called: $Y$ (normal and most dominant), $y_1$, $y_2$ and $y_3$ (most recessive). Again, segregation can be seen clearly in the pedigrees, three of which suggest the dominance order and four indicate crossing-over between genes of the yellow series.

These facts seem to favour a four-receptor theory of colour vision.

In addition, five pedigrees show totally sex-linked forms of minor red and green deviation. These are very mild forms of red and green anomaly, two pedigrees for red, two for green and one for both together. Darkening of the red is shown in one pedigree. In order to explain these, it is necessary to assume a degree of heterozygous manifestation not much less than the defects of the hemizygotes themselves, though not always the same. This may be because the appropriate genes are the most dominant, next to the normal genes in the familiar protanope and deuteranope series, and have the greatest penetrance.

In many of the pedigrees, major red and green and minor blue and yellow variations occur together and may be traced out as segregating independently. Totally sex-linked major blue defects were not found in the population tested, but may occur.

Details of this investigation will be published fully elsewhere.

R. W. Pickford

Psychology Department,
The University,
Glasgow, W.2.
Jan. 25.

[1] Waaler, G. H. M., *Z. Ind. Abst., Vererb.*, 45 (4), 279 (1927).

[2] Franceschetti, A., *Schweiz. Med. Wochens.*, 58, 1273 (1928).

[3] Franceschetti, A., *Bull. Acad. Suisse Sci. Med.*, 5, 227 (1949).

[4] Pickford, R. W., "Individual Differences in Colour Vision" (1951).

[5] Gray, R. C., *Arch. Ophth.*, 29, 446 (1943).

[6] Walls, G. L., and Mathews, R. W., *Univ. Calif. Pub. Psych.*, 7 (1), 1 (1952).

## Predacious Mosquito Larvæ

Apart from the obligatory cannibalism of the genus *Toxorhynchites* and the sub-genera *Mucidus* and *Lutzia*, cannibalism in other mosquito genera has been little studied. Graham[1] stated that the addition of 3 per cent common salt to the breeding water brought about cannibalism in *A. gambiæ*. This was not confirmed by subsequent work. It has, however, been observed in Mauritius that facultative cannibalism exists within the salt-water strain of *A. gambiæ*. Such a tendency has not been observed in the fresh-water strains of *A. gambiæ*.

Third- and fourth-stage larvæ can be seen to seize other larvæ, of all stages, by the abdomen and to commence to feed. This would appear to stimulate neighbouring larvæ, as within a few seconds numerous larvæ are feeding upon the hapless victim, whose vigorous struggles are usually in vain. The head capsule is all that remains, but larvæ can be seen attempting to extract the contents of the head capsule with their mouth brushes. Pupæ are immune from attack.

This tendency to cannibalism, in the presence of abundant larval food, brings about a considerable mortality in a laboratory culture. The breeding dishes are littered with head capsules each morning, the larval numbers being correspondingly reduced.

James G. Halcrow

Malaria Eradication Scheme,
Floreal, Mauritius.
Jan. 17.

[1] Graham, W. M., *Bull. Ent. Res.*, 1, 51 (1910).

# FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

### Monday, June 29

UNIVERSITY OF LONDON (in the Physiology Theatre, University College, Gower Street, London, W.C.1), at 5 p.m.—Dr. Warren S. McCulloch: "Some New Techniques for the Electrophysiological Study of the Central Nervous System".*

### Tuesday, June 30

BRITISH SOCIETY FOR THE HISTORY OF SCIENCE, PHILOSOPHY OF SCIENCE GROUP (in the Joint Staff Common Room, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Dr. Warren S. McCulloch: "Through the Den of the Metaphysician".

### Wednesday, July 1

GEOLOGICAL SOCIETY OF LONDON (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Scientific Papers.

INTERNATIONAL HAEMOPHILIA SOCIETY (at 94 Southwark Bridge Road, London, S.E.1), at 6.30 p.m.—Second Meeting of the London Group *

# APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

SCIENTIFIC OFFICER, Grade I (with university degree of high standard in physics or electrical engineering or equivalent qualification, preferably electronic) in the High Speed Aerodynamics Laboratory, Salisbury, South Australia, to be responsible to a Senior Scientific Officer for the development of instruments for aerodynamic research and the adaptation of existing instruments for special purposes—The Senior Representative (A.P.2), Department of Defence Production and Supply, Australia House, Strand, London, W.C.2 (July 3).

ASSISTANT STATISTICIANS (with first- or second-class honours degree with statistics as a main subject, or a postgraduate university diploma or higher degree in statistics) in Government Departments—The Secretary, Civil Service Commission, Burlington Gardens, London, W.1, quoting 96/53 (July 4).

BIOCHEMIST (Basic Grade) (with B.Sc. degree, preferably with honours in biochemistry or chemistry, or equivalent qualification)—The House Governor, General Hospital, Birmingham 4 (July 4).

EXPERIMENTAL OFFICER at the Ministry of Supply Experimental Flying Establishment, Salisbury, for assessment and proving of aircraft camera installations for photographic survey and reconnaissance, and development of photographic methods applied to aircraft flight-testing—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting F253/53A (July 4).

LECTURER (with a first- or second-class honours degree in physics or electrical engineering or equivalent qualifications) IN THE PHYSICS AND ELECTRICAL ENGINEERING DEPARTMENT—The Director of Studies, Royal Naval College, Greenwich, London, S.E.10 (July 4).

MAY AND BAKER RESEARCH FELLOWSHIP for research work on plant growth-regulating substances—The Registrar, Wye College, Ashford, Kent (July 4).

AGRICULTURAL ECONOMIST (at Bristol), and ASSISTANT AGRICULTURAL ECONOMISTS (4, 2 at Bristol and 2 at Newton Abbot)—The Registrar, The University, Bristol 8 (July 6).

ASSISTANT EXPERIMENTAL OFFICER AT THE POULTRY RESEARCH CENTRE, EDINBURGH, to assist in investigations involving histological, physiological and biochemical techniques—The Secretary, Agricultural Research Council, Cunard Building, 15 Regent Street, London, S.W.1 (July 6).

RESEARCH ENTOMOLOGIST (with good honours degree) for investigations on laboratory and field methods for the development and bioassay of insecticides—The Secretary, East Malling Research Station, Maidstone, Kent (July 7).

TUTORIAL STUDENTSHIP IN PHARMACOLOGY, and a TUTORIAL STUDENTSHIP IN ZOOLOGY (preferably of the vertebrates)—The Registrar, King's College, Strand, London, W.C.2 (July 7).

SENIOR RESEARCH FELLOWSHIP IN NATURAL PHILOSOPHY—The Secretary, The University, Aberdeen (July 8).

SYBIL MARY PILKINGTON FELLOWSHIP for research into diseases of the blood, with particular reference to the causation, treatment, and cure of leukaemia in man—The Registrar, The University, Manchester 13 (July 10).

ASSISTANT IN THE DEPARTMENT OF GEOGRAPHY—The Secretary, The University, Edinburgh (July 11).

ASSISTANT (Grade A) IN THE DEPARTMENT OF MATHEMATICS—The Clerk to the Governors, Woolwich Polytechnic, Woolwich, London, S.E.18 (July 11).

CHEMIST in a Ministry of Supply Establishment, Aldermaston, Berks, to develop and supervise a unit engaged on quantitative analysis of organic compounds by micro-combustion techniques—The Ministry of Labour and National Service, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting F.252/53A (July 11).

GRADUATE ASSISTANT IN PHYSICS (with university degree in physics, and special interest in electronics as applied to biological problems)—The Professor of Physiology, Department of Physiology, University Museum, Oxford (July 11).

STATISTICIAN (honours graduate, Scientific Officer grade)—The Secretary, National Vegetable Research Station, Wellesbourne, Warwick (July 13).

ASSISTANT LECTURER IN ECONOMIC STATISTICS in the Department of Political Economy—The Secretary, University College, Gower Street, London, W.C.1 (July 14).

ELECTRONIC ENGINEER in the Ministry of Supply, London headquarters, to supervise the development by industry of electroni navigation aids for Service use—The Ministry of Labour and Nationa Service, Technical and Scientific Register (K), Almack House, 26 Kin Street, London, S.W.1. quoting D.223/53A (July 14).

EXTENSION LECTURER IN SCIENCE (with special qualifications i natural science, preferably biology)—The Secretary, Universit Extension Lectures Committee, Rewley House, Wellington Square Oxford (July 15).

LECTURER IN EXPERIMENTAL PHYSICS—The Secretary of University Court, The University, Glasgow (July 15).

LECTURER IN MATHEMATICS at the Auckland University College New Zealand—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (July 15)

LECTURER and an ASSISTANT LECTURER IN GEOGRAPHY—The Registrar, The University, Leeds 2 (July 15).

SENIOR EXPERIMENTAL OFFICER (with degree in a scientific or engineering subject or in mathematics, or a H.N.C., or a graduat membership of a professional institution) in the National Physica Laboratory, Teddington, to assist in co-ordinating the work of the workshops and design offices (which produce prototype precisio instruments and the apparatus needed for the laboratory's researc work)—The Civil Service Commission, Scientific Branch, Trinida House, Old Burlington Street, London, W.1, quoting S.4220/5 (July 15).

SENIOR LECTURER or LECTURER (Grade I) and a LECTURER (Grade II) IN CHEMISTRY, a LECTURER (Grade II) or ASSISTANT LECTURER IN ZOOLOGY (preferably with special interests in taxonomy and ecology), and a LECTURER (Grade I) IN MATHEMATICS, at University College, Ibadan, Nigeria—The Secretary, Inter-University Council fo Higher Education in the Colonies, 1 Gordon Square, London, W.C. (July 21).

SENIOR RESEARCH OFFICER (Chemical Engineer) (with university honours degree in science, with chemistry as major subject, or i chemical engineering, and some industrial experience, preferably i research and development) at the Wool Textile Research Laboratory Geelong, Victoria—The Chief Scientific Liaison Officer, Australia Scientific Liaison Office, Africa House, Kingsway, London, W.C.2 quoting 464/52 (July 25).

LECTURER IN BIOCHEMISTRY at the University of Malaya, Singapore—The Secretary, Inter-University Council for Higher Education i the Colonies, 1 Gordon Square, London, W.C.1 (July 31).

SENIOR LECTURER or LECTURER IN GEOLOGY at New South Wales University of Technology, Sydney, to teach geophysics and economic geology, and to undertake research in these fields—The Agent Genera for New South Wales, 56–57 Strand, London, W.C.2 (August 4).

CHAIR OF INORGANIC AND PHYSICAL CHEMISTRY in the University of Adelaide—The Secretary, Association of Universities of the Britis Commonwealth, 5 Gordon Square, London, W.C.1 (Adelaide, Augus 31).

SENIOR LECTURER (heavy current) IN THE DEPARTMENT OF ELECTRICAL ENGINEERING, University of Natal, Durban—The Secretary Association of Universities of the British Commonwealth, 5 Gordo Square, London, W.C.1 (August 31).

LECTURER IN BOTANY (special qualifications in Plant Physiolog would be an advantage) at New England University College (Universit of Sydney), Armidale, N.S.W.—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C. (Armidale, September 1).

ASSISTANT, Grade B (with good honours degree in chemistry, and able to teach organic chemistry to final degree standard) FOR CHEMISTRY—The Clerk to the Governors, South-East Essex Technica College, Longbridge Road, Dagenham, Essex.

ASSISTANT, Grade B (with good degree in physics of a Britis university) IN PHYSICS—The Registrar, Medway Technical College Gardiner Street, Gillingham, Kent.

ASSISTANT (Assistant Experimental Officer grade) for general dutie IN THE PLANT PATHOLOGY SECTION—The Secretary, Scottish Horticultural Research Institute, Mylnefield, Invergowrie, Dundee.

ASSISTANT METEOROLOGIST in Trinidad—The Crown Agents fo the Colonies, 4 Millbank, London, S.W.1, quoting M3B/33626/NF.

ENGINEER, Grade I (Ref. 467) and ENGINEERS, Grade II and II (Ref. 468), for work on major calculations required by design office concerned with nuclear reactors and factories for producing fissil material—The Ministry of Supply, Division of Atomic Energy (Production), Risley, Warrington, Lancs, quoting the appropriate Ref. No

EXPERIMENTAL OFFICERS and ASSISTANT EXPERIMENTAL OFFICER IN THE MINISTRY OF FUEL AND POWER at Sheffield and Kidderminste for underground gasification project exploring new technique to mak gas direct from the coal seam (Ref. F.256/53A); SCIENTIFIC OFFICER FOR SAFETY IN MINES RESEARCH ESTABLISHMENTS at Sheffield an Buxton (Ref. F.257/53A); ASSISTANTS (Scientific) at Sheffield an Buxton (Ref. F.258/53A); SCIENTIFIC OFFICERS IN THE CHIE SCIENTIST'S DIVISION, London (Ref. F.259/53A)—The Ministry Labour and National Service, Technical and Scientific Register (K Almack House, 26 King Street, London, S.W.1, quoting the appropriate Ref. No.

GEOLOGIST IN THE PUBLIC WORKS DEPARTMENT, Sudan—Th Sudan Agent in London, Sudan House, Cleveland Row, Londo S.W.1, quoting "Geologist 1810".

GRADUATE IN METALLURGY, CHEMISTRY or PHYSICS, to join group studying atomic movements in solids by means of radioacti tracers—The Secretary, The University, Leeds.

RESEARCH ENGINEER (good honours degree essential) for gener automobile engineering problems, for investigations concernin mechanical properties (in particular fatigue strength) of materials an components, and for investigations into loadings experienced b vehicle components on the road, riding characteristics of vehicle etc.—The Director, Motor Industry Research Association, Lindley Nuneaton.

SCIENTIFIC OFFICERS and SENIOR SCIENTIFIC OFFICERS for projec assessment groups at the Royal Aircraft Establishment, Farnborough and at Ministry of Supply London headquarters—The Ministry Labour and National Service, Technical and Scientific Register (K Almack House, 26 King Street, London, S.W.1, quoting A.161/53A.

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